Cardiorespiratory effects of acute exposure to formaldehyde in gross anatomy laboratory in medical students – a comparative study

Rashmi Neginhal[1], Anita Herur[2], Surekharani Chinagudi[2], G B Rairam[3], Sanjeev Kolagi[4], Udaya Ambi[5]

[1]Post Graduate, Dept. of Physiology [2,]Associate Professor, Dept. of Physiology [3]Professor, Dept. of Anatomy

[4]Associate Professor, Dept. of Anatomy [5]Asst. Professor, Dept. of Anaesthesiology

S. N. Medical College, Bagalkot-587102, Karnataka, India

Abstract

Background: Formaldehyde has been widely used as a preservative (known as formalin) and disinfectant in medical fields.

Hypothesis: The study is based on the hypothesis that formalin doesnot affect the Peak Expiratory Flow Rate (PEFR), Heart rate, and Blood pressure.

Material and Methods: This comparative study was carried out in the department of Anatomy of S. N. Medical College, Bagalkot. Fifty randomly selected first year medical students between the age group of 17-20 years were included. Informed consent was taken from each student and the Ethical approval was obtained from the Institute's Ethical Clearance Committee. Anthropometric characteristics like height (cm), weight (kg), and body mass index (kg/m^2) were recorded. Cardiorespiratory parameters like heart rate (bpm), blood pressure (mm Hg) and Peak expiratory flow rate (l/min) were recorded before and after 2hrs exposure and 24 hrs post-exposure to formalin in Gross Anatomy dissection laboratory. These values were analyzed by ANOVA followed by posthoc using SPSS version 15.0.

Results: The study revealed statistically significant ($P<0.05$) decrease in value of Peak expiratory flow rate (l/min) when recorded at the end of 2 hours and 24 hours post exposure to formalin. Heart rate significantly reduced from baseline values ($P<0.05$), systolic blood pressure although has reduced it is statistically insignificant, diastolic blood pressure showed higher values when recorded after 24 hours post exposure.

Conclusion: It can be concluded that alternative chemicals like glutaraldehyde, which are safer and non toxic, have to be considred in place of formaldehyde.

Key-words: Formaldehyde, Pulmonary functions, Anatomy Laboratory

Introduction

Formaldehyde has been widely used as a disinfectant and preservative (known as formalin) in medical fields. It has been suggested that formaldehydemay produce physiological alterations of respiratory system. Occupational data suggests that small but significant changes may occur in lung functions following prolonged exposure in the work place[1,3]. It is well known that formaldehyde can cause sick house syndrome. Sick house syndrome (or sick building syndrome) is characterized by nonspecific complaints of mucosal irritation, headaches, and nausea and chest symptoms. It is believed that indoor environmental pollution causes these symptoms[4]. There are few studies to evaluate effects of formaldehyde on cardiac function[5]. We attempt to assess effects of formalin on cardiac and respiratory functions by measuring indirect parameters post exposure. The evaporation of formaldehyde from cadavers in gross anatomy laboratories can produce high exposures among students and instructor [6,7]. A few studies have characterized formaldehyde emission rates in gross anatomy laboratory [8]. We plan to study the acute effects of formalin in first year medical students who are exposed to it routinely during their anatomy dissection.

Materials and Methods

After obtaining approval from institutional ethical committee, the present study was taken up on 50 newly admitted apparently healthy MBBS students, aged 17-20 years, non smokers who were not exposed to the formalin in the past. The study was carried out in the Department of Physiology and Department of Anatomy, S Nijalingappa Medical

Address for correspondence

Dr. Rashmi Neginhal, Post Graduate Student,
Dept of Physiology S. N. Medical College, Bagalkot-587102. Karnataka India
E- mail: rashmineginhal@yahoo.co.in

College and HSK Hospital and Research Centre, Bagalkot. Prior to starting this project written informed consent was taken from the subjects. Following subjects were excluded from the study-Past or Present History of smoking, Students with a past history of any respiratory disorder before joining the college, Students with any history of systemic illnesses like diabetes, epilepsy and cardiac disease. The health status of the Students was ascertained through history taking and clinical examination. Anthropometric measurements like height, weight and BMI was taken for these subjects. Wright's hand held portable peak flow meter (M/s Recorders & Medicare Systems Ltd. India) was used to record the pulmonary functions in the department of physiology. The Heart Rate (HR), Blood pressure (BP) and Peak Expiratory Flow Rate (PEFR) were tested in three sittings. On admission to medical college during their orientation programme before they have started their dissection classes. Immediately after their first dissection class (2 hours duration). Twenty four hours after their first dissection class. Data expressed in terms of Mean ± Standard deviation and analysis was done by ANOVA followed by posthoc to compare the quantitative variables.

Table 1. Anthropometrical parameteres of first year medical students

CHARACTERISTICS	N=50
Age (years)	18.2±0.8
Height (cm)	158.08±7.5
Weight(kg)	56.5±13.4
BMI(kg/ m^2)	22.27±7.2

Values are mean ± S.D., BMI; Body mass index

Results

The characteristics like age, height, weight and BMI of subjects are as depicted in table 1. 95% of the subjects complained about mild irritation in the nose and eyes. 25% of the subjects complained of nausea and mild breathlessness. As shown in the table 2, Heart rate (HR)significantly reduced from baseline values (P<0.05), systolic blood pressure (SBP) although has reduced it is statistically insignificant, diastolic blood pressure (DBP) showed higher values when recorded after 24 hours post exposure.It is observed that mean PEFR values were significantly (p< 0.05) reduced post exposure(2hrs and 24 hrs).

Discussion

Formaldehyde (HCHO) is the gas produced by the oxidation of methyl alcohol. It is colourless and flammable with a strong pungent odour. Formaldehyde is extremely soluble in water and the aqueous solution containing some 37% formaldehyde is called formalin. Commercially available formalin is generally a solution containing 37% formaldehyde together with some 10-15% methanol to inhibit polymerisation.[9] It is used for disinfection or sterilization of instruments used for medical purposes. It is also used as a preservative of biological specimens as well as cadavers. Medical students during their dissection course are exposed to formaldehyde, whose exposure is recently considered to be one of the causes of multiple chemical sensitivity.

The present study was conducted to evaluate the acute symptoms caused by formaldehyde fumes that were experienced by the medical students in the dissection hall. Studies done earlier showed variable results. Study done by Farah *et al* revealed that FVC decreased in subjects immediately after their first

Table 2. Cardio respiratory parameters before and after formalin exposure

parameter (n==50)	1st reading (baseline)	2nd reading (after 2hrs of exposure)	3rd reading (after 24 hrs)	F	P
HR(bpm)	96.86±16.30	90.36±12.89*	90.96±11.44*	3.43	0.03
SBP(mm Hg)	123.58±16.19	120.47±15.27	121.56±10.63	0.61	0.5
DBP(mm Hg)	72.46±8.96	74.9±10.94	74.9±8.12*	1.11	0.3
PEFR(L/min)	338.1±104.54	300.04±104.06**	272.6±106.01**	4.91	0.008

Values are mean ± S.D., BMI; Body mass index

Values are mean ± S.D., HR, Heart rate; bpm, beats per minute; SBP, systolic blood pressure; DBP, diastolic blood pressure; PEFR, Peak expiratory flow rate; Posthoc LSD -p<0.05

exposure. While all other lung function parameters remained unchanged, indicating some mild transient bronchoconstriction on acute exposure to formalin [10]. Contrarily, Chia et al studied 150 first-year medical students exposed to formaldehyde during the dissection of cadavers in a gross anatomy laboratory and reported no significant differences in the pre- and post-exposure mean FEV1 and FVC[11]. A meta analysis done by Rastogi et al showed the mean fall of FVC, FEV1 and FEV1/FVC was not statistically or physiologically considered significant [12]. Wei et al revealed that subjective symptoms during the anatomy dissection course were related to the period spent in the anatomy dissection room. Their study suggests that shortening the time of each anatomy dissection practical class and reduction of the number of cadaver tables could help to reduce the symptoms [13]. In the present study, the PEFR significantly reduced after acute exposure which could be attributed to reflex reaction by sensory irritation of the upper respiratory tract. We also found significant decrease in heart rate after exposure which could be due to direct effect of formalin on cardiac function. These reflex reactions are derived from sympathetic nervous activity rather than parasympathetic nervous activity, and the reflex bradycardia could be caused by inhibiting the transmitter release at the adrenergic nerve[14]. Daisuke Takeshita et al in their rat model concluded that the formalin caused cardiac failure possibly mediated by impaired calcium handling in excitation–contraction coupling mediated via the sarcoplasmic reticulum which could decrease cardiac contractility and reduced systolic blood pressure [15]. We speculate due to this there is increased end systolic volume which in turn increases back pressure and peripheral resistance leading to rise in diastolic blood pressure. Environmental evaluation conducted in the anatomy laboratory showed formaldehyde levels ranging from 0.02 ppm to 2.7 ppm, indicating exposure significant to cause symptoms of irritation in most of the exposed subjects [6]. PFT was observed to be normal in these subjects. The exact concentration of formaldehyde to which our subjects were exposed could not be determined but it is definitely at a concentration causing severe eye and nose irritation (2–3 ppm) [8]. There are few limitations to our study that it needs to be extended to larger number of subjects. The study could be followed for one year to see the chronic effects of formalin on lung functions.

Moreover, the air sampling of dissection hall needs to be done to derive a relationship between the concentration of formalin and its effects.

Conclusion

It can be concluded that alternative chemicals like glutaraldehyde, which are safer and non toxic, have to be considered in place of formaldehyde.

References

1.Kilburn KH, Warshaw R, Boylen CT, JohnsonSJ, Seidman B, Sinclaire, Takaro TJ. Pulmonary and neurobehavioural effects of formaldehyde exposure. Arch Environ 1985; 4: 254–60.

2.Alexandersson R, Hedenstiena G, Kolmodin-Hedman B. Exposure to formaldehyde: effects on pulmonary functions. *Arch Environ Health* 1982; 37: 279–84.

3.Alexandersson R, Hedenstiena G. Pulmonary function in wood workers exposed to formaldehyde: a prospective study. *Arch Environ Health* 1989; 44: 5–11.

4.Hodgson M. Sick building syndrome. Occup Med 2000;15:571–85.

5.Strubelt O, Brasch H, Pentz R, Younes M. Experimental studies on the acute cardiovascular toxicity of formalin and its antidotal treatment. Clin Toxicol 1990;28:221–33.

6.Akbar-Khanzadeh F, Vaquerona MU, Akbar-Khanzadeh M, Bisesi MS. Formaldehyde exposure, acute pulmonary response and exposure control options in a gross anatomy laboratory. *Am J Ind Med* 1994; 26: 61–75.

7.Keil CE, Akbar-Khanzadeh F, Konecny KA. Characterizing formaldehyde emission rates in a gross anatomy laboratory. *Appl Occup Environ Hyg* 2001; 16: 967–72.

8.China SE, Ong CN, Foo SC, Lee HP. Medical students exposure to formaldehyde in a gross anatomy dissection laboratory. *J Am Coll Health* 1992; 41: 115–19.

9.Clark RP. Formaldehyde in pathology departments. J Clin Pathol 1983;36:839-846.

10.Khaliq F, Tripathi P. Acute effects of formalin on pulmonary functions in gross anatomy laboratory. Indian J Physiol Pharmacol 2009; 53: 93–6.

11.Chia SE, Ong CN, Foo SC, Lee HP. Medical students' exposure to formaldehyde in a gross anatomy dissection laboratory. J Am Coll Health 1992; 41: 115-9.

12.Mathur N, Rastogi SK. Respiratory effects due to occupational exposure to formaldehyde: A systematic review with meta-analysis. Indian J Occup Environ Med 2007;11:26-31.

13.Wei CN, Harada K, Ohmori S, Wei QJ, Minamoto K, Ueda A. subjective symptoms of medical students exposed to formaldehyde during a gross anatomy dissection course. Int J Immunopathol pharmacol 2007; 20: 23-5.

14.Tani T, Kogi K, Horiguchi Y. Inhibitory effects of formaldehyde inhalation on the cardiovascular and respiratory systems in unanesthetized rabbits. Jpn J Pharmacol 1986;40: 551-9.

15.Daisuke T, Chikako NT, Juichiro S, Hiroshi H, Tamiji N, Akio K et al. Effects of Formaldehyde on Cardiovascular System in In Situ Rat Hearts. Basic Clin Pharmacol Toxicol 2009; 105: 271-80.