Inhibition of Airway Mucus Production: a Magnetic Nanoparticle Approach

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1) Lung diseases with excessive airway mucus.
Lung diseases with excessive airway mucus production afflict over 24 million people in the US and result in over $30 billion in healthcare costs annually.

Excessive mucus production is a common and significant problem for several prominent human lung diseases such as asthma and chronic obstructive pulmonary disease (COPD).

The mucus barrier poses a significant challenge to drug delivery, leading to increased healthcare cost and poor quality of life for patients.

Magnetic nanoparticles may provide a mechanism to overcome structural and fluid resistance of mucus to penetration.

2) Targeted delivery of magnetic aerosol droplets.
Pathology of Asthma

3) Experimental model system

Primary bronchial epithelial culture (bronchial brushing)

Iron-oxide ($Fe_3O_4$) magnetic nanoparticle (NP) delivery system.

Previous experimental studies [Kircha]:
- No mucus penetration with magnetic field gradients of 10 T/m.

Our permanent neodymium (NdFeB) magnet with an iron cone generates 238 T/m.


4) Results: conventional 30 nm $Fe_3O_4$ NPs.

Harvested mucus:
- Disrupted mucus structure
- Successful penetration of large % of NPs
- NP chaining

Mucus layer on top of cells:
- Un-disrupted mucus structure
- Successful penetration of small % of NPs
- NP chaining

Experiments suggest that the rigid mucin scaffold needs to be disrupted for successful penetration.

5) Next Steps: Use high anisotropy magnetic NPs to increase efficiency of mucus penetration.

- Estimate for oscillating $|H_{app}| = 0.05$ mT:
  - BaNP rotates at a rate of 6 rotations/minute.