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OTHER ARTICLES

Sinonasal Irrigation After Endoscopic Sinus surgery – Past to Present and Future

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Abstract
Functional endoscopic sinus surgery (FESS) is the gold standard treatment for medically refractive chronic rhinosinusitis, aimed at removing diseased tissue and improving natural sinus drainage and aeration. Irrigation of the sinuses has been known to improve sinus mucosal health and is an essential adjunct to surgery. There are a number of methods, devices, and solutions available which are used for nasal irrigation. Neti Pot, squeeze bottle, syringe, rubber bulb and commercially available nasal sprays are some of the simpler used devices used for douching. Electric devices like flosser, Hydropulse and the Navage nasal irrigation systems are available but it's not clear if they provide any advantage over the other methods. We use and propose a gravitational pressure-pulsed device which provides adequate volume and force without the need for external pressure. Salt with sodium bicarbonate is the most used solution base. Hypertonic saline has been described to be more efficacious compared to isotonic saline. Additives such as sodium hypochlorite, antibiotics, corticosteroids, manuka honey and xylitol have proven to be beneficial. Large volume positive pressure irrigations have proven to be beneficial. Optimal position for irrigation varies for low or high-volume irrigation systems. Patient education regarding precautions and disinfection of the device is a must.

Keywords Sinusitis · Functional Endoscopic Sinus Surgery · Sinus Flush · Nasal douche · Nasal lavage · Saline Sniffs · Nasal Irrigation · Nasal washout · Nasal toileting

Introduction

Chronic rhinosinusitis (CRS) with or without nasal polyps is a common disease-affecting people all over the world. Functional endoscopic sinus surgery (FESS) is considered the gold standard treatment for medically refractive disease. The role of sinus surgery is to remove diseased or obstructive sinus tissue, creating an improved drainage pathway and aeration of the sinuses. Post-operative care is as important as sinus surgery to achieve the best surgical results. Post-FESS management includes antibiotics, analgesics and local corticosteroids spray and nasal irrigation.

Nasal irrigation clears mucus and allergens, blood clots, crusts and debris from the nose and sinuses and improves the healing process in post-operative FESS. The direct mucosal cleansing, the removal of antigens, biofilms or inflammatory mediators resolve inflammation and improved mucociliary function. It is safe and inexpensive, representing a non-pharmacological form of treatment. The aim of nasal irrigation is to carry out distribution of the irrigating solution effectively and reliably to all sinuses. This depends upon the surgical state, delivery device, head position, technique, nasal anatomy, respiratory cycle, and carrier vehicle [1].

Nasal irrigation has been practiced around the world since a long time, for a range of purposes. It is also known as saline sniffs, nasal douche, nasal lavage, sinus flush, nasal irrigation, nasal washout, and nasal toileting. It is performed by instilling saline into one nostril and allowing it to drain out of the same or other nostril, bathing and cleaning the nasal cavity. Nasal irrigation can be done with low positive

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pressure from a spray, pump or squirt bottle, with a nebulizer or with gravity-based pressure vessel, such as a neti pot [2].

Nasal irrigation has been found to be an effective and popular mode of adjunct therapy in post-operative endoscopic sinus surgery [3,4,5,6]. It can also be used as a preparation for nasal and sinus surgery [7]. A Cochrane report found some benefit of daily, large-volume (150 ml) saline irrigation with a hypertonic solution when compared with placebo in CRS [2] It may play a role in reducing viral severity and further transmission. However, it is not yet clear whether it provides viral mitigation effects or conversely has a potentiating effect on viral transmission [8]. There are a variety of combinations of solutions and devices advocated by different authors and institutions. There are different home recipes, commercially available powders or solutions and several devices used to perform nasal irrigations.

Sino-Nasal Irrigation

There are several devices used to perform nasal irrigation. Delivery of the nasal solution can be by positive- pressure (squeeze bottles, bulb syringes with or without nasal adaptors, mechanical), negative pressure (sniffing solution into nasal cavity), or nebulizers. Categorizing the devices according to the volume and the pressure of the solution used, three types of devices are available. (1) Low- volume, high pressure (nasal spray) (2) High-volume, Low-pressure using.

gravitational pressure (Neti pot, syringe, bulb). 3) High-volume, high-pressure (syringe with adapter, squeeze bottle). A High-volume device uses more than 100 ml of the solution to irrigate the nose [9]. Piromchai et al. 2019 collected information about 331 devices for nasal irrigation and found that syringes were the most commonly used device in more than 60% of patients [10]. A prospective single- blind randomized study compared postoperative efficacy of nasal irrigation devices after endonasal surgery and concluded that large-volume low-pressure irrigation was associated with better cavity cleansing on the Lund-Mackay postoperative endoscopy score than low-volume high- pressure irrigation [11]. It optimizes the distribution and cleansing power of the irrigation solution in the nasal cavity.

A study by Olson et al., using healthy adult volunteers analyzed the irrigation pattern and found that positive pressure and negative- pressure nasal irrigations were more effective than nebulizers in distributing solutions to the ethmoidal and maxillary sinuses. The distribution was more uniform using positive-pressure irrigation. The delivery with nebulization was poor and resulted in a significantly lower volume of retained solution [12]. Comparing metered nasal sprays, nebulization, and nasal douching with the head on the floor position, Wormald et al. reported that douching was significantly more effective in penetrating the maxillary sinus and frontal recess. Both these studies concluded that the sphenoid and frontal sinuses were the least irrigated by all the techniques [13.

A study from Germany, comparing irrigation devices in nasal models concluded that compression systems delivering ≥ 120 mbar pressure, a tight fit between nozzle and nostril and the possibility of inserting the nozzle into the vestibule and orienting it 45 degrees upward has were able to optimize cavity coverage [14].

History

The earliest use of nasal irrigation has been illustrated in Ayurveda. The nasal wash has been an integral part of the yoga tradition for more than 5,000 years. It was customary to perform jala- neti daily, as part of 'saucha' (cleanliness). It has been proposed to offer significant relief from nasal congestion and irritation and reduces their reliance on antibiotics to combat sinus inflammation, leading to a significant improvement in their quality of life [15] In the present era, the use of nasal irrigation after FESS was promoted by the University of California, San Diego, Nasal Dysfunction Clinic. Their patients reported tremendous benefits and often continued to use irrigation well beyond the prescribed period [16].

Devices

Neti Pot A neti pot is a simple device that looks like a small tea pot. It can be made of glass, metal, plastic or ceramic and can hold 150 to 500 ml of solution. To use a neti pot, while leaning over a sink, tilt the head sideways with forehead and chin roughly at same level. While breathing through the mouth, insert the spout of the saline- filled container into the upper nostril so that the liquid drains through the lower nostril. The procedure is repeated on the other side. (Fig. 1) It is an easy, natural, cheap, and effective method to irrigate the nose, practiced by many at home.

Sinus Rinse Kit or squeeze bottle The squeeze bottle is filled with salt/solution water. (Fig. 2). The bottle is placed against one nostril and squeezed. Water may come out the opposite nostril or out of the mouth. The nose is then gently blown. The procedure is repeated with the other nostril.

Syringing A 20- or 50-mL disposable syringe is used. (Fig. 3) Silicon adapters of different sizes can be attached to the tip. The solution is gently pushed into the nostril with the syringe and then sniffed through the nose into the throat

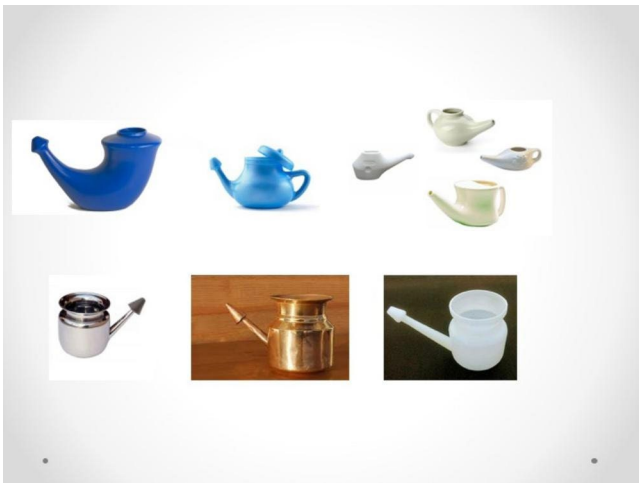

Fig. 1 Types of Neti Pots

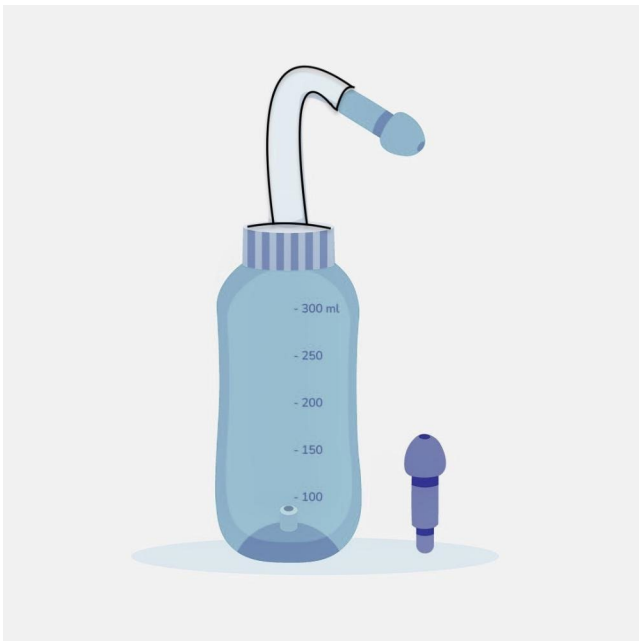

Fig. 2 Squeeze bottle

Fig. 3 Nasal Syringe

and spit out. Use of a syringe with an adapter yields high scores in overall efficacy [17].

Bulb Syringe technique Simple rubber bulb with a tip can be used after proper sterilization. (Fig. 4) Insert the tip just inside nostril, pinch the nostril around it, gently squeeze the bulb to push the solution in the nose and then blow the nose lightly.

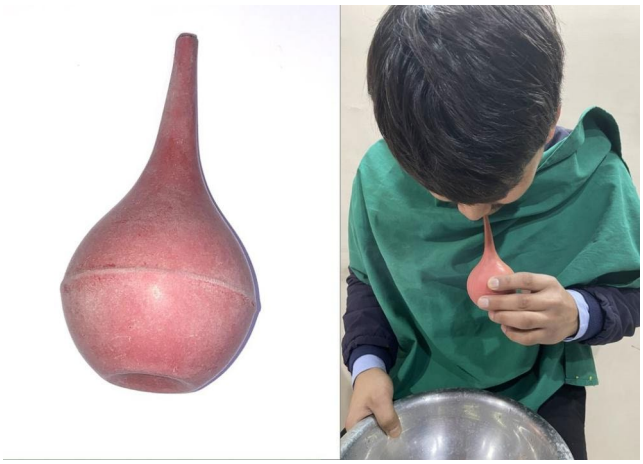

Fig. 4 Bulb Syringe

Flosser Technique Originally used in dentistry for flossing. The machine directs a stream of the solution into the nasal cavities. Set the pressure control as needed. After placing the nozzle inside the nose, switch on the machine. It is better to start with low pressure and increase the pressure as needed. The tip should be aimed postero-laterally and then rotated in all directions.

Hand Palm Technique After washing hands with soap, pour some saltwater into the cup of the palm. Close one nostril and sniff the liquid up your nose, one nostril at a time. Blow your nose lightly. Repeat at least 3 times up each nostril or until no more debris comes out. A shallow dish or a saucer can also be used. It may not be as effective but can be used in situations where nothing else is available for use.

Hydropulse Nasal sinus Pulsatile irrigation system An electromechanical device which provides pulsatile and continuous irrigation in multispeed control flow. While leaning over the sink, with head forward, looking down and mouth open, place the tip snugly against the nostril. Saline will enter one nostril and drain out the other side.125 mL to 250 mL of solution is used for each side.

Navage Nasal Irrigation System - is a powered push saline and suction features. No need to hold the head in a particular position of angle. The solution enters one nostril and is sucked out from the opposite nostril. It can be termed as the electric neti pot of 21st century.

Gravitational pressure- pulsed device (Our method) The popular and inexpensive sinus irrigation technique in our country is the gravitational pulsed procedure which can be

performed at the clinic and patient's home with ease. It is a simple pulsed lavage system providing high volume irrigation without the need for mechanical or electrical assistance to generate the pressure. It consists of an enema kit with a metal or plastic container and silicon or rubber tubing, a clamp and a nozzle. The kit is sterilized. The container is filled with lukewarm water and a tablespoon of customized powder is added (we recommend non-iodized sea salt and sodium bicarbonate in 1:2 ratio with or without steroid). The container is suspended at about 6 feet above the ground. The nozzle is introduced about 2.5 cm into the nostril. The clamp is released, and the solution is allowed to irrigate the nasal cavities using gravitational force. (Fig. 5) The solution moves in a parabolic direction and with up and down movements of the nozzle to perform pulsed washing. While the irrigation is performed, the patient is advised to repeatedly say "KKKK". This helps to close the nasopharyngeal space and prevents fluid entering the oropharynx (Fig. 5).

Position for Nasal Irrigation

A systematic review on the distribution of topical agents to the paranasal sinuses concluded that in postoperative cavity, sinus delivery is improved with 'head down and forward' position, although head position has a smaller impact when high-volume devices are used. Head position has the most impact when using low-volume devices, the distribution shown to be optimal in 'lying head back' or 'lateral head low' positions [1].

Habib et al. 2013 studied the distribution of medication in post-surgical cadaveric cavities using 1 ml of fluorescein solution in lying-head- back vs. head-down- forward positions. They observed a greater distribution of medication, especially in the frontal, ethmoid and sphenoid sinuses in lying-head- back position [18]. In another cadaveric study using computational fluid dynamics model of sinus irrigations in bilateral post-operative cavities, nose to ceiling position had better penetration for sphenoid irrigation and lesser for ipsilateral maxillary sinus compared to nose to floor position [19].

Fig. 5 Gravitational Pulsed Device

Composition of Solutions for Nasal Douche

Various solutions are used, and the composition may vary from institution to institution. The most used commercial combinations are isotonic saline (0.9%) and hypertonic saline (1.5–3%). Both are acidic, with pH values varying from 4.5 to7. Solutions with NaC1 concentrations higher than 3% are not recommended, although the emergence of adverse events due to hyper tonicity – such as sensations of pain, blockage, and rhinorrhea—have been demonstrated to be dose- dependent and occur only when the NaC1 concentration is $\geq$5.4%. Use of hypertonic solutions can also lead to the irritation of nasal mucosa and sensation of burning [20]. Hypertonic saline when compared with isotonic saline for nasal is found to be more effective in improving nasal symptoms and ciliary movement, but there is no significant difference in imaging findings or smell improvement [21].

Instead of traditional saline solutions, some physicians prefer Ringer's lactate, which contains other minerals in addition to sodium chloride and has pH from 6 to 7.5. In a blind random study.

found that douching with lactated Ringer's solution after FESS results in better improvements in sinonasal symptoms, compared with normal or hypertonic saline solutions [5].

Seawater is less rich in sodium ions and richer in bicarbonates, potassium, calcium and magnesium than isotonic normal saline, while alkaline pH and elevated calcium concentration optimized ciliary motility in vitro. Potassium, Zinc, magnesium and sodium bicarbonate promote cell repair and limit local inflammation due to positive effect on epithelial cell integrity and function. Sodium bicarbonate reduces the viscosity of mucus [9] To increase the mineral content, several commercial products use seawater diluted with distilled water to obtain an isotonic or slightly hypertonic solution with neutral or slightly alkaline pH. An even greater content of ions is present in a product based on electro dialyzed seawater (Physiomer) because this method of preparation maintains almost all the minerals of the original seawater. In a randomized controlled blinded in vitro study, undiluted sea water has been found to be a better option for nasal irrigation in terms of ciliary movements and wound repair [22].

Solutions for nasal irrigations can be prepared at home according to the suggestions of several authors and institutions. The most common constituents are salt and sodium bicarbonate mixed in varying ratios of 1:2 to 2:1 and about 2 teaspoons added to a pint (about 500-600ml) of water [23] Various additives can be included in nasal irrigations, most often antibacterial, corticosteroids and antifungal agents. Sodium hypochlorite (NaOC1) is a well-known bleaching and disinfecting agent that has been found to be effective

against several organisms including Staphylococcus aureus and Pseudomonas aeruginosa. Nasal irrigation with 0.5% NaOCl solution in saline was significantly more effective than saline alone in the treatment of S. aureus positive CRS patients in a study where patients used saline irrigation for 3months and afterwards saline irrigation with 0.5% NaOC1 solution [24].

Parenteral antibacterials can be added in the irrigating solutions like gentamycin or tobramycin (160 mg of gentamycin in a liter of normal saline is known as Wilson's solution), bactroban for staphylococcal infection and mupirocin for biofilm.1% baby shampoo in normal saline has been used as nasal irrigation. It prevents the pseudomonas biofilm formation [25]. Additives like betadine, hydrogen peroxide, amphotericin B, itraconazole, and clotrimazole can also be used. Addition of antifungal, antibiotic, and antiseptic solutions has been reported to cause an impairment of mucociliary clearance [26].

Budesonide nasal irrigation has been found to be better that saline irrigation, with lesser mucosal oedema, secretions and scarring and lower incidence of postoperative polypoidal changes [27,28]. In a randomized double-blinded placebo-controlled trial in post sinus surgery patients, the corticosteroid nasal irrigation had greater improvement on nasal blockage, a greater improvement on Lund- Mackay score and less inflammation on modified Lund-Mackay score at 12 months compared to steroid nasal sprays [29]. At the same time, rhinologists should be alerted to the potential risks of long-term use of budesonide nasal irrigations, and monitoring for hypothalamic- pituitary- adrenal axis suppression may be warranted in patients receiving long- term budesonide irrigation therapy [30].

Manuka honey has well- documented antimicrobial and antifungal properties and has been shown to be particularly useful in patients with CRS due to bacteria that produce biofilms. A randomized controlled trial studying patients of active CRS with prior sinus surgery, suggested that manuka honey irrigation alone may be effective for acute exacerbations of CRS [31].

Xylitol is a five-carbon sugar alcohol that has gained extensive attentions in the past decades as natural antibacterial agent. Xylitol can enhance the innate antimicrobial defense at the airway surface by reduces the salt concentration of airway surface liquid. A double-blind, randomized study showed a significant decrease in the number of coagulase-negative Staphylococcus with Xylitol spray compared with saline [32] It can also exert antibacterial actions through disrupting glucose cell-wall transport and intracellular glycolysis, thus inhibiting bacterial growth and inhabiting biofilms formation. 240ml of 5% (Wt./Vol) Xylitol solution is used for nasal irrigation. It is shown to improve the Visual Analog Scale and Sino-Nasal Outcome Test-22 scores and increase the concentration of nasal Nitrous oxide and inducible nitric oxide synthase mRNA in the maxillary sinus [33].

There is limited evidence of whether one solution is better than others. In a systemic review and meta-analysis comparing the outcome measures found various solutions to be more effective than normal saline alone, however, no statistical significance was found in terms of reduced symptom or endoscopic scores [34]. Regular irrigations performed over a prolonged periods produces the desired effect. The greater the volume of the irrigating fluid used, the larger the area covered. The benefits of large volume irrigation are- (1) More effective removal of sticky debris, clots and dried crusts, (2) irrigation reaches and thus cleans a larger proportion of the nasal cavities. Sinus penetration depends upon various factors like head position, partial or complete removal of middle turbinate and size of ostia.

Precautions and Warnings

The process of nasal irrigation needs a bit of practice to get used to. Overuse should be avoided, especially where it is not indicated. Regular use may increase the risk of sinus infections, due to collection of residual fluid. It may also remove some protective elements of the mucus [35].

Nasal irrigation should never be attempted with tap water or undistilled water. Unsterile water has been reported to cause amebic meningoencephalitis leading to severe headache, fever, altered mental status, and seizures [36]. The problem of contamination of the solution and the device is a problem which must be addressed. Devices can be contaminated when they are continuously used without adequate cleaning [37]. Lee et al. reported that irrigation bottles used after undergoing FESS and washed with hot soapy water after each use were still found to be contaminated by a large spectrum of bacteria, after one to two weeks of use [38].

Although microbial safety should in theory be more effective with devices that come with an anti- reflux nozzle and are easy to wash and sterilize, Foreman and Wormald found that a 1-way liquid valve did not completely prevent bacterial contamination of the bottle [39].

Disinfection of the bottles has proven to be an effective method to prevent bacterial growth. The disinfection effect is higher if the bottles are boiled for more than 2 min or microwaved for more than 1 min and 30 s. However, longer duration of heating carries the risk of the irrigation bottle became deformed [40]. Patient education is the most important step in preventing bacterial contamination of the irrigation devices [39].

The risks and side effects associated with nasal irrigation can be easily avoided by following a few simple safety rules: Wash your hands with soap before the sinus flush. Tap

water should never be used, instead use distilled water, or pre-boiled water. Always clean the device, with hot, soapy, and sterile water or run it through the dishwasher after each use. Let it dry completely. It is better to prepare the fresh solution every time and not to store it for long to avoid contamination. Discard the solution if it is cloudy or dirty. Better not to perform nasal irrigation on infants. Stop irrigation if there is pain or discomfort in the ear or nose or head. It should not be advised if there is active bleeding, fever, headache, or CSF rhinorrhea. To remove the residual fluid, bend forward and tilt the head sideways till the fluid drains out.

Drain and Dry

Whatsoever method or device one uses, drying the nose properly is a very important part of the practice. Bending forward with the nose pointing towards the floor, let any residual water drain from the nose. Then point the nose towards knees. Gently breathe in via the mouth and out through the nose about 10 times in each position. Then stand up to do some rapid breathing through the nostrils. 10 breaths through both nostrils together, sniffing in and out moderately with a bit more emphasis on the exhalation. Closing off one nostril with a finger, 10 rapid sniffing breaths are taken through the other nostril. It is repeated on the other side. Finally, take 10 breaths through both nostrils together. This should clear and dry the nose. The whole drying process again may be repeated if necessary. Failure to dry the nose properly may manifest the symptoms of a cold several hours later or leave dirty water in the sinus passages which may result in infection [15].

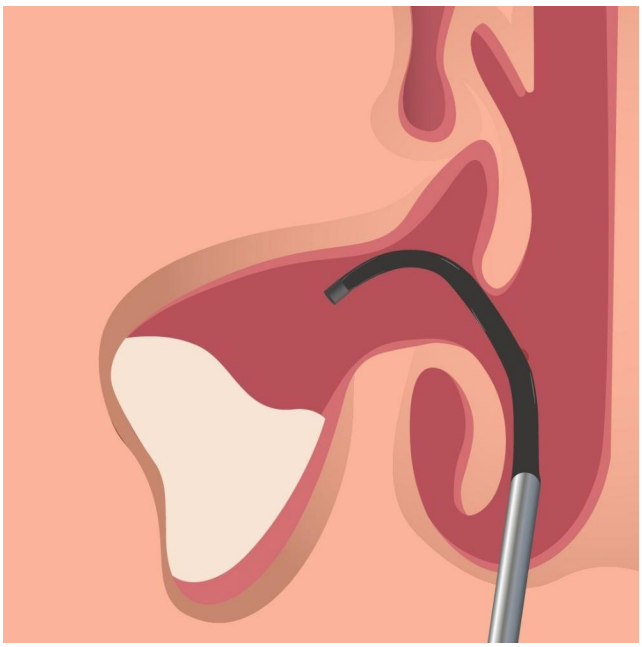

Fig. 6 Intra-sinus catheter

What's New?

Two studies were available which have used in-situ irrigating devices with promising results. These devices were used in individual sinuses (Frontal and Maxillary) via a catheter placed in-situ after surgery, allowing the patient to self-irrigate. Adequate irrigation was achieved without the use of head positioning and patients in both studies did not report any discomfort. These intra-sinus catheters can also be used to deliver topical agents to the paranasal sinuses. These catheters were placed in one or two sinuses and the effect on irrigation of the other areas is not defined. Although no significant side effects were reported, an endonasal device is a foreign body and has the potential to cause complications such as infection, inflammation and granulations [41, 42]. A self-inserting malleable catheter inserted into the sinus along with a source for pressured irrigation may be an ideal tool for flushing the sinuses, but it would require thorough patient education and painstaking compliance (Fig. 6).

Due to the increase in the number of patients with allergies, the common cold, sinusitis, epidemics like SARS-covid and growing awareness about the benefits of nasal irrigations, new and improved nasal irrigation systems are expected to hit the market. These may range from manual, portable, and cost-effective devices to high-end electrical and nanotechnology-based devices. Battery-powered and electric nasal irrigation devices are becoming increasingly popular. Advanced technologies, including nanoparticles, nanofibers, and cell-penetrating peptides have been developed to improve drug solubility, stability, and controlled release may be readily available in future.

Most experts think that douching is primarily a mechanical intervention leading to direct cleaning of the nasal mucosa and removal of inflammatory mediators and by improving nasociliary clearance (increased ciliary beat frequency) by reducing the microbial antigens level and reduces the microbial burden [43]. Reduced edema helps to improves drainage through ostia. It increases penetration & efficacy of intranasal drugs. By flushing out bacteria, it can reduce the length of antibiotic therapy as well [44].

The extent of surgery also has an impact on delivery of irrigating fluids into the paranasal sinuses. It has minimal sinus penetrance in non-surgical patients. In FESS patients the penetration is proportional to the extent of surgery.

Conclusion

There is little doubt about the benefits of nasal irrigation / douche in the aftercare following FESS. It has proven to be effective in reducing symptoms and endoscopic scores in post-operative sinonasal cavities. Besides post-operative

use, it has a place in popular culture and health practices as a non-pharmacological treatment modality for infective and inflammatory diseases of the upper respiratory tract. There are no serious adverse effects, and it is well tolerated by most patients. Problems of nasal irritation, nasal discomfort and a risk of infection, although small, have been documented. Contamination of the device is a concern and patients must be counselled and educated on nasal irrigation hygiene.

Hypertonic saline has been described to be more efficacious compared to isotonic saline. High volume (> 200mL), high pressure irrigation is recommended. To that effect, we propose a gravitational pressure pulsed device which in our experience is easier to use than manual pump devices. A buffered isotonic/ hypertonic saline along with an additive such as a corticosteroid or xylitol is recommended by the authors as the constituents are readily available and the solution is easy to prepare.

There may not be a single best method or device for nasal irrigation but with patient education regarding use and appropriate precautions, most techniques give adequate results. The nasal cavity and ethmoidal gallery can surely be irrigated with any method but clearing of the frontal, maxillary and sphenoid sinuses is often compromised. More innovations may be able to identify an ideal solution and a standardized method.

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