

Nasal Mucociliary Clearance

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1. Introduction

Functioning respiratory cilia is the basis of normal mucociliary clearance. Through the trapping of inhaled particulate matter, coordinated motility of the ciliae to the oropharynx followed by swallowing this mechanism acts as a mechanical barrier.

This process can be investigated by measuring the speed of mucociliary clearance in the nose by following the movement of a ^{99m}Tc nanocolloid droplet across the nasal mucosa for a specific duration of time. The speed of movement of the radioactive droplet is calculated by measuring the displacement of radioactivity, corrected for small head movements.

The investigation of mucociliary clearance can also be performed by means of inhalation of radioactive aerosols and measuring the alveolar clearance. In the trachea, the normal speed is ~4-5 mm/min in healthy non-smoking adults. It is lower in the periphery of the bronchial system and in those who smoke or have COPD. The speed is also reduced with increasing age. This alveolar clearance is however, less easy to perform. If the patient coughs, the combination of mucociliary clearance and coughing clearance is measured. Apart from smoking, aging and asthma/COPD, mucociliary clearance is decreased in cases of abnormal hyperviscous mucus (e.g. cystic fibrosis), abnormal ciliary ultrastructure (e.g. primary ciliary dyskinesia: Kartagener syndrome, a group of rare autosomal recessive diseases with an incidence of less than 1/20.000) and a wide range of chemical, mechanical and inflammatory mediators.

2. Methodology

This guideline is based on available scientific literature on the subject, the previous guideline (Aanbevelingen Nucleaire Geneeskunde 2007), international guidelines from EANM and/or SNMMI if available and applicable to the Dutch situation.

3. Indications

- a. Assessment of nasal mucosa function in recurrent upper respiratory tract infections, pre- and post-surgery
- b. Preliminary screening prior to biopsy in suspected primary ciliary dyskinesia (Kartagener syndrome)
- c. Suspicion of secondary ciliary dyskinesia caused by mechanical factors such as bronchoscopy, endotracheal intubation, surgery, persistent cough, radiotherapy (dose > 2 Gy); or chemical factors such as prolonged exposure to cigarette smoke, severe air pollution, (intranasally administered) drugs or stimulants; or inflammatory/bacterial causes such as *Bordetella bronchiseptica*, *Haemophilus influenzae* and *Pseudomonas aeruginosa*.

Contra-indications: nasal congestion on one or both sides at the time of the investigation should be a reason to consider rescheduling.

4. Relation to other diagnostic procedures

This investigation assesses the functioning of the mucociliary transport mechanism in the nose. It is similar to the saccharin test, in which a saccharin particle is placed in the nasal cavity and the time to tasting saccharine is noted. The latter investigation clearly requires extensive patient cooperation. The nuclear medicine study is more objective.

If delayed or absent mucociliary transport is measured, this investigation must be supplemented by microscopy of ciliar motility and electron microscopy for the detection of dynein arm deficiency in the ciliae of a more invasive nasal mucosal biopsy.

5. Medical information necessary for planning

- a. indication for investigation
- b. knowledge of which nostril should be used for assessment
- c. drug history (both systemic and topical, especially inhaled drugs) and whether the patient has been exposed to the factors mentioned in 3b.

6. Radiopharmaceutical

Tracer: ^{99m}Tc nanocolloid

Nuclide: Technetium-99m

Activity: 2 MBq (one 10 μl drop from a 200 MBq/ml solution)

Administration: Using a 10 μl pipette, a single drop is deposited on the nasal floor, 1 cm behind the anterior section of the concha inferior (inferior turbinate) or naris

According to ICRP 106 there is no need to interrupt breastfeeding, but due to possible free ^{99m}Tc pertechnetate it is advisable to interrupt the feeding for 4 h.

7. Radiation safety

Assuming full resorption of 2 MBq nanocolloid after ingestion, an effective dose of 48 μSv (70 kg adult) to 152 μSv (5-year-old) can be estimated, which is minimal.

8. Patient preparation/essentials for procedure

Patient preparation:

From at least 2 days beforehand, the patient should not use any local drugs that can influence the function of the ciliary epithelium, in particular, decongestants (sympathomimetic drugs) must be avoided. Local corticosteroid sprays may continue to be used.

If a local sympathomimetic drug such as oxymetazoline, is used chronically (>14 days in a row), it must be stopped 14 days prior to the investigation to allow the rebound swelling of the nasal mucosa to recover.

Essentials for procedure:

- a. 2 point sources of 0,2 MBq for reference point marking of the nose and the mastoid.
- b. Nasal speculum
- c. Pipette

- d. Head support
- e. Tape for fixation
- f. Optional: forehead mirror and good light source

9. Acquisition and processing

- a. Confirm that any drugs that could affect the results of the investigation have been adequately suspended.
- b. Tell the patient, prior to drawing up the active droplet, to breathe through their mouth during the imaging and not to sniff before or during the investigation.
- c. Especially in children it is worthwhile showing the pipette beforehand, as, once fixated to the camera, the sight of it might cause distress, accompanied by tears and sniffing, potentially rendering the investigation inconclusive.
- d. Using tape, fixate a point source to the tip of the nose and to the mastoid (behind the ear at the level of the meatus) or in front of the trachus in order to correct for movement but also as an anatomical reference.
- e. The patient sits with the head left or right laterally against the gamma camera, and the head is fixated, preferably with a head support (e.g. a modified eye measurement head support). The patient is positioned in such a way, that the reference markers are aligned horizontally.
- f. Spread the naris using the nasal speculum and inspect the nasal cavity. Using the pipette, a droplet of ^{99m}Tc nanocolloid is deposited on the nasal floor, 1cm behind the frontal section of the concha inferior (inferior turbinate) or naris.
- g. Dynamically acquire 40 frames of 30 sec in a 128x128 or 64x64 matrix for 20 min.
- h. To calculate the transport speed, the pixel size of the gamma camera used must be known. The displacement of the maximum counts of the deposit is measured in pixels/minute and corrected for movement of the head. Head movement is inferred from the displacement of the maximum number of counts of the point sources on the tip of the nose and mastoid. The transport speed is expressed in mm/min.
- i. Repeat the investigation for the other nostril if no nasal mucociliary transport is observed; in all other cases, check with the nuclear medicine physician if the investigation should be repeated for the other nostril for other reasons. Before repetition of the investigation, ask the patient to blow his or her nose thoroughly to remove remnant radioactivity.

Gamma camera and computer

Energy: ^{99m}Tc -setting, 140 keV

Window: 15-20%

Collimator: LEHR/LEAP

Counting time: 20 min

Computer: frames of 30 sec are recorded dynamically, matrix: 128x128 or 64x64

10. Interpretation

Healthy non-smokers have a nasal mucociliary average transport speed of 6 mm/min with a range of 2,3-12,0 mm/min. It should be emphasized that this investigation has a good sensitivity (up to 100%). In primary ciliary dyskinesia little or no mucociliary transport is measured in both nostrils (average 0,2 mm/min, range 0-0,7 mm/min), provided the

patient has been properly instructed and has not sniffed during the investigation. However, the specificity of this investigation is low (approximately 55%). Numerous disorders can ultimately result in greatly reduced or absent mucociliary transport (drug use, viral/bacterial infections, anatomical abnormalities).

If there is no transport of the activity, consider repeating the investigation 1 to 2 weeks later while any local drugs are stopped. If the outcome of the investigation remains the same, this is considered definitive.

11. Report

The report must indicate with which preparation the investigation was carried out. The calculated transport speed of the droplet activity over the nasal floor is stated. If no transport is witnessed in both nostrils, a repeat investigation to increase specificity should be recommended.

12. Literature

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