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Effects of Cadmium on the Olfactory Bulb of Albino Rat Fed with Zinc Deficient Diet

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ABSTRACT

Cadmium, an environmental pollutant, is reported to have toxic effects on nearly all systems of human body though it's toxic effects nervous system are less well documented. It's pathophysiological actions are related to body stores of Ca++, Zn++ and Na++. This investigation was conducted to explore the toxic effects of Cd++ on the olfactory bulb of albino rats fed with the Zn++ deficient diet, to have an idea about it's corresponding toxic effects on humanbeings. 16 charles foster strain rats were taken. 8 rats (control group) and the remaining 8 rats (experimental group) were kept for 30 days on the stock ration and the Zn++ deficient diets, respectively. Experimental group rats were given Cd++ injections. Than 10µ thick sections of the olfactory bulb were stained with H&E, Thionine and Gleese silver stains. On microscopic observation, various layers of the olfactory bulb (of experimental group rats) showed degenerative changes

KEYWORDS : Cadmium toxicity, Zinc deficiency, Olfactory bulb, Albino rats

Introduction

Exposure to toxic environmental pollutants with or without nutritional deficiencies is being increasingly recognized as a serious health hazard. Cadmium, a heavy metal is an environmental pollutant. Cd^{++} is used in industries like plastics, stabilizers, pigments, electroplating alloys, batteries and chemicals and as a component of insecticides, pesticides and fertilizers. Cd^{++} is toxic to every organ. It is mainly toxic to kidneys and liver. Effects of Cd^{++} on human nervous system are less well documented. Though CNS dysfunction and anosmia has been reported.[1&2]. Average intake of Cd^{++} is estimated as 20-50 μ g/day.

Zinc is required for DNA, RNA and protein synthesis3 and gene expression4 for activity of many enzymes. Anencephaly and hydrocephaly have been reported following 'in utero' zinc deficiency in rats5. Many pathophysiological actions of Cd^{++} are related to interaction of Cd^{++} with body stores of essential ions, especially, Ca^{++}, Zn^{++} & Na^{++}. Long term Cd^{++} administration results in increase amount of Zn^{++} associated with metallothionein6 resulting into a deficiency of avai(lable Zn^{++} in the body.

Since no experimental studies were available regarding Cd^{++} neurotoxicity in zinc deficiency states, the aim of this study is to possibly fill the lacuna in the knowledge of this subject.

Material and Methods

Animals

16 Charles' foster strain rats, 8 males & 8 females were taken. They are divided into control and experimental groups, each group containing 8 rats (4 males and 4 females). Control group rats and the experimental group rats were kept for 30 days on stock ration diet and zinc deficient diet, respectively. Experimental groups rats received intraperitoneal $CdCl_2$ (99% pure anhydrous) injection in the dose of 2mg/kg body weight daily. 24 hours after the last injection, rats were sacrificed. Intra venous infusion was used as perfusion apparatus. 10% formalin solution in normal saline was used as perfusion fluid. In perfusion fixation, rats were anaesthetized by intra peritoneal injection of Nembutal (35 mg/kg body weight). Than thorax was opened, 18 gauge needle was introduced into ascending aorta through the left ventricle. Right atrium was widely opened and perfusion was done by formal saline at the pressure of 5 feet of water pressure. Perfusion was stopped when head & tail stiffness got pronounced and there was oozing of perfusion fluid on cutting the snout with the scissors. After this brain was removed, next olfactory bulbs were cut and put in a fixative (formal saline) over night. Then after usual procedures, 10 µ thick sections were cut and stained with H & E, thionine and glees silver stains.

Observation and Results

Histological sections of experimental group rats showed histopathological changes in general, but some layers of the olfactory bulb were more conspicually affected. Mitral cell layer showed the presence of oedma, clumping of mitral cells and spaces. Lamina fibrosa showed loosening and thickening with infiltration by periglomerular cells. In the lamina glomerulosa, the olfactory glomeruli showed distortion, oedema and spaces while while the perigromerular cells showed necrosis and disorganization.

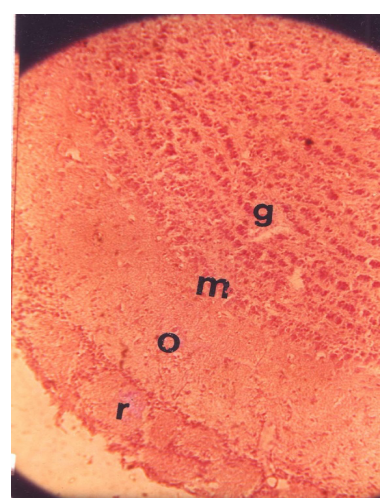

Fig. C-1. H & E x 200
Photomicrograph (control) of the olfactory bulb of an albino rat on normal diet and without cadmium exposure.

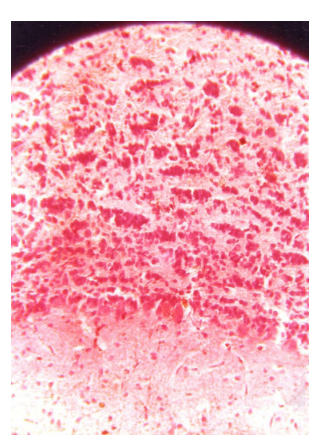

Fig.C-2: H & E x 400

Photomicrograph (control)of the olfactory bulb of an albino rat on normal diet and without cadmium exposure.

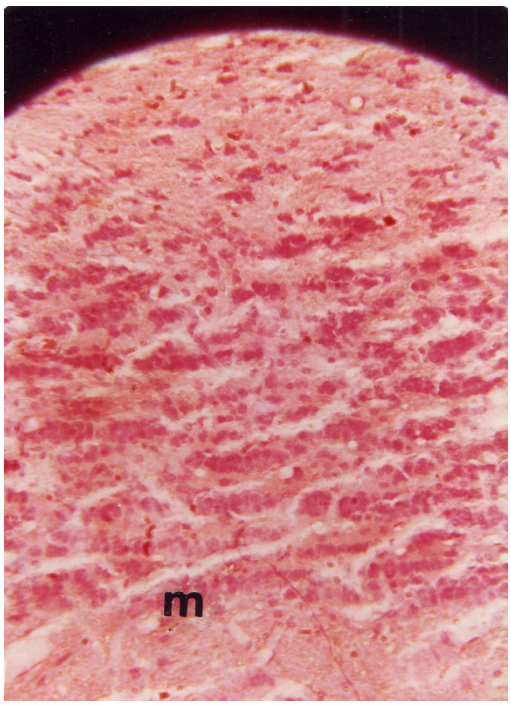

Fig.E-1: H & Ex 400
Photomicrograph (experimental) Showing degeneration of mitral cells and presence of oedema, cell clumping & spaces in the mitral layer

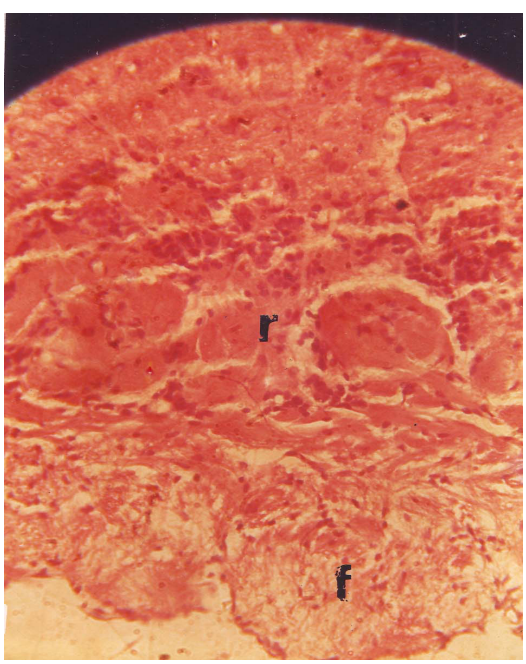

Fig.E-2: Gleese silver x 400
Photomicrograph (experimental) Lamina Fibrosa (f) shows loosening, thickening and infiltration by periglomerular cells. The olfactory glomeruli (r) shows distortion oedema & spaces. The periglomerular cells show necrosis and disorganization.

DISCUSSION

Both Cd^{++} and Zn^{++} belong to the same group, i.e., II b of the d-block-elements (transitional elements) of the periodic table. Most of the zinc ores contain Cd^{++} (like calamine). Very little material is available about effects of Cd^{++} on C.N.S. Reports about Cd^{++} toxicity on the olfactory bulb are all the more scanty. Zn^{++} deficiency may result from Cd^{++} administration6. No report is available regarding histological alteration of olfactory bulb secondary to Zn^{++} deficiency, although disturbance of smell is documented7. In the present study, the dose of 2mg/kg body weight of $CdCl_2$ was chosen in view of the reported 10% mortality with 4mg/kg/body wt. doses of cadmium8 and reported 14th Day LD_{50} value of a single administration of Cd^{++} to be 3.55mg/kg/ body weight by the intra peritoneal route9.

Microscopic Findings

Structural alteration in the olfactory bulb was observed following Cd^{++} intoxication of albino rats fed on Zn^{++} deficient diet Olfactory bulbs were found more vulnerable to Cd^{++} exposure, then other parts of the brain10, any specific site of lesion in the olfactory bulb has not been reported by him. No worker has observed the effect of Cd^{++} exposure on the olfactory bulb of mature rats, neither with concomitant administration of Zn^{++} deficient diet to the animals, which has been taken under in this study. In the present study, atrophic changes were seen in the lamina fibrosa (loosening, thickening of nerve fibres and eodematous changes). The glomeruli showed distortions, oedimatous changes and disorganization of periglomerular cells (appeared irregularly scattered).. Mitral cell layer appeared to be greatly affected and showed clumping of mitral cells, oematous changes and spaces. All these changes under light microscope are possibly due to selective accumulation of Cd^{++} in the olfactory bulb

Conclusion

From the above study it was concluded that olfactory bulb is vulnerable to toxicity of Cadmium in zinc deficient state similar to the other parts of the brain and the histopathological changes mainly included oedema, clumping, distortion and other degenerative changes in it's various layers.

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