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Image-based inhaler deposition analysis during respiratory exacerbation

J. Williams[1], J. Kolehmainen[2], S. Cunningham[3], A. Ozel*[1], U. Wolfram*[1]
*[1] School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS [2] Department of Chemical and Biological Engineering, Princeton University, Princeton, NJ 08544 [3] Centre for Inflammation Research, University of Edinburgh, Edinburgh, EH16 4TJ * Authors share last authorship*

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Abstract

Many respiratory patients suffer from ineffective inhaler technique, making them vulnerable to hospitalising exacerbations, often leading to re-hospitalisation[1]. Treatment efficiency also varies among patients. Therefore, we aim to improve patient health with *in silico* models of drug inhalation which could improve treatment efficiency. This study reports models personalised to the patient's airway to evaluate (i) variation in deposition between normal and exacerbating breathing, and (ii) variation across patients, to determine if a patient-specific approach is needed.

We compare deposition in the airways of a healthy male, a female lung cancer and a child cystic fibrosis patient. We model drug delivery using computational fluid dynamics, coupled to the discrete element method (CFD-DEM)[2]. DEM allowed us to model particle-particle interactions. To model an exacerbation, we used a time-varying velocity inlet based on published breathing profiles[3].

Building on existing work[4], our comparison of three diverse patients using inhalation profiles furthers understanding of deposition changes across diseases. This also provides an understanding of the need for patient-specific breathing profiles and domains in future studies.

We found that during exacerbation, all patients distributed less drug to the distal lung. The distribution of the distal lung dosage across the lobes was similar with each breathing profile. We observed the main deposition influence to be in the complex shape of the upper airways. This is due to the changing orientation and turbulence generated here. This shows image-based domains, including upper airways, are required for accurate drug delivery prediction in our future studies.

Our models did not include ventilation abnormalities or patient physiological reaction. However, we were able to show the influence of varying health conditions, age and particle interactions. We believe such models will allow clinicians to individualise patient inhaler technique and dosing, thereby improving respiratory health.

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References

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