The effects of CaEDTA injection on lead, zinc, copper and ALAD in erythrocyte, plasma and urine in lead-exposed workers: a 24-h observation

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Summary. To evaluate the effects of calcium disodium ethylenediamine tetraacetate (CaEDTA) on the concentrations of lead, zinc and copper in plasma, erythrocyte and urine, and the delta-aminolevulinic acid dehydratase (ALAD) activity in erythrocyte, we administered CaEDTA in 1-h intravenous infusion to ten male gun metal founders with blood-lead concentration of 39 to 64 \( \mu \text{g/dl} \) (mean 49 \( \mu \text{g/dl} \)). We found that the plasma concentration of lead, following a rapid rise within the first 3 h, fell temporarily to the level significantly lower than the initial level 19 h after start of the infusion. The plasma concentration of zinc fell to the minimal level 5 h after the infusion; and the erythrocyte concentration of zinc and the ALAD activity concurrently rose to the maximal level 5 h after the infusion. By contrast, no significant alteration was observed in the concentrations of copper in plasma and erythrocyte. The maximal level of urinary metal excretion was attained during the period between 1 and 2 h after start of CaEDTA infusion for lead; within 2 h for zinc; and between 2 and 4 h for copper. The urinary metal excretion returned to the initial level 14 to 24 h after infusion for zinc and copper; but lead excretion was still higher than the initial level during this period. The difference in the kinetics of the three metals following CaEDTA injection is discussed in the light of these findings.

Key words: Metals (Pb, Zn, Cu) – ALAD – CaEDTA – Blood (Plasma, Erythrocyte) – Urine

Introduction

The behavior of lead, zinc and copper in plasma, erythrocyte and urine following intravenous administration of calcium disodium ethylenediamine tetra-
acetate (CaEDTA) have not been fully elucidated [1–3, 6]. Previously, we examined the behavior of lead and zinc for the first six hours after start of a 1-h CaEDTA infusion in seven lead-exposed workers [2]. It was found in that study that the plasma concentration of lead (PbP) and the mobilization yield of lead in urine by CaEDTA reached their highest levels during the period between 1 and 2 h after start of CaEDTA infusion; on the other hand, the plasma concentration of zinc (PZn) rapidly fell for the first 6 h followed by gradual rises in the erythrocyte concentration of zinc (EZn) and in the erythrocyte delta-aminolevulinic acid dehydratase (ALAD) activity. However, the alterations in the PZn and EZn concentrations and ALAD activity in this study were inconsistent with the findings in two lead workers by Ishihara et al. [6].

In the present study, we intend to clarify the kinetics of those metals and ALAD activity during the 24 h after CaEDTA administration. In addition, the behavior of copper in plasma, erythrocyte and urine are examined.

Subjects and methods

Subjects

Ten subjects were male gun metal founders with blood-lead concentrations (BPbs) of 39 to 64 µg/dl (mean 49). They were employed at a factory for 7 to 15 (mean 13) years; their ages were 44 to 58 (mean 51) years. Neither albuminuria nor glucosuria was found in any of the subjects before or after CaEDTA infusion. No subject had ever suffered from renal disease. Gun metal was composed of lead (5%), zinc (5%), tin (5%) and copper (85%).

CaEDTA administration and collection of blood and urine samples

The nature of the procedure was fully explained to all subjects, and this study was carried out with their informed consent. After collection of 24-h urine samples, CaEDTA was injected intravenously into each subject in a dosage of 20 mg per kg body weight in 250 ml of 5% glucose solution from 10:00 to 11:00 h. Blood samples were collected just before and 3, 5, 8, 12, 19, and 24 h after start of CaEDTA infusion. Similarly, urine samples were collected during the following seven periods after start of CaEDTA infusion: (1) 0–1 h, (2) 1–2 h, (3) 2–4 h, (4) 4–6 h, (5) 6–10 h, (6) 10–14 h and (7) 14–24 h.

Analytical methods

BPb and the concentrations of lead in erythrocyte and urine (EPb and UPb) were measured by atomic absorption spectrophotometry (AAS) (Hitachi Polarized Zeeman Atomic Absorption Spectrophotometer 180–80) after wet ashing, chelation by sodium diethyl dithiocarbamate (DDTC) and extraction to water-saturated methyl-isobutylketone (MIBK); PbP was measured by the method of DeSilva [5]. PZn and the concentration of zinc in urine (UZn) were measured by the AAS after deproteinization by trichloroacetic acid (TCA); EZn and the concentration of zinc in whole blood (BZn) by AAS after wet ashing. The concentrations of copper in plasma and erythrocyte (PCu and ECu) were measured by flameless AAS after deproteinization by TCA; the concentration of copper in urine (UCu) by AAS after wet ashing, chelation by DDTC and extraction to MIBK. The concentration of copper in whole blood (BCu) was calculated from PCu, ECu and blood packed cell volume. The ALAD activity in erythrocyte was measured by the European standardized method [4].

The reproducibility of analysis, when expressed as a coefficient of variation, was 3.3, 3.5, 3.5 and 3.4% for BPb, PbP, EPb and UPb, respectively; 3.0, 3.7, 4.0 and 3.1% for BZn, PZn,