



STATEMENT

Synopsis of Research Report 125

HEALTH
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Variability in Human Response to Ozone Uptake

Ozone is an irritant gas and a major component of smog. Some people exposed to ozone while undergoing moderate to strenuous physical activity experience reversible adverse responses in the lung (eg, irritation, inflammation, and decreased function). The degree of decreased lung function varies substantially among individuals exposed to the same level of ozone. Regulators need to know how the dose of ozone to the respiratory tract is related to the subsequent biological responses in order to estimate the health risks of ozone exposure.

Dr James Ultman and colleagues at Pennsylvania State University hypothesized that: (1) differences in ozone uptake in the lung are responsible for variation in decreased lung function and (2) variation in breathing patterns and lung anatomy among people is responsible for the different uptake. An instrument developed by these investigators in earlier HEI studies enabled quantitative determination of respiratory ozone uptake in exercising individuals.

APPROACH

Ultman and coworkers recruited 32 men and 28 women, all nonsmokers. The subjects first took a series of single breaths of air-ozone mixtures, which allowed the investigators to examine how ozone was distributed in the airways and where the major fraction of ozone was taken up. Two weeks later, the subjects pedaled a bicycle ergometer to produce conditions of moderate exercise for one hour while breathing clean air. Two weeks after that, they exercised under the same conditions while breathing ozone (0.25 parts per million). The investigators characterized each subject's lung anatomy before the 1-hour continuous air or ozone exposure. They computed the average tidal volume (the volume of air expired with each normal breath)

and breathing frequency during each exposure. They also calculated the overall ozone uptake rate and the ozone uptake efficiency during exposure. Before each exposure and 10 and 70 minutes afterward, they measured standard parameters of lung function, including FEV₁ (forced expiratory volume in 1 second) and A_p, a novel measure of bronchial cross-sectional area available for gas diffusion that has been measured in few studies.

RESULTS AND INTERPRETATION

As expected, exposure to ozone caused a wide range of decreases in FEV₁ among the study subjects up to 70 minutes after exposure. These decreases did not correlate with ozone uptake rate, however, and thus did not validate the investigators' first hypothesis. In contrast, decreases in A_p after continuous ozone exposure correlated with ozone uptake rate, leading the authors to suggest that the hypothesis was validated. The use of A_p was a novel approach to evaluating changes in the transport properties of the lungs. However, because the physiologic significance of changes in A_p has not been validated, the strength of the investigators' conclusion is uncertain.

Ultman and colleagues found that the uptake efficiency of ozone was variable among the volunteers and lower in women (whose airways are generally smaller) than in men. This uptake efficiency was inversely correlated with breathing frequency and directly correlated with tidal volume in both sexes. Increased breathing frequency allows less time for ozone absorption during each breath; increased tidal volume drives ozone more deeply into the lung. These findings did validate Ultman's second hypothesis. They are consistent with the results of other investigators.

Continued

Uptake Distribution of Ozone in Human Lungs: Intersubject Variability in Physiologic Response

James S Ultman, Abdellaziz Ben-Jebria, and Steven F Arnold

INVESTIGATORS' REPORT

Abstract

Introduction

- Rationale
- Ozone Dosimetry
- Variability in Physiologic Response
- Localization of Lung Response

Specific Aims

Methods

- Study Design
- Recruitment and Health Screening
- Exposure Sessions
 - Medical Oversight
 - B_{O3} Session
 - C_a Session
 - C_{O3} Session

Measurement Methods

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- CO₂ Expirometry
- Bolus Inhalation
- Continuous Inhalation
- Instrument Calibration
- Statistical Methods and Data Analysis

Results

- First 10 Subjects
- Final Data Analysis
 - Preexposure Data
 - Dosimetry Variables
 - Physiologic Responses
 - Uptake-Response Relations

Discussion

Summary and Conclusions

Appendix A. Computation of A_p

CRITIQUE Health Review Committee

RELATED HEI PUBLICATIONS: OZONE