

## Mucociliary Clearance: Measures and Therapies

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### Abstract

Mucociliary Clearance can be measured clinically with the Saccharine Test in the sino-nasal system. When clearance is slow, treat mucus viscosity and slow ciliary beat frequency. Chronic sinusitis and bronchitis are often due to poor MCC. Therapy to upper or lower respiratory system benefits both.

Therapy for Mucociliary Clearance includes proteolytic enzymes to reduce mucus viscosity, vibrations for improving ciliary beat frequency, irrigation with Locke-Ringer's solution for cilia frequency, glucosteroids and surfactants.

Use of the Saccharine Test can help determine toxic effects of chromium, Sulphur Dioxide, benzines and other toxic products.

In acute allergy, mucociliary clearance speeds up; but sinusitis may follow when mucociliary clearance slows down later.

In slow mucociliary clearance, bacteria remain in place and are able to multiply. This is a significant factor for recurrent sinus infections and indicates a method of treatment that includes restoring normal mucociliary clearance (MCC).

Measuring MCC in the lower respiratory tract is complex and includes inhalation of radioactive particles. Clinically, the results of the Saccharine test of the nasal system may be an indicator of the MCC in the lower respiratory system.

**Keywords:** MCC; Mucociliary; Clearance; Cilia beat frequency; Bronchitis; Sinusitis; Seasonal allergy; Mucus viscosity; Locke-ringer's solution; Oooooommm; Saccharine; Glucosteroids; Cough; Proteolytic enzymes; Surfactant; Irrigation; Bronchodilators

### Introduction

Human airway epithelium is characterized by ciliated cells with mobile cilia, specialized cell surface projection containing axonemes composed of microtubules and dynein arms, which provide ATP-driven motility. In the respiratory system, the combination of moveable cilia and mucus make up mucociliary clearance, MCC, a means of clearing away inhaled particles and pathogens [1].

Mucociliary Clearance (MCC) refers to the respiratory system where pathogens, allergens, debris and toxins are trapped and then moved out by ciliary action [2].

Cilia beat in synchrony to perform effective clearance. However, when the cilia beat is asynchronous, MCC may be ineffective [3,4]. In primary ciliary dyskinesia, the asynchronous movements can be visualized on microscopic analysis [5].

### Functions of MCC

When MCC is normal, bacteria are moved out of the upper and lower respiratory tracts before they have a chance to multiply. When MCC is slowed, bacteria remain in place and multiply to cause illness. The thickened mucus may block sinus openings and Eustachian tube orifices in the head and may block bronchial passages in the chest [6,7].

Mucus is in two layers: outer Gel layer is thick and traps bacteria, dust, etc. Lower or inner Sol layer is thin and contains cilia that move in synchrony to move the outer layer in a single direction. A thin layer of surfactant separates the two layers.

In the upper respiratory system, the mucus layer is moved from the nose, to the nasopharynx, down the throat to the stomach.

In the lower system, mucociliary clearance is accomplished by air passage and cilia beat frequency. Mucus layer is moved up and over the larynx and then is swallowed to the stomach. Stomach acid generally inactivates the bacteria [8].

The outer gel layer produces 1-2 L/day. It contains goblet cells and submucosal glands, mucin (glycoprotein), IgA, albumin, lactoferrin and lysozyme.

## MCC and sinuses

Normal sinus drainage is by MCC. Whichever sinus is draining poorly, may be aided by improving MCC. After most sinus surgery, MCC slows down. Frequently, post-sinus-surgery infection is related to decreased MCC. Methods to reduce post-op sinus surgery infections by restoring MCC are recommended her? [9,10].

## Case Study

### Example of MCC post sinus surgery

John Smith, 33 male had sinus surgery four month ago by a top surgeon. He had expected to be free of sinus disease after his surgery, yet he had been sick with sinusitis since his sinus surgery, despite antibiotics. Pulsed irrigation in the office removed thick mucus and colored exudate. He was continued on pulsed irrigation twice a day in order to thin his mucus and restore his cilia He was free of sinus symptoms in three weeks. His post-surgery sinus infection was due to reduced MCC. Slowed MCC is seen frequently after sinus surgery.

### MCC in lower respiratory system

We know that in Chronic Bronchitis, MCC slows. A typical viral infection slows MCC and this is responsible for the cough and the buildup of toxins [11]. Many studies have been done on the effect of air pollution, diesel fumes and industrial “smoke” on the lower airway. In cigarette smoke, MCL is impaired and this impairment may continue for months after smoking ceases.

MCC is effected by the thickness and the viscosity of the mucus itself. If it is thin and easily moved, cilia beat easily. Or is it thick and sticky? Viscosity of mucus varies significantly. For example, in acute allergy mucus is of low viscosity. To improve mucus viscosity, increase of fluid intake is a crucial factor.

## Discussion

### Viscosity therapy

Thick bronchial mucus is benefitted by inhalation of 7% saline and alpha dornase. Alpha dornase (Pulmazyme) is of particular benefit in CF because of its enzyme action on DNA material in the bronchial passages. Protease products such as papain/bromelain help thin mucus viscosity, as does Mucinex [12].

Thick nasal/sinus mucus is associated with biofilm and is benefitted by the use of surfactin products to effectively remove thick mucus. Adding dilute Johnson’s Baby Shampoo to the nasal irrigation solution is reported to help reduce biofilm. Another product is Hyaluronic Acid. Use of protease products such as papain and bromelain are of value in delivering antibiotics into the biofilm [13].

- In summary, measures to thin the mucus layer include:
- Adequate intake of water, liquids
- Green tea with lemon or lime [14]
- Irrigation with Surfactin such as Johnson’s Baby Shampoo (Isaacs) [15]
- Pulsed Irrigation
- Mucinex
- Pulmazyme
- Inhaling warm moist air for nasal mucus

- Inhaling warm moist air with tongue extended for bronchial mucus.
- Bromelain and Papain [16]

**The sol layer:** The other main factor is the cilia in the Sol layer. Do they move fast enough and in synchrony to move the mucus? Or are they slowed because of cold or toxins such as Chlorine? [5].

Example: Female age 35. Following each spring allergy season, she gets a sinus infection. It is common at the end of a seasonal allergy to get slowed MCC. She was prescribed pulsed irrigation, humming “om,” at a low tone and green tea: these actions helped her to avoid sinus infection following allergy in the future

**Chemistry of tea and chicken soup:** Intake of Green Tea, with its anti-inflammatory effect, benefits all levels of the respiratory system. Green tea contains phenols. Polyphenols in green tea include EGCG, epicatechin gallate, epicatechins and flavanols.

Chicken soup also contains L-cysteine that is released when you take the soup. This amino acid thins mucus in the lungs, aiding in the healing process.

**Measure mucociliary clearance:** A clinical method of measuring nasal MCC is to place a particle of saccharin onto the medial surface of the inferior turbinate one cm back and time how long it takes for the particle to reach the tongue where it is tasted. The saccharine test has established diagnostic standards:

- 1-4 min: Acute Allergy
- 5-7 min: Normal MCC
- 9-15 min: Infection
- 16-28 min: Chronic Infection
- 30+ min: Irreversible poor MCC

In chronic rhinosinusitis, the saccharin test shows significant reduced MCC.

This test can be used to identify toxins in the workplace such as chromium or Sulphur dioxide that are causing illness. Inhaled solvents should be tested. The saccharine test can be used to evaluate air pollution. Hyperbaric oxygen slows cilia, as does high altitude [17].

The saccharin test is also very useful for evaluating therapies. If the medication speeds MCC, that is a significant benefit. Unfortunately, MCC is not tested in evaluating new drugs or therapies [18,19].

Measurement of MCC in the lower respiratory tract is complicated, consisting of inhalation of radioactive products and measuring them as they are extruded. In lower tract impaired MCC, deep breathing, bronchodilators, chicken soup can be effective.

In many respiratory conditions, the viscosity of the mucus, the ciliary beat frequency and the excretion of the goblet cells is often similar throughout the respiratory system. The therapy addressed to the nasal MCC can be of benefit to the MCC of the lower respiratory tract [8].

### Mucociliary therapies

Those therapies include lowering the viscosity of mucus. Increase fluid intake, glucosteroids, surfactants and proteolytic enzymes reduce mucus viscosity and affect the entire respiratory tract.

In the studies by Workman, mechanical stimulation of airway epithelial cells causes apical release of ATP, which increases cilia beat frequency and speeds MCC. This is illustrated by:

- Singing “ooommm”
- Humming
- Jumping Jacks and running
- External Chest Thumping
- Breathing exercises.
- Special coughing
- Pulsed Irrigation
- Oropharyngeal exercises

In the respiratory system, humming at a low tone, “ooommm,” can benefit by affecting the mucus and speeding the cilia. Pulsed nasal/sinus irrigation affects biofilm, thick mucus and cilia movement. Green tea with lemon or lime are of benefit, as are topical glucosteroids, proteolytic enzymes, Mucinex, surfactants and Xylitol. Irrigating with Locke-Ringer’s solution improves cilia movement.

It is important to differentiate between mucus too thick vs cilia too slow. Fact: thick mucus does slow cilia movement and bacteria trapped here are able to multiply. Hence, fluids, green tea, lemon/lime are very important for thickened mucus

### Cold slows MCC

Temperature affects MCC. Freezing cold slows cilia. This is a primary reason why colds and bronchitis are more common in the winter. Good advice is to warm the nasal passages before entering the elevator or classroom.

A common cause of impaired cilia is irrigation solutions that contain benzalkonium. This slows cilia beat frequency.

In Cystic Fibrosis, it is the Na ion that causes the increased viscosity and immobility of cilia due to thickening of the mucus.

#### Special Factors for the Lower Respiratory System:

In the lower respiratory system, corrective breathing exercises, bronchodilators, inhaled glucosteroids, surfactants affect the lower respiratory system. Rhythmic pounding on the chest to break up viscid mucus is a standard therapy for pneumonia and chronic bronchitis. Pulsed nasal irrigation may be of direct or indirect benefit. A deep throated “ooommm” has benefit. When MCC fails, the patient coughs.

For example, a healthy miner may not cough in regular dust. But, he coughs when he inhales a particle too large for mucociliary clearance.

Inhaling warm moist air speeds cilia frequency. For the lower respiratory system, to inhale warm moist air, the tongue should be extended; otherwise the warm air is lost in the upper throat.

### Antibiotics via Bernoulli irrigation

Various sinus infections require antibiotics. To avoid systemic complications, they can be administered via pulsatile irrigation because the steady flow acts via Bernoulli Principle to remove sinus contents and the pulsation fills the vacuumed sinus cavity [20-26].

### Conclusion

It is useful to measure MCC and to differentiate between mucus viscosity and cilia mobility.

The saccharine test of MCC gives an indication of the Respiratory System and provides indication for stressing methods of reducing viscosity of mucus and increasing cilia beat frequency. In most patients with chronic respiratory illness, improving MCC may be of significant benefit and a means of avoiding antibiotic therapy.

Enhancing MCC is clearly of value to prevent as well as to treat many respiratory conditions.

Clinically, improving sinus disease is of value in conditions of the lower respiratory tract. The question that needs to be researched: Does simply improving Nasal CBF aid conditions of Asthma, CF, Bronchitis? I recommend this question as an important research study.

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