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PULMONARY FUNCTION PARAMETERS AMONG ANATOMY LABORATORIES WORKERS EXPOSED TO FORMALDEHYDE.

By

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Abstract

Introduction: Instructors, technicians and workers in anatomy laboratories are at high risk as they deal with formaldehyde. **Aim of work:** To identify the magnitude and patterns of respiratory functions changes among workers in anatomy lab exposed to formaldehyde. **Materials and methods:** This is a cross-sectional analytic design (Ex Post Facto) carried on 34 laboratory workers exposed to formalin from anatomy departments both faculty of medicine and faculty of veterinary in Suez Canal University and 34 workers in the same institute not exposed to formaldehyde. A questionnaire was used to assess socio-demographic data, occupational history and the symptoms resulted from formaldehyde exposure. The pulmonary function tests included FVC, FEV1, FEV1/FVC, FEF25–75% and PEF and was carried out by computerized spirometer. **Results:** The mean age of the exposed group was 33.8 ±9.4 years while that of non-exposed group was 34.8 ± 9.4 years, the difference was statistically non-significant. The most common symptoms experienced among anatomy laboratories workers where cough, nasal and eye irritations, which are 76.4%, 73.5% and 70.5%, respectively. In the non-exposed group, the most commonly reported complaints were throat irritation (14.7%), cough (8.82%) and nasal irritation (8.82%). The difference was statistically significant ($P < 0.05$). All pulmonary function parameters were found to be significantly lower among the exposed group compared to the non-exposed group. The difference was statistically significant ($P < 0.05$). **Conclusion:** exposure to formalin during anatomy dissection is hazardous to workers' health in Anatomy department. Medical colleges should take more safety measures to reduce formalin exposure among Anatomy laboratories workers.

Keywords: Formaldehyde exposure, Respiratory function, Anatomy department and Suez Canal.

Introduction

Formaldehyde has many industrial applications as in the manufacturing of plastics, resins, rubber, fabric coatings, and adhesives. In addition, it is used in embalming to disinfect and preserve animal and human remains (Ochs et al., 2012). Formaldehyde-based solutions (formalin) is prepared by mixing the commercially available formalin solution with tap water in the proportion of 3:1 (Binawara et al., 2010). In gross anatomy laboratories, cadavers are kept in formaldehyde for a long period. During dissection, formaldehyde vapors are emitted and significant exposure of staff members and students has been reported (Khaliq and Tripathi, 2009; Mansour et al., 2012 and Brenner, 2014).

Formaldehyde is a colorless gas and its odor can be detected at concentrations of 0.5-1.0 parts formaldehyde per million parts of air (ppm) (Gurbuz et al., 2016). Formaldehyde enters the human body mainly by inhalation and via skin. More than 95% of inhaled formaldehyde is absorbed in upper respiratory tract, while very little amount will reach the alveolar membranes of the lungs (Saowakon et al., 2015). Once absorbed, it is very quickly broken down and converted to a non-toxic chemical called formate, which is excreted in the urine and is converted to carbon dioxide and breathed out of the body (Uthiravelu et al., 2015).

The threshold limit value for formaldehyde according to American Conference of Governmental Industrial Hygienists (ACGIH) is 0.3 ppm. The legal airborne permissible exposure limits are 0.75 ppm averaged over an eight-hour work shift and 2 ppm not to be exceeded during any 15-minute work period (Methner et al., 2014). Several studies showed that, during the dissection, formaldehyde concentrations within the laboratory ranged from 0.16 to 9.16 ppm (Lakchayapakor and Watchalayar, 2010; Ya'acob et al. 2013). Formaldehyde has been known to cause many acute and chronic health effects. It has both irritant and sensitizer effects on the upper respiratory tract as described in many literatures (Maribelli et al., 2011; Ochs et al., 2012, and Gurbuz et al. 2016).

Symptoms following exposure to low concentrations of formaldehyde

include eyes, nose, upper respiratory airways irritation and nerve toxicity (Ya'acob et al., 2013). Formaldehyde tolerance develop within 1–2 h. and workers remain unaware of their increasingly hazardous exposure (Uthiravelu et al., 2015). Higher concentrations cause impairment of pulmonary function (Lakchayapakor and Watchalayar, 2010). In June 2004, International Agency for Research on Cancer (IARC) classified formaldehyde as a known human carcinogen (group 1) (IARC, 2006). The nasopharyngeal cancer has been observed in cases with long-term exposure to formaldehyde (Uthiravelu et al., 2015).

Pulmonary response to low level of formaldehyde during periods shorter than a shift is controversial. Some studies did not show any change in pulmonary function tests, others showed high prevalence of upper airway disorders and decrease of forced expiratory volume (Mohammad et al., 2006, Vimercati et al., 2010, Rahimifard et al., 2013 and Uthiravelu et al., 2015).

Different studies were conducted in many countries, but there is a lack of data to determine its magnitude among Anatomy Lab staff in Egypt.

Aim of work

To identify the magnitude and patterns of respiratory functions changes among workers in Anatomy lab exposed to formaldehyde.

Materials and methods

- **Study design:** It is a cross-sectional analytic design (Ex Post Facto).
- **Place and duration of the study:** This study was conducted in Anatomy departments of both Faculty of Medicine and Faculty of Veterinary in Suez Canal University during the period from May to August 2016. The Anatomy laboratory in Faculty of Medicine is 260 m2 and had one door and permanently closed glass windows along one side of the room. The air was supplied through eight diffusers and four air conditioners. The room contains 14 stainless steel dissecting worktables. The Anatomy laboratory in Faculty of Veterinary Medicine is 247 m2 and had two doors, six windows and four exhaust fans. It contains 10 dissecting tables.
- **Study sample:** Sixty-eight workers, with at least 1-year work duration,

were participated in this study. The first group exposed to formaldehyde consisted of 34 workers in Anatomy departments of both Faculty of Medicine and Faculty of Veterinary. The second group consisted of 34 workers in the same institute but not exposed to formaldehyde. The exposed group and the controls were matched for age, gender and duration of work. Smokers and subjects suffering from any respiratory disorders were excluded.

- **Study methods:** A questionnaire was filled by the participants after explaining the aim of the study.

Spirometric tests were performed according to the American Thoracic Society guidelines using a portable spirometer, Fukuda Denshi Spirosift 500A Spirometer. Forced vital capacity (FVC), forced expiratory volume in first second (FEV1), and FEF25-75%% and peak expiratory flow were performed and the FEV1/FVC was calculated. Three sets of spirometry tests were performed for all participants. Race, age, gender, height and weight were entered into the software program before testing.

Consent

Authors explained the purpose of study to participating personnels, assured privacy and consent was obtained from them to participate in the study.

Ethical approval

The authors have obtained all necessary ethical approval from suitable Institutional Committee. The authors confirm that this study is not against the public interest, and that the release of information is allowed by legislation.

Data management

Data analysis was performed using SPSS 18.0 for windows. Descriptive statistics, including frequency distribution, percentages, mean and standard deviation were made. Chi-Square test was used to examine the relationship between variables, Fisher exact test was used to examine the relationship between variables when the expected frequency is less than 5. The student's t- test was applied to compare the pulmonary function parameters between formalin exposed and non-exposed groups. p -values of less than 0.05 were considered statistically significant.

Results

Sixty-eight workers, with at least 1-year work duration, were participated in this study. The first group exposed to formaldehyde consisted of 34 workers in anatomy departments of both faculty of medicine and faculty of veterinary. The second group consisted of 34 workers in the same institute but not exposed to formaldehyde.

Table 1: Demographic characteristics of the studied groups.

Parameter	Exposed (No=34)	Not exposed (No=34)	p
Age (yrs): Mean ± SD	33.8 ±9.4	34.8 ± 9.4	>0.05
Gender: No (%) Male Female	 13 (38.2) 21 (61.8)	 13 (38.2) 21 (61.8)	>0.05
Height: Mean ± SD **Weight:** Mean ± SD	168.9 ±9.4 75.4 ±15.2	166.1±6.6 77.3 ±18.8	>0.05
Duration of work (years) Mean± SD	9.4 ±10.0	10.8±10.0	>0.05

Table 1 showed that the mean age of the exposed group was 33.8 ±9.4 years, their mean height was 168.9 ±9.4 cm and the mean weight was 75.4 ±15.2Kg. As regards the control group, the mean age was 34.8 ± 9.4 years, the mean height was 166.1±6.6 cm and the mean weight was 77.3 ±18.8Kg. The difference was statistically non-significant.

Table 2: Occupational characteristics of the exposed group.

Parameters	Exposed (No=34)	
	No	%
Formaldehyde exposure		
>3 times/week	24	70.6
1- 3 times/week	7	20.6
< 1 times/week	3	8.8
Taking Formaldehyde safety training		
Yes	0	0.0
No	34	100
Read articles about Formaldehyde safety		
Yes	11	32.4
No	23	67.6
Use of Protective Equipment *(not mutually exclusive)*		
Aprons	9	26.5
Gloves	32	94.1
Goggles	9	26.5
Mask	11	32.4
Footwear	0	0.00

Table 2 showed that 70.6% of workers in Anatomy laboratories were exposed to formaldehyde more than three times per week. All workers didn't take any training about formaldehyde safety and 94.1% of workers used gloves while using formaldehyde.

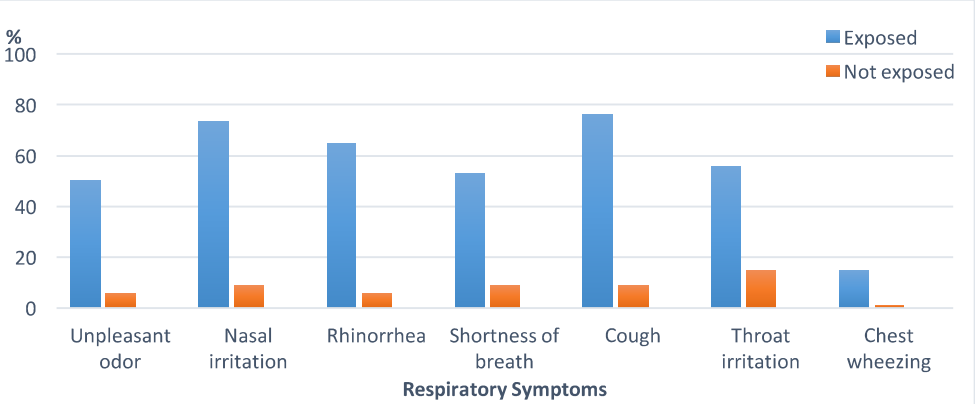

Figure 1: Respiratory Symptoms among the studied groups.

Figure 1 showed that the prevalence of respiratory symptoms due to formaldehyde exposure was greater among exposed workers compared to non-exposed workers. The most commonly reported complaints among exposed workers were cough (76.4%), nasal irritation (73.5%) and rhinorrhea (64.7%). In the non-exposed group, the most commonly reported complaints were throat irritation (14.7%), cough (8.82%) and nasal irritation (8.82%). The difference was statistically significant ($p < 0.05$).

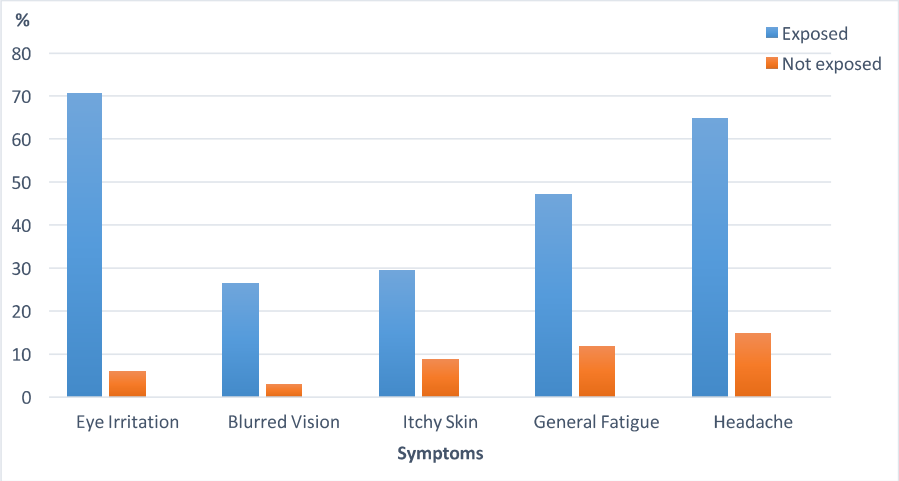

Figure 2: The other symptoms among the studied groups.

Figure 2 showed that, as regards non respiratory symptoms, the most common were eye irritation (70.5%) among exposed group and headache (14.7%) among non-exposed group .The difference was statistically significant ($p < 0.05$).

Table 3: Pulmonary functions among the studied groups.

Parameters	Exposed (No=34)		Not exposed (No=34)		p
	Mean	SD	Mean	SD	
FVC (L)	3.65	0.53	4.53	0.56	<0.05*
FEV_1(L)	3.15	0.49	4.12	0.62	<0.05*
FEV_1/FVC (%)	86.1	4.03	90.8	3.84	<0.05*
$FEF_{25-75\%}$ (L/S)	3.31	0.43	4.48	0.82	<0.05*
PEF (L/S)	7.22	1.29	8.49	1.16	<0.05*

*: Significant

FVC: Forced vital capacity

FEV1: Forced expiratory volume in 1 second, FEF25-75%: Forced expiratory flow

PEF: Peak expiratory flow

Table 3 showed that all parameters were found to be significantly lower among the exposed group compared to non-exposed group. The difference was statistically significant ($p < 0.05$).

Discussion

In medical colleges, the use of formaldehyde in the preservation of human and animals specimens was a common practice for centuries. During dissection, formaldehyde vapors are emitted from the cadavers, resulting in the exposure of instructors, technicians and laboratory workers to high levels of formaldehyde in the laboratory.

The ceiling standard established by ACGIH was 0.3 ppm, while that of The National Institute for Occupational Safety and Health (NIOSH) was 0.1 ppm (Gurbuz et al., 2016). In previous assessment, in the same laboratories, environmental concentration of formaldehyde was determined using formaldehyde detector tubes (Gastec No 91L) and Gastec pump (Gastec GV-100). Air samples were collected from the center and four corners of both laboratories. The mean room formaldehyde concentration in Anatomy laboratories of Faculty of Medicine and Faculty of Veterinary were 0.8 ± 0.06 ppm and 0.5 ± 0.03 ppm, respectively (Gaafar et al., 2016). This means that all exposed subjects were exposed to concentrations of formaldehyde greater than TLV ceiling.

In consistent with other studies, the current study confirms the irritant effects of formaldehyde (Lakchayapakor and Watchalayar 2010, Mansour et al., 2012, Mori et al. 2013 and Ya'acob et al., 2013). In this study, the exposed group reported irritation symptoms of the nose (73.5%), eyes (70.5%) while throat irritation was less reported (55.8%) (Fig 1, Fig 2). This is in consistent with the research findings of Rahimifard et al (2013), who found that eye irritation, throat irritation and cough had more prevalent among exposed subjects compared to non-exposed group.

The current study, skin irritation was only reported by 29.4% of the exposed group (Figure 2). In the Anatomy laboratories, where our study was performed, protective gloves were available and used by 94.1% of workers (Table 2). In different studies, participants indicated that double gloving was used in anatomy laboratories (Saowakon et al., 2015). This practice is likely to be the reason for the low frequency of skin irritation symptoms.

The parameters in pulmonary function tests are influenced by many

factors such as variability in the measurement, the observer and the study subject. In this study, a single researcher carried out the tests and they were performed during the same time of day.

In our study, all the five parameters of pulmonary function tests were reduced among the exposed group in comparison with non-exposed group (Table 3). These can be attributed to the adverse effect of formalin on respiratory system as found in several studies (Mohammad et al., 2006; Khaliq and Tripathi, 2009; Shrivastava and Yogesh, 2013 and Saowakon et al., 2015).

Uthiravelu et al (2015) evaluated symptoms of irritation and results of spirometry tests of 50 healthy formalin exposed subjects from department of Anatomy and Pathology of Medical College Hospital and Research Centre in India and 50 healthy controls of same age group. There was a significant difference in mean and standard deviation of all pulmonary parameters in formalin exposed, which shows that they have lesser ventilatory drive.

In contrary, Binawara et al (2010) found a significant ($p<0.0001$) decrease in values of FVC, FEV1 and PEF after exposure to formaldehyde but the FEV1/FVC ratio and FEF25–75% did not show any significant change. Also, Rahimifard et al (2013) said that although the respiratory function parameters such as FVC, FEV1 and PEF diminished among the exposed subjects compared control one, the differences were statistically insignificant. This indicates that there may be a mild broncho-constriction which can be confirmed by studying the exposure on larger number of subjects.

Conclusion and recommendations

All workers in anatomy laboratories were exposed to high concentrations of formaldehyde in excess of TLV ceiling limit by ACGIH. Formaldehyde levels should be measured periodically specially during the dissection in the Anatomy laboratory. Local exhaust ventilation system should be installed and personal protective equipment , such as safety eyeglasses and gloves should be available and be used to prevent formaldehyde adverse effects.

Conflict of interest

Authors have declared that no

conflict of interests exists, no financial or personal relationships with other people or organizations that could inappropriately influence (bias) their work.

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