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# Effect of Ringer-Lactate and isotonic saline solutions on mucociliary clearance of tracheal epithelium: an experimental study in rats

Murat Ünal, Hakki Oktay Seymen*

**Abstract**
Isotonic saline solution is frequently used in nasal and tracheal lavage. In a previous clinical study, it was found that Ringer-Lactate solution, as a nasal lavage, was better for mucociliary clearance function than isotonic saline solution after nasal septal surgery. In this experimental study, the effects of Ringer-Lactate and isotonic saline solutions on mucociliary clearance of healthy rat tracheal epithelium were investigated by measuring the transport of carbon particles. We found that tracheal segments that were irrigated with Ringer-Lactate had better mucociliary transport than those irrigated with isotonic saline ($p = 0.035$).

**Key words: Nasal Lavage Fluid; Mucociliary Clearance; Carbon**

## Introduction

Mucociliary clearance is a physiological process that provides a flow of mucus over ciliated epithelial cells. It is the first defensive barrier against potentially harmful biological and physical particles with a diameter between 0.5 to 5 μm in both the upper and lower respiratory tract. Mucociliary clearance depends on the number of cilia, the frequency of the ciliary beat, whether they are synchronous and the quality and viscoelastic properties of the mucus.[1] The physiological factors controlling mucociliary clearance are largely unknown but even in the absence of neural control it is well preserved.[2] Endonasal irrigation has frequently been recommended in the treatment of patients with acute and chronic rhinosinusitis and in the post-operative care of patients who have undergone nasal or sinus surgery. Isotonic saline is one of the most frequently used solutions for nasal lavage. Our previous clinical study has demonstrated that Ringer-Lactate solution is better for mucociliary clearance than isotonic saline solution after nasal septal surgery.[3] The aim of this experimental study was also to compare the effects of these two solutions of the mucociliary clearance in healthy rat tracheal epithelium.

## Materials and methods

The study was approved by the Animal Research Committee of the Cerrahpasa School of Medicine Istanbul University and the animals received care in compliance with 'The Principles of Laboratory Animal Care' formulated by the National Society for Medical Research and the 'Guide for the Care and Use of Laboratory Animals' prepared by the National Academy of Sciences. Fifteen Wistar-Albino type female rats, weighing 180 to 230 g, were observed for five days at the animal care laboratory to exclude any underlying diseases.

*Experimental design* After anaesthesia with ketamine hydrochloride 40 mg/kg intraperitoneally, a vertical neck incision was made. The trachea was exposed by blunt scissor dissection, and a 1 cm in length cervical tracheal segment was excised. Each animal was decapitated immediately. This C-shaped tracheal segment was divided longitudinally into two equal pieces by microsurgery in order to avoid any damage to the epithelium. After marking the lower part of each piece, one of them was irrigated with Ringer-Lactate solution (Group A) and the other was irrigated with isotonic saline solution (Group B) for three minutes and then the respiratory epithelium was carefully dried. These surgically divided identical tracheal segments were washed with only one type of solution. The pieces of trachea were put into paraffin-filled smooth surfaced plates. Then carbon particles that had been prepared from an active carbon preparation (Eucarbon™) by crushing were placed on the lower parts of each piece (mucociliary activity in trachea is upward). In order to standardize the procedure, carbon particles that had 100 μm diameter was used. The size of particles was determined under a dissection microscope (Carl Zeiss Co., Germany) that provides a three dimen-

From the Department of Otorhinolaryngology Head and Neck Surgery, School of Medicine, Mersin University, Mersin and the Department of Physiology*, Cerrahpasa School of Medicine, Istanbul University, Istanbul, Turkey.
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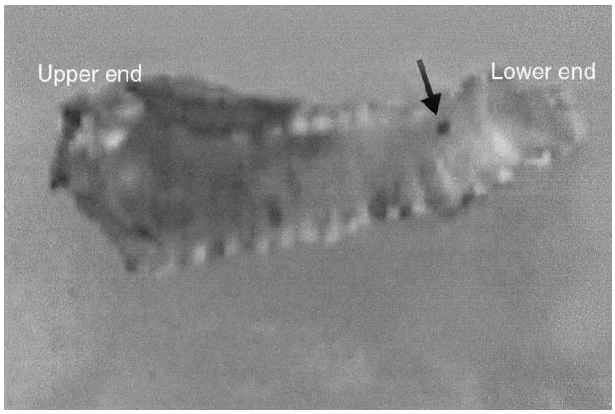


FIG. 1
Transportation of carbon particles by mucociliary movement.

sional assessment at a scale of μm. The distance (from the lower end to the upper end) that the particles had moved was measured with the dissection microscope after 15 minutes (Figure 1).[4] It was observed that the mucociliary transport did not change after this 15 minute period. This process was performed for each trachea. The measured distance of mucociliary clearance for each solution as compared by the paired samples *t*-test and a *p* value lower 0.05 was accepted as significant.

## Results

The average distances the carbon particles moved in Group A and B were 0.49 mm and 0.32 mm respectively. The difference between the groups was found to be statistically significant ($p<0.05$). Statistical results were summarized in Table I. The mucociliary clearance – in the Ringer-Lactate group was better than in the isotonic saline group.

TABLE I
MUCOCILIARY TRANSPORT DISTANCE (μm)

| Solution | n | Mean μm ± SD | Correlation | *p* |
|---|---|---|---|---|
| Ringer-Lactate | 15 | 0.49 ± 0.17 | | |
| Isotonic saline | 15 | 0.32 ± 0.12 | | |
| | | | 0.9 | 0.035 |

SD = Standard deviation

## Discussion

Many methods have been recommended for the measurement of mucociliary clearance such as the saccharine test, the measurement of ciliary beat frequency (CBF), scintigraphy and transport of resin or carbon particles.[5–10] The method used here was based on the direct measurement of the movement of the carbon particles that is provided by the mucociliary apparatus of the respiratory epithelium.[4] Although this method is less sensitive than measurement of CBF and scintigraphy, it may be applied easily and the findings are objective.[10,11] The results of this experimental study confirmed our previous clinical findings that Ringer-Lactate solution is better for mucociliary clearance than isotonic saline solution.[3]

Several different solutions such as isotonic, hypertonic or alkaline-buffered saline, ocean water, have been used for nasal lavage. Nasal lavage removes excessive debris, mucus or mucopus and as part of the primary treatment of sinonasal pathology, these effects may provide additional symptomatic relief and allow for better topical drug delivery to the diseased mucosa.[12] Systemic diseases such as diabetes mellitus decrease mucociliary clearance time and nasal lavage is recommended for those patients.[13] As well as nasal lavage, prolonged oral antibiotic therapy improves mucociliary clearance in patients with chronic rhinosinusitis.[14] Homer *et al.*, obtained a better mucociliary clearance time with hypertonic saline solution (five per cent) than isotonic saline solution.[15] Talbot *et al.*, investigated the effect of buffered hypertonic saline solution on mucociliary clearance and concluded that it was better than isotonic saline solution.[16] However Homer *et al.*, did not find a significant difference between non-buffered hypertonic solution and hypertonic solution buffered to pH 8 for mucociliary clearance (both solutions significantly improved mucociliary clearance time compared to the baseline).[12] Min *et al.*, assessed whether CBF was affected in vitro by the use of hypertonic, isotonic or hypotonic saline solutions in human nasal turbinate mucosa and concluded that isotonic and hypotonic solutions did not produce slowing of the cilia but hypertonic saline solutions decreased CBF and caused a disruption of the nasal epithelial cells.[17] Boek *et al.*, investigated the effects of 0.9 per cent seven per cent and 14.4 per cent saline solutions on CBF in vitro and compared this data with the results measured in Ringer-Locke solution.[18] This study demonstrated that Ringer-Locke solution had no effect on CBF, but isotonic saline solution had a moderately negative effect on CBF, seven per cent saline solution led to a reversible ciliostasis and 14.4 per cent saline solution had a irreversible ciliostatic effect.

Ringer-Lactate and Ringer-Locke solutions are isotonic solutions and very similar in composition; in Ringer-Lactate sodium lactate is present however in Ringer-Locke solution the compound's elements affect its action. According to Boek *et al.*, this solution has an ideal composition that more closely approximates the extracellular fluids and is more deserving of the adjective 'physiological'.[18] Ringer-Lactate does not have local or systemic side-effects and is also inexpensive.

Our previous clinical study clearly demonstrated that Ringer-Lactate solution has a significantly better effect on mucociliary clearance time than isotonic saline solution after nasal septal surgery.[3] This experimental study supported that conclusion especially in healthy respiratory epithelium.

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Address for correspondence:
Dr Murat Ünal,
Yeniçamlica mah. Baraj yolu cad.,
Çamalti sit., 3.Blok D:22,
81260 Ümraniye, Istanbul,
Turkey.

Fax: +90 324 3374305
E-mail: muunal@hotmail.com



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