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Diesel-Exhaust Particulates and Their Health Effects

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Abstract

Approximately half of the particulates floating in city air are of diesel exhaust (DE) origin. As to the influence of DE on health, pulmonary problems such as lung cancer, allergic rhinitis, and asthma, have been identified, and so far, studies have focused on these problems. More recently, a correlation between ischemic heart disease and particulate concentrations was revealed by epidemiologic studies. DE contains gas components and particulates (DEP). Nanoparticulates emitted from engines increase with advances in engine technology. DEPs are believed to have a core spherical carbon to which a chemical substance, such as aromatic hydrocarbon, sulfate, or metal, is attached. There are more than a thousand chemical substances that can attach to the core carbon. Although the details have not been clarified, the core carbon itself as well as the attached chemical substances produce active oxygen species. Electron microscopic images of particulates collected from a dilution tunnel have shown spherical particles as well as nanotube-like fibers. In terms of their actions and effects, the similarity of these particles to asbestos is drawing attention.

Generally, sensitivity to chemicals is considered to be higher in fetuses than in adults. We exposed pregnant mice to DE and examined its effects on the male genital system and cranial nervous system of the newborn mice. The concentration of DE we gave to the mother mice was equal to or thirty-fold that measured in heavily polluted zones in Tokyo. Generally, risk posed by a chemical is determined by multiplying the value obtained from animal studies by a factor of 1000. However, please note that our procedure is fundamentally different from ordinary risk assessments. The mice were exposed to DE using equipment from the National Institute for Environmental Studies and the Research Institute of Tuberculosis of Japan.

As a result, we obtained the following findings:

- (1) In the male fetuses, a decrease in the expression of mRNA related to sex differentiation factors was observed.
- (2) In the newborn male mice, a decrease in the daily sperm production, a change in the blood testosterone level, a change in the appearance of testis tissue, and a change in

testis-specific genes were observed.

- (3) Collapse in the Sertoli cell mitochondria cristae was confirmed in the image.
- (4) Images of the brain revealed that the particulates, presumably of DEP origin were taken into the granules of scavenger cells surrounding peripheral vessels in the brain. Also, initial apoptosis or other morphologic abnormalities were observed in the cells containing these particulates and in surrounding cells. These cells were distributed in the cerebral cortex, the hippocampus and other parts of brain.
- (5) With respect to the behavior pattern of the mice that were continuously exposed to DEP from the fetal stage to 7 weeks after birth, a significant change in locomotor activity was observed. Changes in the dopamine systems and the serotonin systems were also revealed by measurement of the brain transmitters.

These results indicate the possibility that ultrafine particulates will pass through the blood vessels of fetuses and newborn mice in which the blood-brain barrier is not fully developed, accumulate in some cells, and affect these cells and surrounding cells. Based on these findings, we are now conducting another study to demonstrate the effect of ultrafine particulates from DE on health. Additionally, we have just begun a study on the "health science of nanoparticulates" in an effort to clarify the mechanisms of absorption, transition, excretion, metabolism, and toxic manifestation of the various types of nanoparticulates produced in nanoindustries and related industries. We will work on this subject as a new aspect of toxicology.