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Title of the article: Effect of formalin on pulmonary function : a nine months longitudinal study

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ABSTRACT

Formalin is used in gross anatomy laboratories as a preservative of biological specimen as well as cadavers. Medical students specially 1st year are exposed to vapours emitted during dissection.To study the long term effect of formalin exposure(during dissection practical) on pulmonary function of 1st year MBBS students.This is a longitudinal study which comprises of nine months duration.Ninety six medical students [Mean (SD) age of 20.45(1.68)years] were assessed using MIR Spirolab for PFTs within 7 days of admission to their college and reexamined at the interval of three, six and nine months. Analysis was done by one way Anova test.Significant effect was seen in Forced Vital Capacity (FVC), FEV1, PEFR and FEF 25-75% at the end of nine months,however no significant change was seen over the duration of three and six month.Formalin is having adverse effects on the respiratory system over a period of nine months and we recommend a need of precautionary measures to be taken so as to decrease the exposure and also a need for multiple longitudinal studies to be done.
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INTRODUCTION

Formalin is used extensively in industrial application in manufacturing plastic, rubbers, plywood, adhesives and paints. It is also used as preservative, disinfective and embalming agent especially in the medical education. It has been reported tha the formalin causes acute and chronic effects on health [1-4] Formalin is highly soluble in water and so 95% of inhaled formalin is absorbed through upper respiratory tract [5]. It is due to this fact, the upper airway irritation is the commonest respiratory effect found after exposure to formalin. Some studies suggest that there are small but significant changes in the lung function following prolonged exposure [3,4,6,7] Uchiyama I et al also had recommended the exposure concentration of formaldehyde to medical students should be limited because formaldehyde is an irritant gas having a sensitizing potential, and is also a human carcinogen [8]. So the adverse effects of formalin are well known but chronic effect of formalin had not been studied extensively, especially in India, Hence we endeavored to undertake longitudinal study showing the effect of formalin on the 1st year MBBS student so as to see the chronic effect in the students over a period of nine months and their by to see whether precautionary measures are to be taken or not.

MATERIALS AND METHODS

The study comprises of 96 medical students (inclusive of male and female students)in whom all readings were taken. To start with, sample size was 120 but 24 students were dropped out because of some reasons, mainly, continuous absence from the class. Age group was 18-23yrs [mean(S.D) age of 20.45(1.68) years]. Healthy, non-smoker students, not suffering from any respiratory or cardiac diseases were selected.

Exclusion criteria were

- H/o chronic respiratory disease
- H/o cardiac disease
- Examination finding suggestive of respiratory or cardiac disease
- Abnormal pulmonary function test
- Extremes of weight and height
- Continuous 7 days absence from the class.
- Previous history of exposure to formalin

This was longitudinal study done over the period of nine months. Initial baseline readings were taken within 7 to 10 days of admission to college then 2nd , 3rd and 4th readings were taken at the end of 3rd , 6th and 9th month respectively. After nine months they went for summer vacations.

Approval was taken from the institutional ethical committee.

For pulmonary function test:-MIR Spirolab was used. Pulmonary function test was recorded in PFT laboratory at around morning session before the start of dissection so as to avoid any acute effect of formalin. On the previous day, students were told to avoid any physical exertion and take proper rest and diet.

All the subjects were made familiar with the instrument and the procedure for performing the test. The data of the subject as regards to name, age, height, weight, sex, date of performing the test, atmospheric temperature was fed to the computerized MIR Spirolab.

The tests were performed in sitting position. The subject was asked to take full inspiration which was followed by as much rapid and forceful expiration as possible in the mouthpiece of MIR Spirolab. Three consecutive readings were taken and the best reading amongst the three was selected. We have followed the guidelines of American Thoracic Society.[9]

All these tests were repeated three times i.e. at the end of 3^{rd}, 6^{th} and 9^{th} month. Then these readings were compared using one way Anova and Bonferroni's post test and P values < 0.05 were taken as significant.

The above students were having daily dissection class of two hours. Dissection hall is 200sq.m and having 20 dissection tables. One cadaver is given to 10 students, so there was equal exposure to all the subjects. During present study, the first year students were exposed to formalin 2 hours per day for 5 days a week during dissection.

RESULTS

Total 96 subjects{ [Age(range:18-23yrs, mean(S.D) age of 20.45(1.68) years], [Height :- mean(S.D) height of 165.3(11.6) cms], [Weight:- mean(S.D) weight of 60.89 (6.47) kg]} were able to successfully complete the study. On observing the table carefully, it is seen that, at the end of nine months, significant decrease is seen in FVC(forced vital capacity) , FEV1(forced vital capacity at the end of 1 sec) and FEF25-75 (Mid expiratory flow rate). Also one thing is also clear that six months are not enough for significant change to occur in the PFT parameters. Also in this duration of nine months, none of the patients was having any history suggestive of obstructive lung disease. Most of the students (91%) complained of nose and eye irritation on the first exposure in dissection hall. (Refer table no. 1)

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TABLE 1 : PULMONARY FUNCTION CHANGES IN STUDENTS AT INITIAL AND AT THE END OF 3RD , 6TH AND 9TH MONTH (n=96)

PAAMETER	INITIAL	3 MONTH	6 MONTH	9 MONTH	P value					
					0 Vs 3	0 Vs 6	0 Vs 9	3 Vs 6	3 Vs 9	6 Vs 9
FVC(L)	3.242 (0.803)	3.211 (0.792)	3. 21 (0.744)	3.117 (0.718)	ns	ns	*	ns	ns	ns
FEV1(L)	2.838 (0.64)	2.827 (0.636)	2.769 (0.54)	2.757 (0.543)	ns	ns	*	ns	ns	ns
FEV1/FVC(%)	88.75 (14.00)	89.22 (14.47)	88.79 (18.75)	91.19 (20.38)	ns	ns	ns	ns	ns	ns
FEF25-75(L)	3.388 (1.184)	3.383 (1.184)	3.291 (0.9561)	3.275 (954)	ns	ns	*	ns	ns	ns
PEFR(L/s)	5.252 (2.057)	5.209 (2.068)	5.088 (1.982)	5.083 (1.995)	ns	ns	*	ns	ns	ns

Values are mean (standard deviation)
*= $p < 0.05$ significant change,
0 Vs 3 : comparison between initial and third month
0 Vs 6 : comparison between initial and sixth month
0 Vs 9 : comparison between initial and ninth month
3 Vs 6: comparison between initial and third month
3 Vs 9 : comparison between third month and ninth month
6 Vs 9 : comparison between sixth month and ninth month

DISCUSSION

In the present study, significant change was seen at the end of nine months but not at the end six months or three months that means nine months` duration is the minimum requirement to cause deleterious effects on the pulmonary function test. During the present study, we got mixed findings i.e. decrease in PEFR and FEV1 which is suggestive of obstructive lung disease and there was no change in the ratio of FEV1/FVC but decrease in both FEV1and FVC which is suggestive of restrictive lung disease. Thus formalin is causing mild obstruction and mild restriction over a period of nine months.

Similar results were seen by some authors [1,3,10] while some authors found result contradictory to us [11,12]. This may be because of the sensitizing potency of formaldehyde, Wantke F et al found that 1-month exposure to formaldehyde and phenol during an anatomy dissection course did not induce specific IgE against formaldehyde [13]. In the present study also no significant change was found over the period of six months but at the end nine months significant change was found. Thus, for the sensitizing potency nine months may be required. Also levels to which our students were exposed may be little bit higher as Main DM et al revealed no decrease in ventilatory function among the workers (exposed to formaldehyde (at levels between 0.12 and 1.6 parts per million [ppm]) [12].

Recommendations and outlook

One of the advantages of our study is that this is a longitudinal study where same subjects were followed and examined so the chances of their individual variations were limited and also our subjects were from the similar age group. Disadvantage of the study was that the exact concentration of the formaldehyde to which our students were exposed cannot be determined, but it was definitely at concentration causing nose and eye irritation (more than 1.6 ppm) [12, 14]. So we recommend that more and more longitudinal studies with exact concentrations are needed to be carried out, so as to know the minimum concentration to which the medical students can be exposed without ill effect for the minimum classes per week. But measuring the exact concentration is tedious procedure and practically this cannot be followed in every medical college, like in Japan, Takayanagi M et al found that medical students and instructors are exposed to higher concentrations of FA than allowed by the guidelines of the Japan Ministry of Health, Labor and Welfare [15], also it is hard to measure everyone's exposure level. So we 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 specialised 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. [16]
- Students should have ready access to goggles and respirators when working in dissection laboratories.

We do not recommend use of gloves as Environmental Health Criteria 89 of International Program of Chemical Safety states, "It must be regarded that formaldehyde fluid is not absorbed directly into tissues through the skin". So the students may be allowed in some cases to touch the cadaver, treated by formaldehyde content fixative, by bare hands to understand the feel of certain organs and tissues [17].

Wei CN, et al [18] suggested that shortening the time of each anatomy dissection practical class and reduction of the number of cadaver tables could help to reduce symptoms.But according to us it should not be used unless utmost needed because it will hamper the education standard. Whitehead MC et al [19] 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

Formalin may be having diverse effect on the respiratory system over a period of nine months and we recommend need of the precautionary measures (mentioned above) to be taken so as to decrease exposure and also need of multiple longitudinal studies.

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