Computer simulation of inspiratory nasal airflow and inhaled gas uptake in a rhesus monkey

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Abstract

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There is increasing evidence that inspiratory airflow patterns play a major role in determining the location of nasal lesions induced in rats by reactive, water-soluble gases such as formaldehyde, hydrogen sulfide, and chlorine. Characteristic lesion patterns have also been seen in inhalation toxicity studies conducted in rhesus monkeys, whose nasal anatomy resembles that of humans. To examine the hypothesis that regions of high airflow-dependent uptake and lesions occur in similar nasal locations in the primate, airflow and gas uptake patterns were simulated in an anatomically accurate computer model of the right nasal airway of a rhesus monkey. The results of finite-element simulations of steady-state inspiratory nasal airflow for the full range of resting physiological flow rates are reported. Simulated airflow patterns agreed well with experimental observations, exhibiting secondary flows in the anterior nose and streamlined flow posteriorly. Simulated airflow results were used to predict gas transport to the nasal passage walls using formaldehyde as an example compound. Results from the uptake simulations were compared with published observations of formaldehyde-induced nasal lesions in rhesus monkeys and indicated a strong correspondence between airflow-dependent transport patterns and local lesion sites. This rhesus computer model will provide a means for confirming the extrapolation of toxicity data between species by extrapolating rat simulation results to monkeys and comparing these predictions with primate lesion data.