Influence of Citric, Ascorbic and Lactic Acids on the Gastrointestinal Absorption of Aluminum in Uremic Rats

J.L.		Domingo ^a
M.		Gomez ^a
J.M.		Llobet ^a
D.		del Castillo ^b
J.		Corbella ^c

^aLaboratory of Toxicology and Biochemistry, ^bSurgery Unit, School of Medicine, Reus;
^cToxicology Unit, School of Medicine, University of Barcelona, Spain

Dr. J.L. Domingo, Laboratory of Toxicology and Biochemistry, School of Medicine, San Lorenzo 21, E-43201 Reus (Spain)

Al(OH)₃

Dear Sir,

Aluminum (Al) hydroxide and several other Al-containing phosphate-binding agents and antacids are the most important sources of Al for renal patients who cannot excrete absorbed Al and are, therefore, at risk for serious sequelae of Al accumulation and toxicity [1]. In recent years, it has been demonstrated that oral citrate as well as other frequent dietary constituents (e.g., ascorbic, gluconic, lactic, malic acids) enhance the gastrointestinal absorption of Al [2, 3]. In the present study, we evaluated the effects of concurrent ingestion of citric, ascorbic or lactic acid and Al(OH)₃ on the gastrointestinal absorption and retention of Al in uremic rats. These organic factors appear to be of highest clinical importance as they are available in the diet at relatively high concentrations. Also, because citric, ascorbic and lactic acids are considered to be safe, these compounds are widely used as food additives.

Four groups of partially (5/6 N) nephrectomized rats were given 346 mg Al(OH)₃/kg/day for 10 days by gavage. Simultaneously, animals in three groups received by gastric intubation citric (62 mg/kg/day), ascorbic (56.3 mg/kg/day) or lactic (28.8 mg/kg/day) acids. The fourth group was designated as control group. Urinary Al excretion was measured daily during the entire period of treatment. Ascorbic and citric acids significantly enhanced Al excretion starting on day 6 of treatment. Moreover, citric, ascorbic and

300,
250

lactic acids significantly increased the cumulative urinary excretion of Al over 10 days (fig. 1). On the other hand, the Al concentrations in the bone, kidney and spleen were significantly increased by complexing compounds (table 1).

In summary, ascorbic, citric and lactic acids significantly raised the elimination of Al into urine, presumably because of enhanced gastrointestinal absorption of the element. This agrees with the significant increases in the tissue accumulation of Al observed in this study as well as in a previous investigation

Al(OH)₃ Al(OH)₃ Al(OH)₃

+ + +

citric acid ascorbic acid lactic acid

with healthy rats [4]. From these results, as well as from previous human studies [3, 5], it seems clear that uremic patients should be advised to avoid the concurrent ingestion of diets which contain substantial amounts of citric, ascorbic and lactic acids and Al-containing compounds.

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Table 1. Aluminum concentrations ($\mu\text{g/g}$) in some tissues of uremic rats given oral aluminum hydroxide and citric, ascorbic and lactic acids

Brain

Kidney

Liver

1.27 $\pm$ 0.53 1.82 $\pm$ 0.45* 2.64 $\pm$ 0.98** 0.71 $\pm$ 0.28*

Al(OH)₃ 1.57 $\pm$ 0.80 1.26 $\pm$ 0.56

Al(OH)₃ + citric acid 1.67 $\pm$ 0.50 1.48 $\pm$ 0.27

Al(OH)₃ + ascorbic acid 2.05 $\pm$ 1.57 1.06 $\pm$ 0.41

Al(OH)₃ + lactic acid 1.58 $\pm$ 1.12 0.77 $\pm$ 0.53

Values are mean $\pm$ SD. * p < 0.05; ** p < 0.01; *** p < 0.001, vs. Al(OH)₃ group.

Spleen

1.96 $\pm$ 1.28

5.82 $\pm$ 2.73* 3.36 $\pm$ 1.07* 1.02 $\pm$ 0.70

Bone

2.96 $\pm$ 1.52 8.82 $\pm$ 4.78** 6.37 $\pm$ 1.72*** 6.28 $\pm$ 2.67*

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