Elucidating How $PM_{2.5}$ Leads to Respiratory Dysfunction

Keywords: Air pollution、$PM_{2.5}$、Airway cilia、Reactive aldehydes

【Key findings of the study】

- $PM_{2.5}$, a major component of air pollution, impairs airway function.
- Oxidative injury in the airway induces the generation of reactive aldehyde species that selectively damage airway cilia.
- Aldehyde dehydrogenase ALDH1A1 plays a critical role in detoxifying reactive aldehydes in the airway.
- These findings highlight ALDH1A1 as a potential therapeutic target to mitigate the negative health consequences of air pollution.

❖ **Summary**

A research team led by Dr. Noriko Shinjyo and Dr. Yasutaka Okabe at the Immunology Frontier Research Center (IFReC), The University of Osaka, in collaboration with the National Institutes of Biomedical Innovation, Health and Nutrition, the Graduate School of Dentistry at the University of Osaka, and the Institute for Integrated Cell-Material Sciences (iCeMS) at Kyoto University, has elucidated the mechanism by which exposure to air pollution causes airway dysfunction.

$PM_{2.5}$, a fine particulate matter widely present in our environment, is known to induce severe airway damage upon inhalation. The research group has demonstrated that oxidative stress caused by $PM_{2.5}$ exposure leads to the generation of reactive aldehydes, which are detrimental to human health. Furthermore, the study revealed that these reactive aldehydes selectively damage the airway cilia, impairing mucociliary clearance— a critical defense mechanism against respiratory pathogens (Figure).

The research group also discovered that the enzyme aldehyde dehydrogenase ALDH1A1, which detoxify reactive aldehydes, plays a crucial role in repairing damaged ciliary function. Mice lacking ALDH1A1 showed significantly impaired recovery of ciliary function after $PM_{2.5}$ exposure, resulting in a greatly increased risk of pneumonia. On the other hand, administration of a small molecule compound that enhances ALDH1A1 enzymatic activity was found to accelerate the restoration of mucociliary clearance function.

These findings are expected to contribute to the development of new preventive healthcare strategies for respiratory disease onset. The results of this study were published online in *The Journal of Clinical Investigation* on May 23, 2025.

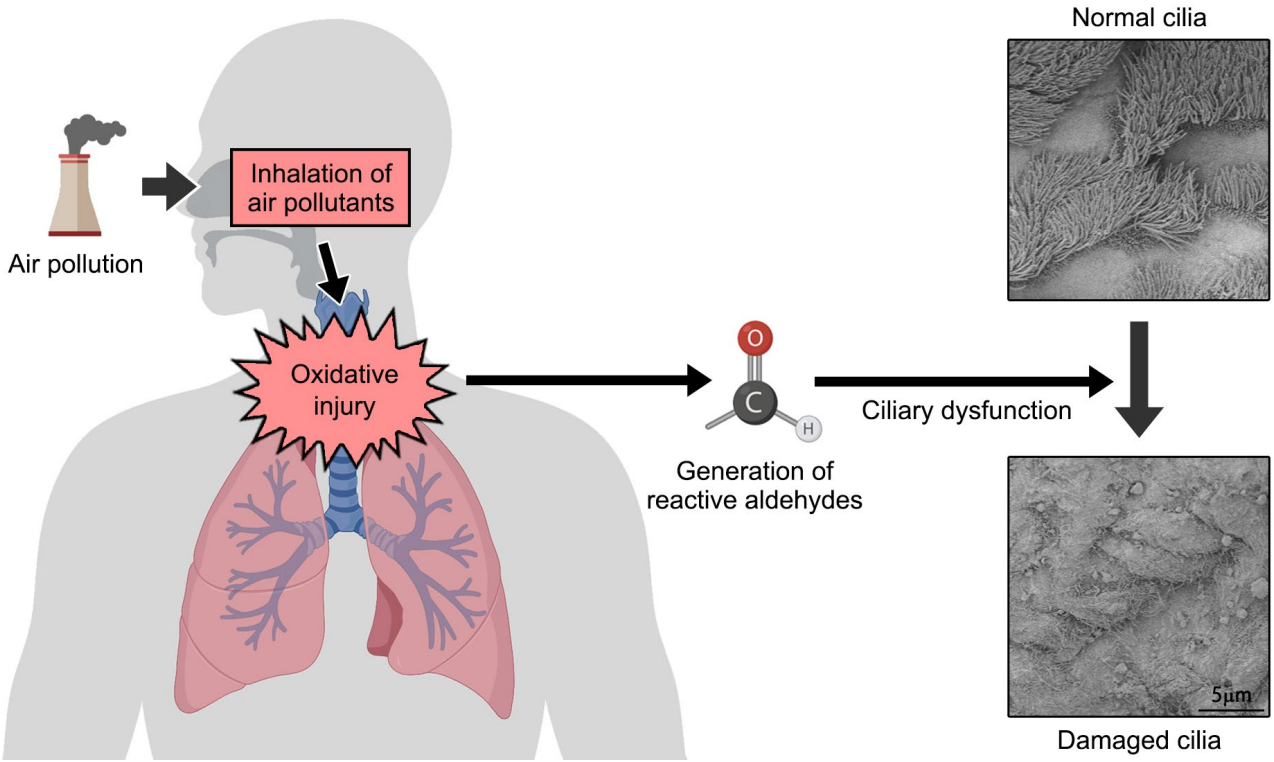

Figure*
Exposure to $PM_{2.5}$ induces the generation of reactive aldehydes, resulting in ciliary dysfunction. (* made by Biorender)

Title：“Aldehyde metabolism governs resilience of mucociliary clearance to air pollution exposure”

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