LUNG AGE, DYNAMIC LUNG FUNCTIONS VS FORMALIN EXPOSURE IN FIRST YEAR MEDICAL STUDENTS IN RELATION TO GENDER AND BMI

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Abstract:

Background: Formaldehyde is widely used as a preserving, disinfecting and embalming agent in medical colleges and laboratories.First year medical students are exposed to formalin during their dissection hours, as formalin is used to preserve cadavers. It is noxious chemical which vaporises at room temperature and may cause respiratory problems. Calculation of 'Lung age' as an index of potential lung damage has been validated for detection of abnormalities caused by lung diseases. As there are very few studies of lung age in relation to formalin exposure, though many on lung functions, this study was conducted to know the effects of formalin on lungs.

Aims And Objectives: This study is conducted to evaluate the effect of formalin exposure on lung age and dynamic lung functions, along with gender differences and correlate lung age with BMI and ventilatory variables.

Materials And Methods: This study was carried out on ninety one healthy first year medical students who volunteered to take part in the study. Prior approval from Institutional ethical committee was obtained. Written, informed consent was taken from all the volunteers. The anthropometric measurements like height, weight were recorded and BMI calculated using quitelets index. Computerized Spirometer (RMS-Helios 702 Medspiror) was used to measure pulmonary function tests. Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV1), FEV1/FVC ratio,Peak Expiratory Flow Rate (PEFR), and lung age were obtained and statistically treated.

Results: This study shows that FVC, FEV1 and PEFR decreases and lung age increases after exposure to formalin (statistically significant). This effect is more on females, though statistically not significant. The FEV1/FVC % ratio did not show any significant change.Also, the effect of formalin on dynamic lung functions and lung aging is more on individuals with increased BMI.

Conclusion: It can be concluded that exposure to formalin in first year medical students has effects on pulmonary functions and lung age, more so in females and individuals with increased BMI . Hence protective measures or alternative chemicals like glutaraldehyde has be considered instead of formalin.

Keywords: Body mass index, dynamic lung functions, formalin, gender difference, lung age.

Introduction

Formaldehyde is widely used as a preserving, disinfecting and embalming agent. In addition to its technical benefits, formaldehyde has eliminated many health hazards during histological procedures in anatomy and pathology laboratories. Paradoxically, formaldehyde itself is a noxious chemical, highly unpleasant to the user, and a well-recognized occupational health hazard.[1–4] Formaldehyde has been reported to produce allergic contact dermatitis[5], neurobehavioral changes[6] and carcinogenesis.[7]

'Lung age' an index of potential lung damage was introduced by Morris and

Temple in 1985 as a tool for motivating cessation of cigarette smoking.[8] Lung age is commonly estimated from regression equations for the forced expiratory volume in one second (FEV1) in healthy never-smokers, and constitutes the age at which the FEV1 measured in an individual equals the predicted value of FEV1, taking into account age, height, sex and ethnicity. More recently, the calculation of lung age has been validated for detection of abnormalities caused by lung diseases.[9]

Taking into consideration that the literature has few studies of lung age in relation to formalin exposure, while at the same time many studies point to changes in lung function on exposure to formalin in medical students, the hypothesis of this study is that formalin exposure may have an early pulmonary aging compared to non exposed group. Similarly, lung age is compared in different BMI groups along with formalin exposure.

Since formalin exposure leads to several co-morbidities, strategies must be designed to combat this through awareness of its harm to health. Thus, the objective of the present study was to evaluate the effect of formalin exposure on lung age and dynamic lung functions, and to correlate lung age with BMI, and ventilatory variables.

The concept of lung age, when added to spirometric results, is a new alternative understanding of lung damage caused by formalin exposure, and provides a simple, easy, and straightforward interpretation.

Materials And Methods

The present study was carried out on ninety one (inclusive of male and female students) healthy first year medical students who volunteered to take part in the study. Prior approval from Institutional ethical committee was obtained. Written, informed consent was taken from all the volunteers. The study sample was selected after screening for history of hypertension, cardiac or pulmonary diseases, smoking and alcohol consumption.

Inclusion criteria being clinically healthy, non-smokers, without any chronic respiratory disease/ systemic illness like diabetes and hypertension.

Exclusion criteria were related symptoms, stress, type-I allergy, respiratory diseases, systemic illness and smoking habits.

The anthropometric measurements like height, weight were recorded and BMI calculated using quitelets index. Computerized Spirometer (RMS-Helios 702 Medspiror) was used to measure pulmonary function tests, which is solid state electronic equipment. The subjects were familiarized with the set up and detailed instructions and demonstrations were given to their satisfaction. Spirometry was performed on subjects immediately before the start of dissection class and once again after two hours of dissection class. The subject had to respire into a sophisticated transducer, which is connected to the instrument by means of a cable. The tests were performed in sitting position. The subject's were instructed to take deep inspiration which was followed by as much rapid and forceful expiration as possible into the mouthpiece of Spirometer and again deep inspiration through the mouth piece. Nose clips were applied to prevent air leakage through nose. Three consecutive readings were taken and the best reading amongst the three was selected. The apparatus provides a detailed analysis of predicted and derived values. The computer printouts of Forced Vital Capacity (FVC), Forced Expiratory Volume in 1st second (FEV_1), FEV_1/FVC ratio,Peak Expiratory Flow Rate (PEFR), and lung age with graphic curves were obtained.

Results

As shown in Table 1 and fig 1, the decrease in values of FVC, FEV_1 and PEFR and increase in lung age after exposure to formalin were statistically significant. The FEV_1/FVC % ratio did not show any significant change. Table-1 shows values of Pulmonary Function Tests in our subjects.

Table 2 and fig 2 shows significant decrease in FVC, FEV_1 and PEFR and increase in lung age post exposure to formalin both in males and females. Though formalin exposure has shown more effect on females, the differences between males and females values post exposure are not statistically significant.

Table 3 and fig 3 shows that difference between pre and post exposure values increases with increase in BMI indicating that the effect of formalin appears to be more as BMI increases, though significantly only with lung age.

TABLE 1: Lung parameters in pre and post exposure to formalin

	Pre exposure	Post exposure
FVC (lits)	3.09±0.72	2.54±0.69*
FEV1(lits)	2.69±0.59	2.21±0.633*
FEV1 / FVC %	87.05±6.23	87.01±7.4
PEFR (lit/s)	6.82±1.909	5.72±1.88**
Lung age (yrs)	18.95±1.62	22.19±2.54*

Values in mean and standard deviation. *significant, p=0.00001. **significant p= 0.0001

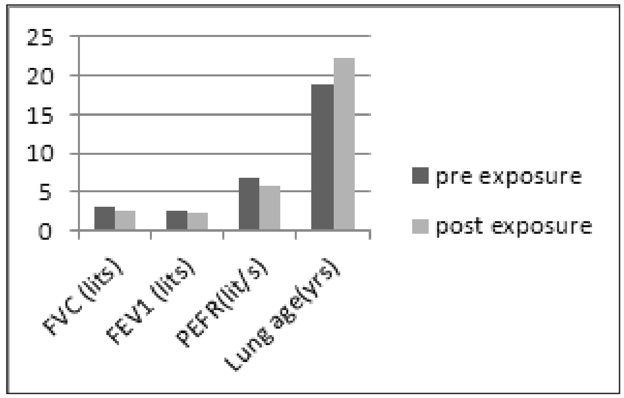

Figure 1: Lung parameters in pre and post exposure to formalin

TABLE 2: Gender differences between pre and post exposure to formalin in PFT

	Males			Females		
	Pre expo	Post expo	Difference	Pre expo	Post expo	Difference
Lung age (yrs)	18.64±1.76	21.48±2.57*	2.84	19.02±1.56	21.98±2.53*	2.96NS
FVC (lits)	3.4±0.64	2.845±0.63**	0.55	2.83±0.68	2.183±0.63*	0.647NS
FEV1(lits)	2.97±0.47	2.61±0.58**	0.36	2.36±0.57	1.98±0.59**	0.38NS
PEFR (lit/s)	7.7±1.86	6.75±1.82**	0.95	6.08±1.62	4.85±1.45**	1.23NS

*Significant p=0.00001 , **Significant p=0.001. NS – Not significant

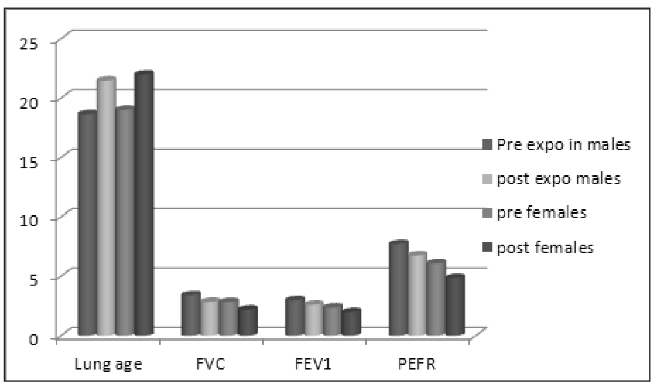

Figure 2: Gender differences between pre and post exposure to formalin in PFT

Table 3: Lung parameters pre and post exposure to formalin in relation to Body Mass Index (BMI)

	<18.5			18.6 – 21.5			21.6 - 25			>25		
	Pre	Post	diff	Pre	Post	diff	Pre	Post	diff	Pre	Post	Diff
Lung age (yrs)	18.6 ±1.12	21.28* ±2.57	2.68	18.58 ±1.08	21.24* ±2.12	2.66NS	18.83 ±1.58	21.11* ±2.28	2.28NS	19.75 ±1.75	25.13* ±3.14	5.38*
FVC (lits)	3.06 ±0.81	2.62* 0.724±	0.44	3.06 ±0.6	2.5* ±0.60	0.56NS	3.23 ±0.96	2.6* ±0.82	0.63NS	2.9 ±0.66	2.18* ±0.91	0.72NS
FEV1 (lits)	2.66 ±0.66	2.41NS ±0.69	0.25	2.7 ±0.51	2.28* ±0.56	0.42NS	2.7 ±0.72	2.18* ±0.71	0.52NS	2.5 ±0.51	1.87* ±0.86	0.63NS
PEFR (lit/s)	7.08 ±2.22	6.12NS ±2.04	0.96	6.66 ±1.69	5.49* ±1.7	1.17NS	6.87 ±2.1	5.68* ±2.12	1.19NS	6.29 ±2.15	4.03* ±1.95	2.26NS

*** Significant, NS – Not Significant.**

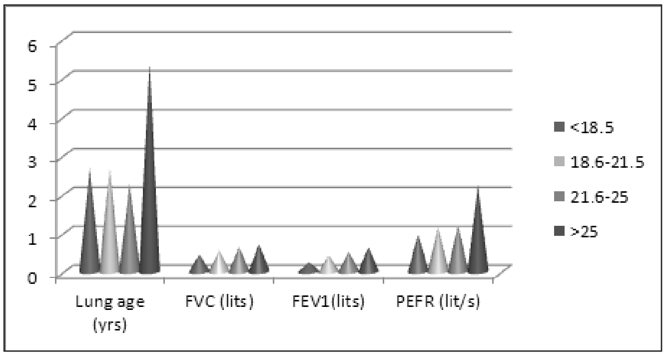

Figure 3: Lung parameters pre and post formalin exposure differences in relation to Body Mass Index (BMI)

Discussion:

Formaldehyde is a flammable, colourless and readily polymerized gas at ambient temperature, and is one of the major pollutants in indoor air. The chemical is extensively used to preserve cadavers in departments of anatomy. The primary route of exposure to formaldehyde is by inhalation, where it is absorbed by the lungs and gastro-intestinal tract and to a much lesser extent through the skin .Medical students during their dissection classes are exposed toformaldehyde, whose exposure is recently considered to be one of the causes of multiple chemical sensitivity. The binding of formaldehyde to endogenous proteins creates heptens that can elicit animmune response. Chronic exposure to formaldehyde has been associated with immunological hypersensitivity as measured by elevated circulating IgG and IgE autoantibodies to human serum albumin. In addition, a decrease in the proportion of T-cellswas observed, indicating altered immunity.[10]

Our study shows that the decrease in values of FVC, FEV_1 and PEFR and increase in lung age were statistically significant after exposure. However, the FEV_1/FVC % ratio did not show any significant change (Table1, Fig 1).

Study conducted by Binawara BK et al also showed similar findings with decrease in values of FVC, FEV1 and PEFR (statistically highly significant) after exposure whereas the FEV_1/FVC ratio and FEF25–75% did not show anysignificant change.[11]

The study done earlier revealed that FVC decreased in subjects immediately after their first exposure, while all other lung function parameters remained unchanged indicating broncho constriction on acute exposure to formalin.[12] Akbar Khan zadeh et al evaluated acute pulmonary response in group of 34 workers exposed to formalin in gross anatomy dissection hall, also reported decrease in FVC but FEV_1/FVC ratio increased during exposure.[13] Farah Khaliq et al reported decrease in FVC immediately after 2 hours exposure to formalin. A trend towards decrease in values of FEV_1 immediately after exposure was observed but it was not statistically significant.[12]

On the contrary, Chia et al reported no significant difference in the pre and post exposure in mean values of FVC and FEV1.[14] Alexanderson and Hedenstiernaevaluated lung function tests and immunoglobulin levels in 34 wood workers who were exposed to formaldehyde. A significant decrease in FVC, FEV_1, FEF25-75 was reported.[15] Mean while, the effect of formaldehyde exposure in plywood workers resulted in significantly reduced FEV_1, FEV_1/FVC ratio, FEF25-75 but not FVC.[16]

Earlier, the concept of lung age was established with the objective of becoming a tool of awareness of damages that smoking causes to the lung, leading to premature aging of the organ. Parkes et al[17] conducted a study with 561 smokers with age up to 35 years, and found that telling smokers their lung age significantly improved the probability of an individual to quit smoking.Similarly, expressing the effects of formalin exposure on lungs in terms of lung age may have more influence in adopting several measures to prevent formalin exposure.

This present study shows that lung volume decreases and lung age increases with increase in BMI and effect of formalin is more on group with BMI>25 though statistically significant only with lung age (Table 3, Fig 3).

Pulmonary aging related to obesity was also observed in the study by Mitsumune et al.[18] which investigated the relationship among lung age, cigarette smoking, and BMI, and verified that a higher BMI was significantly associated with older lung age, regardless of cigarette addiction. However, in their study, obese people were considered as those with a BMI equal to or greaterthan 25 kg/m^2, according to the classification of obesity by the Japanese Respiratory Society, which differs from that of the World Health Organization.

A correlation of lung age with BMI was also observed by Melo et al.[19]

Richard L et al[20] in their study showed that there were significant linear relationships between BMI and vital capacity and total lung capacity. However, functional residual capacity (FRC) and expiratory reserve volume (ERV) decreased exponentially with increasing BMI. An important finding was that the greatest rates of changein FRC and ERV occurred in the overweight condition and in mild obesity. At a BMI of 30 kg/m^{2}FRC and ERV were only 75% and 47%, respectively, of the values for a lean person with a BMIof 20 kg/m^2.

Several previous studies[21-22] have reported that increased body weight decreases lung volumes.

Others[23] studied obese subjects before and after surgery-induced decreases in body weight, and showed that decreasing bodyweight has the expected positive impact on lung mechanics.

For the numerous health challenges that formaldehyde causes on the students in anatomy dissection hall, it cannot be considered as an ideal chemical for embalming of cadaver. The laboratory attendants working in anatomy dissection hall for years are being continuously exposed to formalin vapours. They should be informed of potential health hazards of formalin and attempts should be done to reduce the concentration of formaldehyde by using other chemicals like glutaraldehyde, which can serve a good substitute for formaldehyde [24]. As quoted by BS Mitchell “Reduction in formaldehyde concentration is not deleterious to specimen preservation, but leads to a safer working environment”.[25]

So would like to recommend

- Proper ventilation system in the dissection hall
- Students should be allowed to use mask so as to reduce personal exposure
- Use of specialized dissection beds which incorporate an internal motor that cause a down flow of formaldehyde rich vapours which are absorbed by a replaceable active carbon filtration system. Coleman R had recommended use of these beds.[26]
- Students should have ready access to goggles and respirators when working in dissection laboratories.

Whitehead MC et al[27] found that InfuTrace and Perfect Solution, substituted for standard formaldehyde embalming, and InfuTrace infused through the vasculature after formaldehyde embalming, resulted in lower concentrations of formaldehyde than embalming with formaldehyde solution alone or in combination with body cavity injection of InfuTrace. This solution may be used provided it is cost effective.

Conclusion

It can be concluded that exposure to formalin in first year medical students has effects on pulmonary functions and lung age, more so in females and individuals with increased BMI. Hence protective measures or alternative chemicals like glutaraldehyde has be considered instead of formalin.

References

1. COUNCIL ON SCIENTIFIC AFFAIRS (CSA), J.A.M.A., 261 (1989)1183.

2. AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH), Formaldehyde. In: Documentation ofthe Threshold LimitValues and Biological Exposure Indices. 6th edition.(ACGIH, Cincinnati, 1996).

3. AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS (ACGIH): Threshold limit values for chemical substances and physical agents. (TLVs® and BEIs®,Cincinnati, 2002).

4. OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION(OSHA): Occupational exposures to formaldehyde: Final rule. (U.S. Governmental Printing Office, Federal Register 57(102)22289–22328, OSHA, Washington DC, 1992).

5. NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH): Criteria for a recommended standard: Occupational exposure to formaldehyde.(U.S. Department of Health, Education, and Welfare, Public Health Service,Center for Disease Control, DHHS (NIOSH) Publication No. 77–126,Cincinnati, 1976).

6. KILBURN, K. H., R. WARSHAW, J. C. THORNTON,Arch. Environ. Health, 42 (1987) 117

7. National Institute For Occupational Safety And Health (NIOSH): Formaldehyde:Evidence of carcinogenicity. (NIOSH Current Intelligence BulletinNo. 34, Cincinnati, 1981).

8. Morris JF, Temple W. Spirometric “lung age” estimation for motivating smoking cessation. Prev Med 1985;14:655-62.

9. Toda R, Hoshino T, Kawayama T, Imaoka H, Sakazaki Y, Tsuda T, et al. Validation of “lung age” measured by spirometry and handy electronic FEV1/FEV6 meter in pulmonary diseases. Internal Medicine. 2009;48:513-21

10. Thrasher JD, Wojdani A, Cheung G and Heuser G. Evidencefor formaldehyde antibodies and altered cellular immunity insubjects exposed to formaldehyde in mobile homes. ArchEnviron Health 1987; 42(6):347–50.

11. Binawara BK, Rajnee, Choudhary S, Mathur KC, Sharma H, Goyal K. Acute effect of formalin on pulmonary function tests in medical students. Pak J Physiol 2010;6(2)pp8-10.

12. Khaliq Farah, Tripathi Praveen. Acute effect of formalin on Pulmonary function in Gross Anatomy Laboratory. IJPP 2009; 53: 93–96.

13. Akbar-Khanzadeh F, Mlynek JS. Changes in respiratory function after one and three hours of exposure to formaldehyde in non-smoking subjects. Occup Environ Med 1997; 54(5): 296– 300.

14. 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(3): 115–119.

15. Alexandersson R, Hedenstierna G. Pulmonary function in wood workers exposed to formaldehyde: a prospective study. Arch Environ Health 1986; 44(1): 5–11.

16. Malaka T, Kodama AM. Respiratory health of plywood workers occupationally exposed to formaldehyde. Arch Environ Health 1990; 45(5): 288–294.

17. Parkes G, Greenhalgh T, Griffin M, Dent R. Effect on smoking quit rate of telling patients their lung age: the Step2quit randomized controlled trial. BMJ 2008;336:598-600.

18. Mitsumune T, Senoh E, Nishikawa H, Adachi M, Kajii E. The effect of obesity and smoking status on lung age in Japanese men.Respirology 2009;14:757-60.

19. Melo SMD, De Melo VA, De Melo EV, Menezes Filho RS, De Castro VL, Barreto MSP.Accelerated lung aging in patients with morbid obesity.J Bras Pneumol. 2010;36:746-52.

20. Richard L. Jones, and Mary-Magdalene U. Nzekwu. The Effects of Body Mass Index on Lung Volumes. ChestSeptember 2006; 130(3) : 827-33.

21. Ray CS, Sue DY, Bray G, James E, Hansen, Wasserman K. Effects of obesity on respiratory function.Am Rev Respir Dis 1981; 128:501–506.

22. Sahebjami H. Dyspnea in obese healthy men. Chest 1998;114:1373–1377.

23. Thomas PS, Cowen ER, Hulands G, MilledgeJ S. Respiratoryfunction in the morbidly obese before and after weight loss. Thorax 1989; 44:382–386.

24. Pabst R. Exposure to formaldehyde in Anatomy: An occupational health hazard ? The Anatomical Record 1987; 219(2): 109–112.

25. O’Sullivan E, Mitchell BS. An improved composition for embalming fluid to preserve cadavers for anatomy teaching in the United Kingdom.J Anat 1983; 182: 295–297.

26. Coleman R. Reducing the levels of formaldehyde exposure in gross anatomy laboratories Anat Rec 1995; 243: 531-3.

27. Whitehead MC, Savoia MC. Evaluation of methods to reduce formaldehyde levels of cadavers in the dissection laboratory. Clin Anat 2008; 21(1): 75-81.