EFFECT OF EXPOSURE OF FORMALDEHYDE VAPOURS ON SOME OXIDATIVE STRESS MARKERS, TOTAL PROTEIN AND ALBUMIN IN ALBINO RATS

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ABSTRACT

Human exposure to formaldehyde is associated with multiple adverse effects. Its exposure may cause oxidative stress in some vital organs like liver, kidney, lungs and cardiac functions. This study was aimed to assess the effect of formaldehyde exposure to some oxidative stress markers, total protein and albumin in albino rats. Thirty male Albino Wistar rats weighing 120g – 140g were randomly divided into 3 groups: group A (control group), Group B (exposed to 100 ppm of formaldehyde for 4 weeks), Group C (exposed 200 ppm of formaldehyde for 4 weeks). The animals were exposed to formaldehyde vapors 6 hours per day using an inhalation chamber. They were sedated with chloroform after 4 weeks and 4 ml of blood samples collected for biochemical analysis using standard spectrophotometric methods. The levels of MDA were significantly higher in exposed subjects (the two weeks and four weeks post exposure ($p < 0.05$) when compared with the control, Also, the activities of Superoxide dismutase (SOD) and glutathione peroxidase (GPX) were significantly lower in exposed subjects (the two weeks and four weeks post exposure ($p < 0.05$) when compared with the control and across the exposed groups, activities SOD/GPx were significantly decreased respectively, while the levels of MDA were significantly increased. However, serum total protein and albumin levels did not differ significantly (65.87 ± 4.19g/l) and (30.41 ± 2.43g/l) when compared with the control and among the exposed groups, ($p > 0.05$).This findings suggest that inhalation of formaldehyde vapors may induce oxidative stress.

Key words: Formaldehyde, Superoxide Dismutase, glutathione peroxidase, MDA, Total protein, Albumin and Albino rats.

1. Introduction

Formaldehyde is a simple aldehyde with the molecular formula CH_2O. It was discovered in 1867 by the British chemist, August Wilheld Von Hofmann. At room temperature, it is a colorless gas, highly flammable properties, irritating pungent odor and extremely soluble in water. Formalin is the chemical most commonly used for embalming (Raja, 2012). The process of embalming a cadaver is by introducing a fixative into the body tissues. This helps to preserve the cadaver by maintaining, as far as possible, a life-like state, and in the process, retaining the normal anatomical relations as are required for dissection purposes (Onyije *et al.*, 2012). The formulation for the preparation of embalming fluid varies. It depends on the laboratory and other factors like the size, extent of edema and stage of decomposition of the cadaver (Onyije *et al.*, 2012). Despite the widespread usage of formaldehyde in tissue fixation and embalmment, a major concern about formaldehyde is safety (IARC, 2006).

Formaldehyde can be toxic, allergenic and carcinogenic (Binawara *et al.,* 2012). Exposure occurs primarily by inhalation, where it is absorbed by the lungs and gastro intestinal tract. Disorders of exposure include airway irritation and obstructive disorders such as bronchial asthma, (Hauptmann *et al*., 2004) ocular irritations, corneal clouding, leukemia, nasopharyngeal cancers, spontaneous abortions, congenital malformations, and menstrual irregularities (Keil *et al.*, 2001). Furthermore, formaldehyde may induce oxidative stress and cause liver toxicity in morticians exposed to formaldehyde (Osadolor, *et al.*, 2014; Euphoria, *et al.*, 2015).

On the other hand, the oxidation of formaldehyde to formic acid is catalyzed by several enzymes such as NAD-dependent formaldehyde dehydrogenase which requires reduced GSH, Supreoxide dismutase, catalase and Glutathione peroxidase (Ayres *et al*., 1985; Heck *et al*., 1990; Kum *et al*., 2007).

The toxicity of formaldehyde gets worse by the tendency of the exposed individuals to develop tolerance within a few hours of exposure. Accordingly, those individuals remain in environments of gradually raised formaldehyde concentrations without being appreciative of the increased exposure levels and consequent hazards (Emue *et al.*, 2011). The Occupational Safety and Health Association (OSHA) recommended permissible exposure limit (PEL) of formaldehyde is 0.75 ppm averaged over an eight-hour work shift and 2 ppm not to be exceeded during any 15-min work period. The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) of formaldehyde is 0.016 ppm averaged over a 10-h work shift and 0.1 ppm not to be exceeded during any 15-min work period. (NIOSH, 2005). This research was conducted to assess the dose dependent toxicity of formalin inhalation on Albino rats.

II. Methods

Animals and Procedure of Formaldehyde Exposure

The experimental protocol was approved by the Ethical Committee of Nnamdi Azikiwe University teaching Hospital, Nnewi on Human and Animal Experimentation. Additionally, Principles of laboratory animal care (NIH publication no. 85-23, revised 1985) were followed. Three groups of adult male albino Wistar rats consisting of 10 rats each (weighing 140 ± 5gm) were obtained from the Animal house of Department of Physiology, University of Nigeria, Nssuka. After an acclimatization period of one week, the rats were randomly assigned to 3 different groups A,B and C and then the last two groups B and C were exposed (whole body exposure) to atmospheres containing 100 and 200 ppm formaldehyde continuously (8hrs per day), 5 days per week, for a period of 4 weeks. The doses were prepared by serial dilution of stock solution containing 10% formaldehyde. The exposure was performed in horizontally placed glass chambers. Animals were housed (10 rats per cage) in a chamber with adequate ventilation, maintained at temperature of 25 ± 2 °C, with a

relative humidity of 45-55% and a 12- hour light/dark cycle during the observation periods. Neither food nor drinking water was present in the inhalation chambers during the exposures. During the non-exposure periods the animals were provided with bottled tap water and the livestock diet for rats ad libitum. The rats were checked daily and body weights were recorded weekly. At the end of the 4-week exposure period, the rats were sacrificed by decapitation under chloroform anesthesia, and 4 ml of blood samples was collected from each rat into a plain bottle. The whole blood was allowed to clot, retracted and centrifuged at 3000 rpm for 10 minutes and serum separated. The serum was stored at -20˚C until analysis of superoxide dismutase, glutathione peroxidase, malondialdehyde, albumin and total protein using standard spectrophotometric methods.

III. Results

Table 1. Mean±SD and Post Hoc Analysis of Animal Groups Exposed to Formaldehyde

Group	MDA (nmol/ml)	GPx (U/ml)	SOD (U/L)	Protein (g/l)	Albumin (g/l)
A. Control	2.08 ± 0.25	0.80 ± 0.11	22.17 ± 1.82	64.39 ± 2.08	32.70 ± 1.84
B. Low dose	3.44 ± 0.58	0.76 ± 0.08	11.47 ± 1.35	65.22 ± 1.34	34.52 ± 1.95
C. High dose	4.22 ± 0.43	0.57 ± 0.09	12.97 ± 1.12	62.48 ± 3.37	33.09 ± 2.55
f-value	42.399	29.628	110.409	2.377	1.408
p-value	<0.001	<0.001	<0.001	0.121	0.270
A vs B	<0.001	0.005	<0.001	0.525	0.129
A vs C	<0.001	<0.001	<0.001	0.156	0.740
B vs C	0.004	<0.001	0.010	0.058	0.226

The mean levels of MDA in group A (control) were significantly lower when compared with the exposed groups B and C ($p < 0.05$). Also the mean levels between the exposed groups were significant.

Furthermore, the mean levels SOD and GPx of group A (control) were significantly higher control when compared with the exposed groups B and C ($p <0.05$). Also the mean levels of SOD and GPx between the exposed groups were significant.

However, there were no significant differences in the mean levels of albumin and total proteins in group 1 (control) and exposed group B and C ($p >0.05$).

IV. Discussion

In the present study, in all groups, inhalation exposure to Formaldehyde in rats did not affect serum concentrations of total protein and albumin ($P >0.05$). Although, there were limited data on the effects of

formaldehyde inhalation by animals, our findings are in line with data of Vargova *et al*. (1993), who used the oral formaldehyde in male rats observed no significant changes in the serum albumin and protein. In this study, GPx and superoxide dismutase activities decreased in exposed group which is dose dependent when compared with the control which was statistically significant ($p < 0.05$) and this was similar to the findings of Kum *et al*., 2007. In earlier studies, it was reported that SOD localized in the cytoplasm and in the mitochondria of cells (Fridovich, 1995; Kum *et al*., 2007), indicating that it may be used more during the detoxification and metabolism of formaldehyde. Lipid peroxidation damaged the cell membrane leading to an increase in MDA, but did not damage cell components such as mitochondria. Other studies showed increases of MDA levels in response to formaldehyde (Rana and Kumar, 1994;Al-Ghamdi et al., 2003a) and decrease in GPx levels (Beall and Ulsamer, 1984; IARC, 1995), these results were similar to those of the present study for the formaldehyde exposed group. It has been suggested that oxidative stress causes the release of reactive oxygen species (ROS) and hydroxyl radicals which damage the cell membrane and cell components, thus leading to cell death and also to the production of free radicals (Beall and Ulsamer, 1984; Heck *et al*., 1990; Rana and Kumar, 1994; Kum *et al*., 2007). Present study shows that even though low dose of formaldehyde exposure can induce oxidative stress, short durations of exposures may not affect the synthetic functions of the Liver.

V. CONCLUSION

Exposure to formaldehyde increases MDA levels and decreases enzymatic antioxidants activities and may induce oxidative stress as previously observed by some Authors. However, this study shows that at low concentrations within one week, it may not affect the synthetic functions of the liver. Albumin and proteins are major synthetic products of the liver. Glutathione peroxidase and superoxide dismutase activities of liver tissue were affected from Formaldehyde toxicity with dose dependent manner in our study.

VI. References

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