Radiographic Comparison of Three Methods for Nasal Saline Irrigation

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Objective: To compare intranasal distribution of saline solution delivered by three popular methods for nasal saline irrigation. Study Design: Prospective, controlled comparison. Methods: Eight healthy adult volunteers received nasal irrigation with 40 mL of isotonic, nonionic contrast material immediately before having coronal computed tomography to visualize distribution of solution in the paranasal sinuses. For each study subject, three methods of irrigation were used: irrigation using positive-pressure irrigation, irrigation using negative-pressure irrigation, and irrigation using a nebulizer. For each subject, three-dimensional computer reconstructions of the irrigated paranasal sinus airspaces were used to compare contrast solution volume and distribution achieved by the three methods. Results: Of the three methods used, two methods, positive-pressure and negative-pressure irrigation, distributed contrast solution widely to ethmoid and maxillary sinuses, but distribution of contrast solution was more uniform using positive-pressure irrigation than using negative-pressure irrigation. The nebulization method distributed contrast solution poorly and resulted in a significantly lower volume of retained contrast solution (P < .05). Conclusion: Judged solely on the basis of solution distribution in the nasal sinuses, nasal irrigation is effective when either positive-pressure or negative-pressure irrigation is used but is ineffective when a nebulizer is used. Key Words: Equipment design, irrigation, nasal, isotonic solutions, paranasal sinuses, rhinitis, sinusitis.

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INTRODUCTION

The nasal saline rinse has long been a mainstay of treatment for sinonasal disease because of its economy, safety, and apparent efficacy. Hypertonic and isotonic saline rinses have proved to be effective therapy against chronic sinusitis and chronic rhinitis. The weight of evidence is sufficient for the international consensus report of the Allergy Foundation to recommend routine use of these rinses in rhinitis. Formulation of saline rinses varies widely from study to study: Concentrations range from physiological (0.9%) to hypertonic (various concentrations as high as 7%). Regardless of formulation, a growing consensus holds that the mechanism by which the saline acts is to increase the efficiency of the mucociliary transport system by decreasing the viscosity of the mucociliary blanket, decreasing edema, or both. Common to all theories is the premise that the saline must be in direct contact with the target tissue to be effective.

There are numerous techniques available to deliver nasal saline rinses. These techniques range from simple inhalation into the nasal cavity to delivery by sophisticated devices that aerosolize saline under pressure. Despite this diversity, few studies have examined distribution of saline irrigation in the nasal cavity and paranasal sinuses, and no published study has compared distribution by different methods.

Radiographic techniques have been employed in past studies using a radiopaque marker in place of the saline. Radiographic techniques have been employed in past studies using a radiopaque marker in place of the saline. However, given the anatomic complexity of the nasal cavity and paranasal sinuses, traditional techniques such as technetium-99m imaging have shown little more than a rough qualitative picture of the distribution of tracer material. At present, with three-dimensional computed tomography (CT) imaging, the shape and volume of complex structures such as the sinonasal system can be delineated. Therefore, a combination of radiocontrast imaging and three-dimensional CT reconstruction can be used to accurately measure the spaces in the paranasal cavity as well as the distribution of contrast material on the mucosa.

In the present study, we compared three widely used methods for nasal irrigation by using three-dimensional CT imaging as well as qualitative and quantitative outcome measures to elucidate the optimal technique based on the distribution of rinse solution.

SUBJECTS AND METHODS

The Kaiser Permanente Northern California Institutional Review Board approved the study protocol, and participant consent was obtained. Eight healthy adult volunteers (five men and three women) with no history of acute or chronic paranasal sinus disease, symptomatic septal deviation, seasonal allergies, aller-
Fig. 1. (A) Sinus Rinse nasal irrigation applicator (shown by permission of NeilMed Products, Inc.) and (B) RinoFlow nebulizer.

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<th>Table I. Flow Rate and Plume Height Achieved by RinoFlow Nasal Irrigation Method Using Each of Two Irrigation Solutions.</th>
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<td>Plume Height (cm)</td>
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nuses in two of eight subjects, significantly fewer than with either negative-pressure or positive-pressure irrigation ($P < .05$). Distribution of contrast solution to maxillary sinuses differed most between methods: The maxillary sinuses were irrigated by negative-pressure irrigation in five subjects (bilaterally in one subject), by positive-pressure irrigation in seven subjects (bilaterally in five subjects), and by the nebulizer in two subjects (bilaterally in no subjects). The nebulizer was significantly less effective than positive-pressure irrigation for distributing contrast solution to the maxillary sinuses.

The volume of contrast solution retained in the nasal sinuses varied widely between study subjects (Fig. 4). The highest mean volume (1.1 mL [range, 0.1–4.9 mL]) was distributed by positive-pressure irrigation. Negative-pressure irrigation distributed a mean volume of solution (0.7 mL) that was lower than but not significantly different from the volume delivered by positive-pressure irrigation. The nebulizer distributed the lowest mean volume, and even the highest volume distributed by the nebulizer (0.6 mL) was lower than the mean volume distributed by either of the other two techniques. A significantly higher volume of contrast solution was retained by use of positive-pressure irrigation than by use of the nebulizer.

DISCUSSION

The three methods tested in the present study were chosen to represent fundamentally different approaches to nasal irrigation. Negative-pressure irrigation uses internally generated nasal inhalation to draw saline into the nasal cavity. Because it uses no external equipment for delivery, negative-pressure is the simplest, least expensive irrigation method and is maintenance free. However, delivery of saline is difficult to control with this method, and it has the disadvantage of preferentially irrigating the side of the nasal cavity able to generate the strongest negative pressure (i.e., the more “open” side). This factor may be why the negative-pressure irrigation technique tended to irrigate one maxillary sinus or the other, but not both.

The second method, positive-pressure irrigation, uses an external device to generate pressure and drive saline into the nasal cavity. Positive-pressure irrigation retained a larger volume of contrast solution and irrigated the sinuses more consistently than the other methods, although results were not significantly different from those of negative-pressure irrigation. Other devices within the positive-pressure category include the bulb syringe and the Grossan Nasal Irrigator Tip (Inmunotek, Madrid, Spain).

The third approach, the RinoFlow nebulizer, uses technology previously applied to oral nebulizing devices for delivery of drugs to the bronchopulmonary system. The system is comfortable and easy to use but is expensive ($159.00 per unit) and time-intensive, requiring approximately 10 minutes per treatment. Of the three methods for nasal irrigation, the nebulizer gave the poorest results: Distribution of contrast solution beyond the nasal cavity was poorest, and volume of retained contrast solution was lowest. These findings contradict results of an earlier study,8 which showed maxillary sinus penetration by solution in two of five study subjects using the RinoFlow nebulizer. That study8 used technetium-99m and a gamma camera, a technique with much lower spatial resolution than CT imaging.

In the present study, qualitative description of contrast distribution and quantitative measurements of retained contrast volume were used to infer optimal technique for nasal saline rinsing. Use of radiopaque contrast material and helical CT imaging has clear advantages over other radiological techniques. Computed tomography has unmatched spatial resolution, and the source image data may be used to create three-dimensional computer reconstructions and to take precise volumetric measurements for objects of interest (i.e., sinus...
cavities and retained contrast solution). The technique has limitations as well. Isotonic Omnipaque clearly does not “coat” the mucosal surfaces perfectly with a single, low-volume rinse, but is instead distributed primarily to dependent areas. Examination of coronal CT source images showed that the contrast solution was present mainly on horizontal surfaces and in narrow spaces, where cohesive forces between mucosal walls “trap” the contrast material. Thus, contrast material shown in a given area must be assumed to represent the minimum distribution to that area; actual extent of distribution cannot be accurately delineated. However, the volume of contrast material retained dependently in the sinonasal cavity is a reasonable proxy for the extent of distribution because one can expect that some material will be trapped if it reaches the sinonasal subunit.

CONCLUSION

Eight healthy subjects had nasal irrigation using radiopaque contrast material delivered by three different methods, followed by coronal CT scanning. Three-dimensional reconstruction of scan results showed the extent to which the contrast material was distributed throughout the sinonasal cavity, and volume of retained contrast material also was measured. Of the three methods studied, both negative-pressure and positive-pressure irrigation distributed contrast material reliably to the ethmoid and maxillary sinuses, and positive-pressure irrigation was distributed to the bilateral maxillary sinuses in the majority of study subjects. The nebulizer method did not distribute contrast material reliably.

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Fig. 3. Distribution of contrast solution in nasal sinuses of eight healthy volunteers who received each of three methods of nasal irrigation.

Fig. 4. Mean volume of contrast solution retained in nasal sinuses of eight healthy adult volunteers after using each of three sinus irrigation methods. Error bars indicate range.
BIBLIOGRAPHY


