Transfer of Cadmium Ion Instilled Intratracheally into Rats and Its Effect on Lung Essential Elements

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Lung and trachea are target organs for cadmium when the metal is inhaled, and the uptake through the airway is known to occur more efficiently than that through the gastrointestinal tract. However, detailed information on cadmium uptake through the airway or lung is lacking owing to the instrumental and experimental limitations in inhalation experiments. Intratracheal instillation of cadmium has been considered as an alternative to inhalation of the metal, since it is convenient, without requiring any special instruments. The present study was undertaken to examine the uptake and transfer of cadmium instilled intratracheally into rats and its effect on the essential elements in the lung.

Cadmium chloride was instilled intratracheally into male rats of the Wistar strain (10 weeks old; body weight, approximately 270 g) at eight doses (40 to 0.313 μg Cd/rat in two-fold dilutions; the metal was dissolved in 0.4 ml of saline). Control animals received saline (0.4 ml). The animals were killed after 2 d and the concentrations of calcium, copper, iron, magnesium, phosphorus, sulfur and zinc were determined on an ICP (inductively coupled argon plasma-atomic emission spectrometer), while the concentration of cadmium was determined on a Zeeman flameless atomic absorption spectrophotometer.

Rats given a dose of 40 μg Cd/rat died within 2 d, and only the results from the other experimental groups were analyzed. Body weights were decreased significantly with increase of the dose, while the lung weight or the ratio of lung to body weight

increased linearly with the dose. Cadmium in the lung increased with the dose; the concentration ($\mu\text{g/g}$ lung) increased linearly with the dose up to a dose of 2.5 μg Cd/rat and leveled off at a dose of 10 μg Cd/rat, while the content ($\mu\text{g/lung}$) continued to increase up to a dose of 20 μg Cd/rat. However, the relative amount of cadmium retained in the lung decreased with the dose, suggesting that the amount of cadmium removed or transferred from the lung increased with the dose. The sum of cadmium in the lung, liver, kidney and spleen almost paralleled the dose throughout. Cadmium transferred to the liver was shown to increase with the dose. The result indicates that cadmium is mostly taken up and retained in the lung at a low dose (up to 2.5 μg Cd/rat) and that the amount of cadmium transferred to the liver increases at a high dose (higher than 5 μg Cd/rat).

Among essential elements in the lung, sulfur, iron, magnesium, zinc and phosphorus showed similar dose-dependent changes in concentration and content; the concentration decreased with dose and the content increased with dose. Calcium concentration remained constant, resulting in a sharp increase in calcium content. Copper was decreased in both concentration and content at a low dose (lowest at 1.25 μg Cd/rat), but at a higher dose (higher than 10 μg Cd/rat) both the concentration and content of copper were at the same levels as those of the control.

The distribution of copper in the lung supernatant was determined by the HPLC-ICP method on an Asahipak GS-520 column. The major copper-binding protein in the control was superoxide dismutase, and ceruloplasmin was a minor component. With the increase of cadmium dose, the copper peak that corresponded to superoxide dismutase decreased and those of ceruloplasmin and metallothionein increased.