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REVIEW

UPPER RESPIRATORY TRACT INFECTIONS AND RHINO-PHARYNGEAL CLEARANCE IN CHILDREN: MYTHS AND CLINICAL EVIDENCE FOR A PICTORIAL ESSAY

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ABSTRACT

Upper respiratory tract infections (URTI) have a high incidence in young children leading to Eustachian tube (ET) dysfunction and middle ear impairment, due to anatomical and physiological connections between these structures. In recent years, pharmacological treatments have started to be avoided. Moreover, there is no evidence of an effective pharmacological treatment of URTI in children, since antibiotics, narcotics, antihistamines, and decongestants are not recommended. Thus, effective rhino-pharyngeal clearance could avoid the deleterious evolution of the child's health condition by reducing or eliminating nasal secretions, re-establishing nasal breathing, and preventing dissemination, which may result in bacterial infection. Several studies have underpinned the benefits and immediate effects of rhino-pharyngeal clearance, such as the improvement of nasal obstruction and middle ear pressure on tympanometry in children under 3 years of age with URTI. However, a consensus on future research directions and clinical trials is required to establish and implement efficient protocols with adequate treatment monitoring and outcome measures. This article aims to highlight the best evidence, clarify some goals among different areas of expertise, and suggest future research.

Keywords: children, future research, rhino-pharyngeal clearance, , treatment outcomes, tympanometry, upper respiratory tract infections

INTRODUCTION

Upper respiratory tract infections (URTI) have a high incidence in young children leading to Eustachian tube (ET) dysfunction. There are several studies with the purpose of determining the risk factors; however, there is considerable variation in the quality of the research and there are many confounding variables to be considered (1,2). At the same time, several non-pharmacological treatments (nasal saline irrigations, nasal aspirators, or respiratory manoeuvres) are

being considered and used by otorhinolaryngologists, physiotherapists and paediatricians. Moreover, there is some evidence of efficacy and safety of non-pharmacological treatments in decreasing the need for medication in children during the treatment of URTI, besides their role in prevention (3,4,5,6). However, there is still some scepticism/misunderstanding among clinicians from the above-stated areas of expertise regarding the use of these new treatment approaches.

Considering this, the present article summarizes the state of the art on rhino-pharyngeal clearance in children, clarifies the benefits and limitations of non-pharmacological treatments of URTI, highlighting the new trends and recommendations for future research.

Upper Respiratory Tract Infections (URTIs)

URTI is commonly caused by viruses, with rhinovirus being the most frequent etiological agent, as well as Respiratory syncytial virus and Influenza A + B viruses (7,8,9,10). It includes infections of the respiratory tract situated above the glottis, such as common cold, acute rhinitis, pharyngitis, tonsillitis, and acute otitis media, although some authors also consider in this group epiglottitis and laryngitis (11). Other studies include case definitions of URTI according to the observed or reported following signs and symptoms, such as nasal discharge, cough and nasal congestion (12,13,14,15), or signs of middle ear impairment. Nevertheless, other signs and symptoms of URTI are also accepted, such as reduced appetite, decreased fluid intake, fever and disturbed sleep (15). The clinical assessment of a child with URTI should consider the presenting symptoms, as well as previous medical history, relevant risk factors, relevant comorbidities, and the clinical examination to identify relevant clinical signs (16). The great heterogeneity among the literature about the management of signs and symptoms of URTI in children limits the ability to make specific recommendations about its treatment.

Preventive and therapeutic strategies include nasal hydration with saline solutions, which have demonstrated efficacy in reducing congestion and improving quality of life, particularly in paediatric populations (6,9,10). Nasal hygiene, when combined with caregiver education, has a positive impact on paediatric respiratory health; however, early and appropriate intervention is crucial to prevent complications and reduce the burden on healthcare services (2,4,6,8).

Allergic and Non-Allergic Rhinitis

Allergic rhinitis (AR) is an IgE-mediated inflammation of the nasal mucosa, characterized by symptoms such as nasal pruritus, sneezing, rhinorrhea, and nasal obstruction, and may be associated with allergic conjunctivitis (17). It is classically divided into two phases: the early-phase reaction occurs within minutes of exposure to an allergen (e.g., pollen, dust mites, pet dander), involving the release of histamine and prostaglandins; the late-phase reaction (4–24 hours post-exposure) involves the recruitment and release of eosinophils, cytokines, and T cells to combat nasal inflammation (18). Diagnosis is based on clinical history, physical examination, and sensitization tests, including skin prick testing or specific IgE quantification (19).

Environmental control strategies and nasal cleansing with isotonic or hypertonic saline solutions are recommended to reduce allergen load and improve mucociliary function (20,21). Nasal irrigation, in particular, has demonstrated efficacy in symptom reduction and quality of life improvement, representing a safe and cost-effective adjunctive therapy (22).

Acute and Chronic Sinusitis

Sinusitis refers to inflammation of the paranasal sinuses, commonly associated with viral, bacterial, or fungal infections, or allergic factors such as AR or nasal polyps (23). Diagnosis is primarily clinical, based on symptoms such as nasal congestion, purulent discharge, facial pain, hyposmia, and cough. Imaging studies, particularly computed tomography, may be used to identify anatomical variations or complications (24). While acute sinusitis is typically self-limiting, chronic sinusitis may require prolonged treatment, including intranasal corticosteroids and, in refractory cases, endoscopic sinus surgery (23).

Nasal cleansing and hydration strategies, such as saline irrigation, are recommended to reduce inflammatory burden and enhance mucociliary clearance, especially in chronic sinusitis (22,25). Patient education regarding nasal hygiene and control of triggering factors, such as allergens, is essential for effective disease management.

COVID-19

Nasal irrigation, in particular, has demonstrated efficacy in symptom reduction and quality of life improvement, representing a safe and cost-effective adjunctive therapy (22).

A (patho) Physiological Triangle: upper respiratory tract, Eustachian tube, and middle ear

URT is anatomically connected to ME by the ET. Irrespective of the initial site of infection, it can easily spread to all structures involved in the various URTIs mentioned above. This happens more often during childhood, since acute respiratory tract infections are the most frequent illnesses at this age (1,11,31,32). Intense exposure to viral respiratory infections, not-yet-fully-mature respiratory and immune systems, and a more horizontal, narrower and shorter ET may be the reason why children are a major risk group for acute respiratory infections (ARI) (11,31,32,33).

Therefore, acute otitis media (AOM) is a common complication of URTI in children. In fact, URTI often spreads into the paranasal sinuses, producing mucosal oedema and accumulation of mucus (34). These factors lead to inflammation of the nasopharynx causing an obstruction of the ET and creating a negative pressure inside the middle ear, which results in effusion and aspiration of nasopharyngeal secretions (Otitis Media with Effusion – OME), facilitating viral and bacterial colonization and causing AOM (33,34,35,36).

In the presence of AOM/OME and URTI, due to this anatomical and functional connection, the following ET functions might be compromised: pressure equalization and ventilation of the middle ear, mucociliary clearance of secretions from the middle ear, protection of the middle ear from sounds, and from pathogens and secretions from the nasopharynx (33,36,37). The latter dysfunctions are assessed by otoscopic or otomicroscopic evidence of tympanic membrane retraction and/or tympanogram indicating negative middle ear pressure (33).

Non-Pharmacological Treatment

Non-pharmacological methods to treat URTI, such as nasal saline irrigations, nasal aspirators and respiratory techniques, are often prescribed for both the prophylaxis and therapy of URTI to children, since they are usually well tolerated and potentially reduce the need to use medication, having no significant adverse effects (3,38).

Nasal irrigation

Nasal irrigation is a widely used adjunctive technique for nasal hygiene, consisting of the instillation of a saline solution directly into the nasal cavity, promoting the liquefaction and mobilization of secretions (25,39). The mechanism of action of nasal irrigation solutions is based on two fundamental principles: a physical (mechanical) cleansing effect on the nasal mucosa, which facilitates the removal of accumulated secretions, and a biological/physiological effect, primarily related to the osmotic activity of ions on the nasal epithelium (30). Typically, this technique involves the movement of an aqueous solution from one nasal cavity to the other, administered via syringe, manual irrigators, or pressurized sprays. Gravity, combined with the pressure generated by certain devices (such as seawater or pressurized saline), aids in the external elimination of secretions (40). The solution should ideally be instilled during the expiratory phase of the respiratory cycle, preferably following a brief apnoea.

Nasal irrigation is considered a safe and effective technique, even in young children, with multiple benefits reported in the literature. These include improved mucociliary function and reduced nasal congestion, facilitating the liquefaction and removal of secretions and promoting nasal breathing (5,6,25,30,41). Additionally, it appears to contribute to the reduction of local inflammation and the risk of recurrent respiratory infections (9,25). Studies suggest that the use of saline solution may shorten the duration and lessen the severity of symptoms in acute respiratory infections in children (6,9). Moreover, regular nasal irrigation seems to reduce the accumulation of irritant particles, thereby decreasing nasal mucosal inflammation.

Although nasal irrigation is generally considered safe, certain adverse effects have been reported, particularly with hypertonic saline solutions, such as seawater with high saline concentration, which may cause local irritation, nasal mucosal edema, burning sensation, or itching. Therefore, saline concentrations above 3% are not recommended (30,41). In contrast, isotonic solutions, such as physiological saline, are associated with fewer adverse effects, the most common being mild discomfort or anxiety during application (25,30). Additionally, the temperature of the solution should be close to body temperature, as solutions that are too cold or too hot may impair tolerance and trigger vasomotor responses in the bronchial mucosa (25).

Nevertheless, despite its benefits, nasal irrigation is still not fully used by the parents of young children in the management of acute URTI. Perhaps this is the biggest barrier to the routine use of nasal irrigation in children, that is, the assumption by both parents and physicians that children will not tolerate it, especially

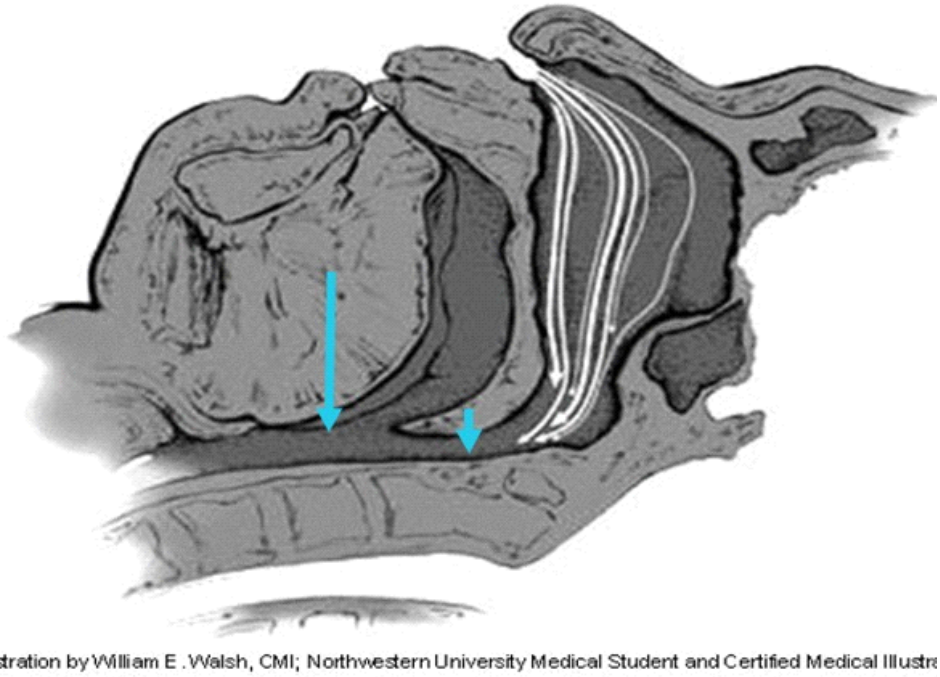


Figure 1. Schematic representation of the proposed potential risk of middle-ear contamination during nasal irrigation in the supine position. The figure depicts the tongue and soft palate, the movement and accumulation of nasal secretions near the ET opening, and the potential temporal coincidence between secretion movement and ET opening; arrows indicate the direction of secretion movement and airflow (William E. Walsh, Northwestern University, Feinberg Medical School, USA, with permission).

when they are young (24,37). There are also some doubts, mainly in the clinical setting, whether this type of intervention could itself increase the risk of middle ear contamination, if the ET opening occurs within the time-lapse of instillation. If we consider a supine position, both the tongue and the soft palate suffer the gravity action towards the lying surface, causing a small decrease of the radial traction of the pharynx. Together with the instillation of serum into the nostril and the consequent mobilization of the nasal secretions towards the oropharynx, there may eventually be an instant where they accumulate near the ET opening. Although this is transitory and only lasts for a few seconds, if it coincides with the opening of the ET, at that time there may be a potential risk of middle ear contamination (Figure 1).

It is performed by prolonging the expiratory phase of the breathing cycle of the child, to get benefit from the Hering–Breuer deflation reflex and from the active inspiratory effort induced by pulmonary deflation, when, at the end of expiratory time, the child's mouth is briefly closed, provoking a rapid and profound nasal inspiration (42,43,47). This manoeuvre should be repeated as many times as necessary, until the secretions are displaced into the oropharynx, which can be evaluated by a significant reduction of the nasopharyngeal obstruction noise during the DRR manoeuvre. The secretions mobilized to the oropharynx are usually swallowed but may also stimulate the cough reflex, if they descend below the oropharynx, to expel them from the respiratory system. A pharmacological substance or a saline solution (0,9% NaCl) can also be instilled to aid the elimination of the mucus from the nasopharynx (42,45,46).

The purpose of DRR is to eliminate all the secretions from the nasopharynx, especially those situated in the posterior region, so called cavum, where the communications to the ET are located (42). According to Bernoulli's principle, when an airstream moves through a frictionless channel of constant diameter, its pressure remains unchanged along the entire length of the channel. However, the human airway does not behave in this manner, as it includes regions of varying diameters—such as the wider nasal cavities and the narrower nasopharynx. This anatomical variability causes changes in airflow velocity and pressure, with an increase in velocity and a corresponding decrease in pressure as air transitions from a wider to a narrower region, a phenomenon known as the Venturi effect (42,48). This effect may also explain the displacement of

secretions from the region of the ET ostia, facilitating their mobilization toward the main airflow pathway. Such dynamics promote normal aeration of the middle ear and may contribute to the prevention or mitigation of ET dysfunction and associated risks, such as otitis media (34,36).

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DRR is indicated in all URTIs of young children, such as rhinosinusitis or pharyngitis, and can be taught to parents in the case of repeated infections. It should not be applied on children with an impaired cough reflex, as it happens in some neurological conditions, as well as in the presence of a laryngeal stridor, which suggests a severe obstruction (42,47). Objective and physiologic measures such as nasal auscultation, otoscopy, and tympanometry have monitored the effectiveness of this technique with the normalisation of middle ear pressure due to the ET opening after only one session (4,33,49). However, further studies are required due to different factors that should be considered. One of them is positioning.

A variation of DRR suggests that if the head of the child is slightly rotated in the direction of an ear, the effectiveness of the manoeuvre is improved in relation to that ear, due to gravity's effect towards the inferior ear. It intends to create the Venturi effect before the sinus orifices and the ET, which tends to favour the mobilization of secretions from these cavities to the mainstream (43,48,49). Moreover, if the physiotherapist inserts a small dose of saline solution immediately before the DRR, it would improve the rheology of the secretions, decreasing the stasis of the secretions in the posterior region of the nasopharynx (cavum) where the ET ends. Several studies suggest that this stasis is responsible for the proliferation of microbes, being responsible for the development of AOM since they may move on to the ET when the Eustachian ostium opens for middle ear aeration (35,50). The adapted positioning of DRR manoeuvre allows the selective washing of the nasal sinus, as the serum passes through the cavum, removing secretion away from the Eustachian ostium. Although this physiotherapy technique is described with the child lying in a supine position, other studies have included an adaptation of the principle of forced nasal inspiration in a sitting position (4,49). This adaptation in positioning could be an advantage regarding the mobilization of secretion towards the line of gravity, away from the ET.

In a sitting position, gravity is felt in the lower direction, along the longitudinal axis of the nasopharynx, without major implications in its radial traction, which means that the secretions move to the oropharynx more easily, with less probability of temporal coincidence with the opening of the ET (Figure 2). Moreover, if we add to this a rapid and profound nasal inspiration, it will cause a turbulent nasal flow, which by Venturi effect, creates a pressure differential, whereas a higher flow generates lower pressure, forcing the secretions to move from the ET to the main air flow towards the oropharynx, due to a

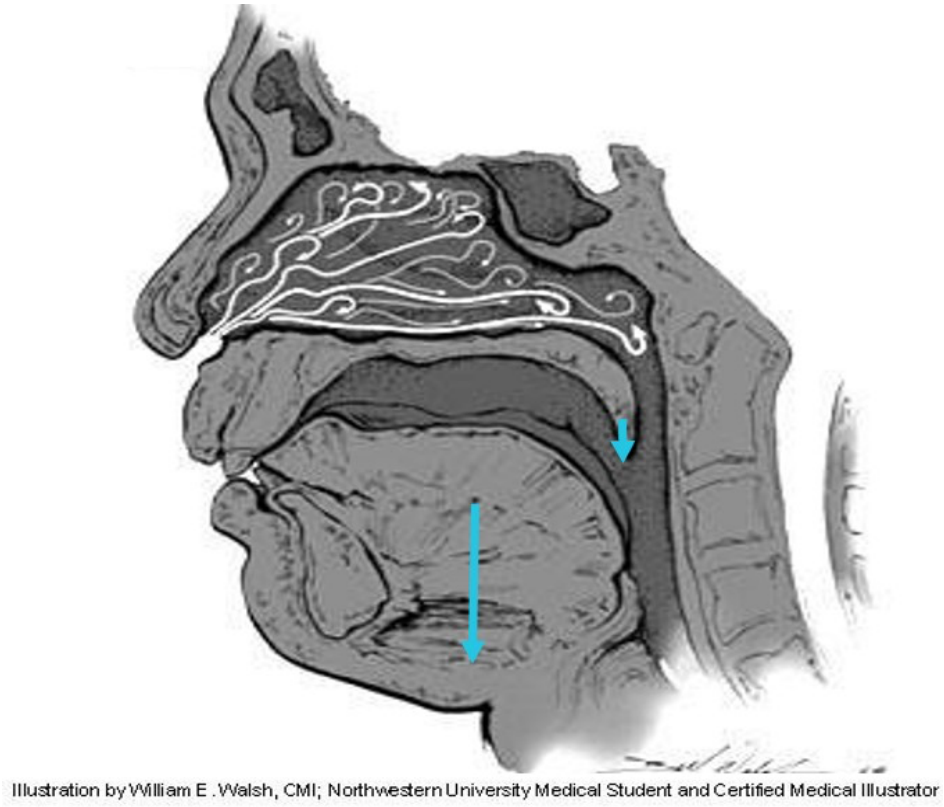


Figure 2. Schematic representation of rhino-pharyngeal clearance in the sitting position. The figure depicts the downward movement of secretions toward the oropharynx, away from the ET opening, during rapid nasal inspiration; arrows indicate the direction of airflow and secretion movement (William E. Walsh, Northwestern University, Feinberg Medical School, USA, with permission).

greater gas-liquid interaction. Thus, in this case, the risk of contamination of the ET could be almost non-existent, resulting in an immediate improvement of the middle ear condition (47,48).

Moreover, assuming there exists a time delay between the presentation of symptoms of URTI and the onset of AOM and OME, nasal obstruction, and consequent normalization of PP, could be seen as a prophylaxis against the development of OME and AOM in young children (35,50). However, other studies are needed to further analyse this hypothesis.

Nasal aspirators

The use of nasal aspirators is very widespread among parents of small children, although it is poorly documented from a scientific point of view (3,5,51,52,53,54). Various nasal suction devices are commercially available, most of which operate on a similar principle: one end of the device is placed in the infant's nostril, while the other end is held in the caregiver's mouth to generate suction. The secretions are collected in a reservoir equipped with a small sponge filter. The mechanism relies on the creation of a negative pressure gradient, which facilitates the mobilization and removal of secretions from the nasal cavity and, in some cases, the nasopharynx (5,52,53,54).

Only a few studies were found regarding nasal cleaning with these devices in toddlers reporting some effectiveness of the procedure and improvement in the children's condition during the treatment period, including: improved nasal patency, reduced respiratory effort, and potential prevention of secondary infections such as acute otitis media and sinusitis (3,52). Evidence suggests that when nasal aspiration is combined with saline solutions, it is associated with a lower incidence of respiratory complications and improvements in feeding and sleep quality in infants (5,52,53,54). These studies suggest that, whether parents were taught to use nasal aspirators and irrigation, or health professionals performed the treatment, this may account for the reported effectiveness. Such training does not occur with most of the parents, which may call into question the effectiveness and safety of the use of these devices. In fact, despite its widespread use, nasal

secretion aspiration presents several drawbacks that warrant consideration. One of the primary concerns is the risk of cross-contamination. Although manufacturers recommend replacing components that come into contact with secretions after each use, the cost of doing so may lead caregivers to reuse them. Even with proper cleaning, the potential for pathogen transmission between the infant and caregiver remains significant (2,3,5,54). Another concern is the possibility of nasal mucosal injury, particularly if the infant moves unexpectedly—such as turning the head or moving the hands—during the procedure. Additionally, frequent aspiration may negatively affect middle ear pressure, increasing the risk of ET dysfunction and acute otitis media due to the creation of excessive negative pressure (2,35).

Recommendations for future research

In our opinion, the future research lines should include:

1) Differential characteristics of URTI, including rigorous case definitions, as well as associated symptoms in target-populations (schools, primary care, and hospital populations), psychosocial impact, and relation to preceding or subsequent AOM or OME.

2) The development and use of objective measures/instruments which can validate non-pharmacological interventions in children with URTI, such as parents/patient-reported symptom scores (e.g. Eustachian Tube Dysfunction Questionnaire (ETDQ-7) (55), as well as objective instruments to aid diagnosis and to assess disease severity (e. g. otoscopy, multifrequency tympanometry (660 and 1000 Hz probe tone) or rhinomanometry).

3) Well-designed randomised controlled trials with larger samples, longer intervention protocols and longer follow-ups, including community-based research to assess external validity of these findings.

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