Medical Xpress

Aerosol modeling targets sinus inflammation

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Hitting the sweet spot can make all the difference, especially for patients suffering from chronic sinus infection.

New instructions for using nasal sprays may help deliver at least eight times more inflammation-reducing medicine to diseased sinus tissues, according to South Dakota State University assistant mechanical engineering professor Saikat Basu. He has been using computational fluid dynamics to model aerosol sprays designed to help patients with chronic sinus problems as part of a National Institutes of Health project at the University of North Carolina Chapel Hill Medical School.

Basu began working with associate professor Julia S. Kimbell of the UNC Department of Otolaryngology as a postdoctoral researcher in April 2016. He has continued that collaboration since coming to SDSU in January 2019.

"Topical sprays are the first line of treatment to reduce sinus inflammation. Surgery is used only when medications no longer work," Basu said. The new protocol may help more patients get relief without resorting to sinus surgery, thereby reducing health care costs.

More than 14% of Americans have chronic sinusitis—and those numbers are increasing, according to a July 2019 article on Medscape.com. Treating the condition costs an estimated \$3.4 to \$5 billion annually.

Adjusting angle, depth

The researchers found the spray nozzle should be inserted five-eighths of an inch into the nostril and be held at a 35- to 45-degree angle for optimum medication distribution.

"This is a deeper insertion and a steeper angle than the current nasal spray guidelines and will result in an eight- to tenfold greater chance the medicine will reach the desired site," Basu explained. He is the lead author on an article describing the aerosol modeling results in the June 2020 issue of *Scientific Reports*.

"When more drug reaches those critical areas, the effect should be better," said Basu, who has published nearly a dozen journal papers on intranasal transport and topical drugs.

"This study demonstrates how engineering analysis tools can revolutionize health care," said Basu, pointing out that these findings "are also relevant to intranasal vaccines that are developed to mitigate the COVID-19 pandemic."

Building, validating model

To determine how to get the steroid spray to the affected sinus cavities, the research team used CT scans from chronic sinusitis patients to build 3-D-printed models. Basu then computationally integrated the 3-D models into ANSYS software and simulated drug transport and inhaled airflow.

"One of the challenges is the intricate structure of the nasal passages," said Basu. To overcome this challenge, he divided the nasal passages into 12 segments. Then he incorporated data on the aerosol droplet sizes, which ranged from five to 25 microns, as well the force with which the spray bottle is activated into the computational model.

"Smaller drops penetrate further into the air space," he said. "To get larger droplets to hit the target, we need to orient the spray bottle correctly."

After conferring with medical doctors, the researchers chose a narrow corridor in the sinuses called the ostiomeatal complex as the optimum location to deposit the anti-inflammatory medicine. Mucus from the upper sinus chambers drains through this channel into the lower areas beneath the cheeks, Basu explained.

To validate Basu's computational modeling experimentally, the researchers added radioactive particles to the spray to track where the droplets were deposited within the flexible 3-D-printed nasal models. To replicate the spray nozzle's angle and depth of insertion into the nasal passages, the researchers used a specially designed positioning device.

In addition, a vacuum line attached to a flow valve mimicked airflow based on breathing data. "The airflow in the sinuses of these patients who were in need of sinus surgery is often compromised by their conditions," he noted. This rigorous experimental testing confirmed the accuracy of Basu's predictive model.

The next step will be to recruit patients for clinical trials. To do this, Basu and the UNC researchers are applying for further NIH funding to collaborate with medical schools at Duke University and the University of Wisconsin.

More information: Saikat Basu et al. Numerical evaluation of spray position for improved nasal drug delivery, *Scientific Reports* (2020). DOI: 10.1038/s41598-020-66716-0

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