

Total ATPases activity in different tissues of albino mice exposed to aluminium acetate

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Abstract: This study has revealed significant variation in total ATPase activity after administration of aluminium acetate in different tissues of albino mice. With sublethal dose (3.5 mg/kg body weight) of aluminium acetate, total ATPase activity was decreased in brain (-50.61), liver (-50.69), kidney (-30.74), heart (-64.07), muscle (-51.50) and testis (-65.53) of albino mice. The decrement was enhanced with the increase of aluminium acetate. ATPases play an important role in the maintenance of cell permeability and energy transformation in the biological system. The results suggest that ATPase has a particular sensitivity to aluminium acetate.

Key words: Aluminium acetate, ATPases activity, Albino mice

Introduction

Trace metals play an important role in biological processes, both as essential components and toxins. The general mechanism of metal action is by influencing the enzymes present in the body. Metal that enters the body gets distributed to all parts of the body and causes toxicity. Exposure to aluminium in the environment is high because it is the most abundant metal in the earth's crust. The toxic consequences in human after aluminium exposure are well established (Nayak, 2002). In rats aluminium has a pro oxidant effect and thus acts as a neurotoxin (Nehru and Anand, 2005). Aluminium acetate interferes with detoxification enzymes and lipid peroxidation in different regions of brain of albino mice (John Sushma *et al.*, 2006). Though aluminium may have certain essential functions, yet it can also induce toxic conditions. Living system needs a continuous input of energy for building up and maintenance of its organization. The energy rich compounds are stored as ATP and its derivatives in a biosystem (Lehninger, 1984). ATPases represent a complex enzyme system which has requirement for Mg²⁺, Ca²⁺, Na⁺ and K⁺ ions for their activity. They are not only responsible for asymmetric distribution of Na⁺ and K⁺ ions across the cell membranes but also in junction with other transport proteins, mediate the bulk movement of ions and fluids in a variety of tissues. The enzymes Na⁺/K⁺ ATPases and Mg²⁺ ATPases have a relatively high sensitivity to certain classes of heavy metals and other pollutants. It has been observed that toxicosis from pollutants may develop primarily from ATPases inhibition. Therefore the present study was designed to determine the aluminium acetate induced alterations in total ATPase activity in different tissues of albino mice.

Materials and Methods

Healthy adult albino mice of same age group 60 ± 2 days and weight (25 ± 5g) were taken from veterinary college, Bangalore and maintained in laboratory conditions (26 ± 2°C; 12 hr light and 12 hr darkness). Toxicity of aluminium acetate was evaluated as per Finney (1964) and was found to be 35 mg/kg body weight. Ten

fold lower concentration of LD₅₀ i.e. 3.5 mg/kg body weight, was selected as sublethal dose. Adult animals were divided into four groups. The animals of the first group were considered as controls. To the animals of second group, single dose of aluminium acetate was given. To the third group, a double dose was given while to the fourth group, multiple doses were given. After stipulated time, the animals were dissected and the tissues like brain, liver, kidney, heart, muscle and testis were isolated for enzyme analysis. ATPase activity was assayed by the method of Fritz and Hamrick (1966) as reported by Desai and Ho (1979).

Results and Discussion

Data presented in Table-1 represents the total ATPase activity. The activity levels were expressed as μ moles of inorganic phosphate formed /mg protein/hour. The lyotropic series in terms of total ATPases activity in different tissues of control mice is as follows:

Kidney > Brain > Muscle > Liver > Testis

The total ATPase activity has shown a significant decreasing trend in all the tissues of albino mice treated with sublethal dose of aluminium acetate. The decrement was enhanced with the increase of aluminium acetate. Hence, the inhibition was more pronounced in multiple dose administered animals in which the order of elevated levels of inhibition in tissues was as follows:

Testis > Heart > Muscle > Liver > Brain > Kidney

The results suggest that ATPase has a particular sensitivity to aluminium acetate (Table 1). Many metals are essential to man, but for the metals like cadmium, lead and aluminium, biological functions have not yet been discovered. These non physiological metals are known to be toxic and they can affect multiple organ systems in man. Aluminium is associated with dialysis encephalopathy (Alfrey and Froment, 1990; Alfrey *et al.*, 1976) and with alzheimer's disease (Garrot, 1986).

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Table - 1: Changes in total ATPase (μ moles of inorganic phosphate/mg protein/hr) levels in different tissues of control and aluminium acetate treated albino mice

	Control	Single dose	Double dose	Multiple dose
Brain	6.625±	5.601	4.685	3.272
SD	0.161	± 0.171	± 0.193	± 0.20
% Change		(-15.45)	(-29.28)	(-50.61)
Liver	5.332	4.492	3.490	2.629
SD	± 0.137	± 0.124	± 0.146	± 0.168
% Change		(-15.75)	(-34.54)	(-50.69)
Kidney	7.071	6.695	6.008	4.897
SD	± 0.146	± 0.224	± 0.254	± 0.167
% Change		(-5.31)	(15.03)	(-30.74)
Heart	4.774	3.811	2.799	1.715
SD	± 0.17	± 0.19	± 0.13	± 0.16
% Change		(-20.17)	(-41.36)	(-64.07)
Muscle	6.33	5.159	4.052	3.070
SD	± 0.22	± 0.17	± 0.23	± 0.21
% Change		(-18.49)	(-35.98)	(-51.50)
Testis	4.523	3.368	2.260	1.559
SD	± 0.15	± 0.19	± 0.20	± 0.10
% Change		(-25.53)	(-50.03)	(-65.53)

Values are mean \pm SD of six individual observations. Tissue was pooled from six to eight animals. The value $p < 0.0001$, considered extremely significant

The toxic effect of many metals may be mediated *via* cell membrane integral proteins acting as enzymes, *e.g.* ATPase (Hypponen *et al.*, 1993). ATPase regulates the sodium metabolism and active cation transport through the membrane and maintains the ingredients required in the propagation of the nerve impulse. Total ATPase activity was markedly inhibited by cadmium, lead and slightly by aluminium (Hypponen *et al.*, 1993). Treatment of animals with toxic agents is known to produce pathological lesions being associated with increased proteolysis. Aluminium acetate has altered the protein metabolism in experimental albino mice (John Sushma *et al.*, 2006). Following aluminium exposure, a significant decrease in the activity of Mg^{2+} dependent ATPase was observed in cerebrum and cerebellum of rat (Nehru *et al.*, 2006). Nehru and Dua (1997) have reported that when selenium was administered concomitantly with lead, inhibited total ATPase activity in cerebral hemispheres and cerebellum regions of brain of rats. Total ATPase activity was markedly inhibited by fenvalerate in albino rat and was reported by Swarnalatha and Ramamurthi (1996). Jagannatha Rao (1990) reported the inhibition of ATPase activity by metals in different animals. Aluminium directly interferes with -SH groups of enzyme at the active site, thus preventing the sulfhydryl groups from functioning in certain chemical reactions (Zaman *et al.*, 1993). The changes in the active sites will affect the phosphorylation and dephosphorylation mechanisms of ATPase reaction and thereby causing decrement in the ATPase activity (Spallhotz, 1997). Aluminium lactate caused decreases in total ATPases and

AchE activities concentration dependently (Kohila *et al.*, 2004). Aluminium accumulation upon chronic dietary aluminium chloride administration significantly decreased the (Na^+/K^+) ATPase activity (Virgilia *et al.*, 2005). The inhibition of ATPase activity could change the gradients of sodium and potassium across the cell membrane and disturb several functions of nerve cells. Thus in the present investigation, the mice tissues recorded significant reduction in total ATPase activity under aluminium acetate intoxication.

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