The influence of ascorbic acid on selected parameters of cell immunity in guinea pigs exposed to cadmium

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Zusammenfassung: Der Einfluss von Ascorbinsäure auf die immunotoxischen Wirkungen von Cadmium untersucht.

Einfluss von Ascorbinsäure auf ausgewählte Parameter der zellvermittelten Immunität bei cadmiumexponierten Meerschweinchen

Summary: The study investigated the possibility of influencing immunotoxic effects of Cd through ascorbic acid. Guinea pigs with high and low intake of ascorbic acid were perorally exposed to cadmium chloride (1 mg Cd/animal/day).

The daily vitamin C intake was 2 and 100 mg per animal, respectively. Phagocytic activity of polymorphonuclear leucocytes and monocytes as well as the percentage of active and total T lymphocytes in peripheral blood of animals were evaluated.

Five- and 12-week experiments showed a mutual potentiation of negative effects of Cd on the immune system by suboptimal intake of ascorbic acid. Toxic effects of Cd on the immune system can be reduced by a sufficient intake of vitamin C.

Key words: Cadmium - immunotoxicity - ascorbic acid - guinea pig

Schlüsselwörter: Cadmium – Immunotoxizität – Ascorbinsäure – Meerschweinchen

Introduction

Both deteriorating ecological situation and disproportions in nutritional habits which are acquired and stabilized at a very young age contribute to the alarming increase of cardiovascular and oncological diseases. One of the risk factors whose incidence in our environment has dangerously grown is cadmium (Cd).

We chose Cd as the xenobiotic for a laboratory model of a situation in which disproportions in nutrition – an insufficient intake of a protective antioxidant in food – act together with the environment polluted with a toxic xenobiotic. The guinea pig was chosen as an experimental model which allows extrapolation of the experimental results to man. Guinea pigs, like man, do not synthesize endogenous ascorbic acid.
Vitamin C was chosen as a model antioxidant with respect to the contemporary nutritional situation of the Middle and East European population: a chronic latent vitamin C deficiency can be considered the main limiting nutritional factor (7).

Cadmium is a frequent environmental contaminant of food, water and air in industrialized areas and induces a wide variety of toxic manifestations. Cigarette smoke, too, constitutes an important exposure route. The Cd inhaled by smokers exceeds 1 μg/day. According to the WHO, a tolerated weekly intake of Cd is 0.4–0.5 mg/person (23).

Cd metabolism is an example of an extreme accumulation of chemical injurant in the human organism. The highest accumulation occurs in kidneys and liver, the biological half-time of Cd in these organs being approximately 20–30 years. Cd taken up and accumulated in the target organ is mostly bound to an inducible low molecular weight protein, metallothionein (MT), and the metal sequestered as MT is known to be non-toxic in the cell (5). Therefore, Cd not bound to MT in the cell has been implicated as the toxic form and is called free Cd ions (active or toxic form of Cd) (18).

The Cd absorption depends on the composition of the diet. The interaction between Zn and Cd is known. A lower intake of Zn can increase the absorption of Cd.

Materials and methods

Design of experiment

Male guinea pigs (Velaz Praha) with an initial body weight of 350–450 g were housed in polycarbonate cages in groups of four per cage. They were given food and water ad libitum. An ambient temperature of 22±2 °C, relative humidity of 50±5 % and 12-h light/dark cycle were provided. Guinea pigs were allowed to adapt to these conditions for 2 weeks and over this period they were fed standard laboratory diet (MOK, Velaz Praha). The control group continued to receive standard laboratory diet. Four groups were fed an experimental diet (ED). Diet simulating nutritional disorders commonly appearing in economically developed nations (high content of saturated fatty acids and sodium chloride, low content of dietary fiber and antioxidants). The experimental diet lacked vitamin C, but contained higher levels of saturated fatty acids, saccharose and salt (49 % oat flakes, 30 % dried milk, 1 % sodium chloride, 10 % butter, 10 % sugar).

The animals were divided into five groups, each with eight guinea pigs:
1) group – control, the animals were fed a conventional pelletedized complete laboratory diet with vegetables;
2) group – experimental diet (ED) + low intake of vitamin C;
3) group – ED + high intake of vitamin C;
4) group – ED + low intake of vitamin C (2 mg/day + cadmium);
5) group – ED + high intake of vitamin C (100 mg/day + cadmium).

Two groups of animals drank water with low or high content of ascorbic acid. An actual intake of ascorbic acid and cadmium was calculated from the volume of drinking water daily consumed and from the decline of ascorbic acid concentration due to oxidation determined by the dinitrophenylhydrazine method (17). The intake of ascorbic acid was 2 mg and 100 mg/animal/day, respectively. Exposed groups drank water with cadmium chloride (10 mg Cd/l). The intake of cadmium was 1 mg/animal/day.

Animals were weighed each week. After 5 and 12 weeks, respectively, they were sacrificed by exsanguination 17 h after the removal of food.

Immune function assays

Phagocytosis: Phagocytic activity of polymorphonuclear cells was assayed by the method of Fornusek (4). We used the uptake of metacrylate beads (particles) by poly-