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Original Research Article

EFFECT OF FORMALIN ON C REACTIVE PROTEIN AND PULMONARY FUNCTION TESTS IN UNDERGRADUATE MEDICAL STUDENTS IN ANATOMY DISSECTION LABORATORY

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ABSTRACT

Introduction: Formalin is the commonest fixative chemical used for preserving cadavers by embalming and other biological specimens which is commonly used in Medical colleges in Anatomy Dissection hall. C reactive Protein is an annular pentameric protein found in blood plasma. CRP is synthesised by the liver and its concentration increases rapidly during inflammatory processes. The aim of the present study is to reveal the correlation between exposure to formalin and changes in pulmonary function tests in undergraduate medical students and to find out the correlation between exposure to formalin and C reactive protein.

Materials and Methods: The study was conducted on eighty (40 girls and 40 boys) first year undergraduate medical students of both the gender between 18-22 years of age in Department of Anatomy and Physiology, ACS Medical college, Chennai. Pulmonary function tests was carried out by Computerised Spirometer before and after two hours exposure to formalin in the Anatomy dissection hall. Blood sample for serum CRP level estimation was also taken.

Results: There is decrease in values of FVC, FEV1, FEV1/FVC, PEFR and FEF_{25-75} after 2 hours exposure to formalin. There is decrease in values of FVC, FEV1, FEV1/FVC, PEFR and FEF_{25-75} in the male participants after 2 hours exposure to formalin and the only parameter which is statistically significant is PEFR in the female participants after exposure to formalin. The values of FEV1 and FEV1/FVC are statistically significant in male and female participants before exposure to formalin. The values of FEV1/FVC, PEFR and FEF_{25-75} are statistically significant in male and female participants after exposure to formalin. About 64 students have CRP range of 10.1-40.0mg/l (80%). About 4 students have more increased levels of CRP within the range of 40.1-80.0 mg/l (5%).

Conclusion: There is great impact of formalin on CRP and Pulmonary function tests in first year undergraduate medical students who are constantly exposed to formalin in Anatomy dissection laboratory. To avoid this, either protective measures or alternative measures should be taken.

KEY WORDS: Embalming, Preservation, Cadaver, Exposure.

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INTRODUCTION

In 1867, the German chemist August Wilhelm Von Hofmann discovered formaldehyde[1]. Formaldehyde is a colourless, flammable gas which is produced by the oxidation of Methyl alcohol and it can be used at room temperature. It exists as a gas at room temperature and has noxious and irritating properties and a strong pungent odour too. Formalin is 37% aqueous solution of formaldehyde[2]. Formalin is the commonest fixative chemical used for preserving cadavers by embalming and other biological specimens since ages. Embalming of cadaver is done by introducing a fixative into the body tissue which helps to preserve the cadaver by maintaining in a life-like state and also retains the normal anatomical relations required for dissection purposes. This chemical is commonly used in Medical colleges in Anatomy Dissection hall and Pathology Museum[3].

Even though formalin is utilised in the manufactures of resins, particle board plywood, leather goods paper, pharmaceutical and other products but the exposure of students to formaldehyde in the Department of Anatomy is continuous and higher than its use in other areas. Because of widespread use and toxicity of formalin, exposure to such chemical has to be considered for human health[4]. Formaldehyde enters the body by inhalation or when the chemical comes in contact with skin. Formalin is mainly absorbed through the nose and in the upper respiratory tract but it is quickly broken down which is done by almost every tissue. Formalin that is broken down is converted to a non-toxic chemical called formate which is excreted outin the urine and sometimes converted to carbondioxide which is breathed out of the body. In spite of all these, formalin can be toxic, allergic and carcinogenic[5].

Exposure to formalin produces symptoms like sore throat, itching and burning sensation of the nose and nasal congestions and even induce bronchial asthma at high exposure rates.. Chronic exposure may lead to bronchitis and pneumonia[6].Formalin is also prone to “sick house syndrome” or “sick building syndrome” characterised by non specific symptoms like mucosal irritation, headache, nausea and chest symptoms[7]. Many research papers have shown that upper respiratory tract is the critical target of the continuous exposure to formaldehyde and also associated with adverse effects on the respiratory tract[8]. Occupational data also reveals that significant changes may occur in lung function, respiratory system and cardiac function following prolonged exposure to formalin and this study aims to reveal the correlation between exposure to formalin and changes in pulmonary function tests in undergraduate medical students.

C reactive Protein is an annular pentameric protein found in blood plasma. CRP is synthesised by the liver and consists of 5 identical polypeptide chains forming a 5 membered ring in response to factors released by macrophages and fat cells. In normal adults, the normal range of CRP is upto 6mg/l . CRP is most sensitive of the acute phase reactants and its concentration increases rapidly during inflammatory processes. The rate of CRP also increases in response to infection, necrosis, malignancy and allergic reaction.. Wie et al[9] studied the circulating immune markers in Chinese workers occupationally exposed to formaldehyde and since no study has been done in the past in Indian Population, this study aims to find out the correlation between exposure to formalin and C reactive protein.

MATERIALS AND METHODS

Study Setting: Department of Anatomy and Physiology

Study Design: Observational study

Study Period: 2 months

Study Population

Inclusion criteria: First year undergraduate medical students of both the gender between 18-22 years of age

Exclusion criteria: 1. Students with a history of smoking, any chronic respiratory disease and Type I allergy

2. Students with congenital anomalies of spine and thoracic cage

3, Students with connective tissue and Musculoskeletal disorders

The sample size will be 80 healthy adult student volunteers.

Study procedure:

The study population will be first year undergraduate medical students aged 18-22 years of age of both the gender attending Anatomy Dissection Laboratory classes eight hours per week for 6-8 months . The participants will be selected without any bias and a informed consent will be obtained from the students enrolled in the study after eligibility screening.

Following Informed consent, the parameters like age, sex, height, weight will be recorded and BMI will be calculated.

Pulmonary function tests will be carried out by Computerised Spirometer which is solid state electronic equipment. The individual has to respire into a transducer which is connected to the instrument by means of a cable which gives a detailed analysis of Forced Vital Capacity (FVC), Forced Expiratory Volume in first second(FEV_1), FEV_1/FVC ratio, Forced Expiratory Flow between 25 % and 75 % of vital capacity (FEV_{25-75}) and Peak Expiratory Flow Rate (PEFR) with graphic curves . The test should be done twice for each student and the maximum reading will be taken for analysis. This study will be done just before and during the dissection hours of laboratory so that pre and Post analysis of Formalin can be obtained.

Lung Function test will be done on the selected students before and after two hours exposure to formalin in the Anatomy dissection hall.

The participant is asked to give blood sample for serum CRP level estimation. Blood is drawn in a vial and will be sent for analysis and CRP was measured immunoturbidimetrically.

Statistical Analysis:

The data collected was entered in the MS excel spreadsheet and the descriptive table was obtained. Pre exposure value of pulmonary Function tests will be compared with post exposure values to formalin vapours and statistically analysed by Student's T test to determine the significance of values and to evaluate the changes in the respiratory function of the student. The data was expressed as Mean±S.D. A significance level of p<0.05 was considered for the students t test.

RESULTS

Following are the results of the present study conducted on 80 first year undergraduate medical students who are exposed to formalin in Anatomy dissection Laboratory.

Table 1: Anthropometric Parameters of the Study Participants (Male n=40, Female n=40, Total n=80).

S.No	Gender	Age (Years)	Height (Cm)	Weight (Kg)	Body Mass Index (Kg/m^2)
1	Male	18.47±0.68	172.45±6.20	68.37±12.62	23.02±4.10
2	Female	18.33±0.65	160.85±5.27	59.95±10.48	23.28±3.51
3	Total	18.40±0.66	166.65±8.19	64.16±12.33	23.15±3.81

Table 1 shows the anthropometric profile of the participants involved in the study . The mean age, height, weight and BMI of the study participants (n=80) are 18.40 years, 166.65 cm, 64.16 kg and 23.15kg/m^2 respectively.

Table 2: Pulmonary Function Test Comparison in the study Participants (n=80) before and after 2 hours exposure to formalin (p value < 0.05*, p value <0.001**, p value < 0.00***).

S.No	Parameters	Before Exposure Mean±S.D	After Exposure Mean±S.D	p value	Significance
1	FVC (L)	3.06±0.65	2.94±0.66	0.014*	Significant
2	FEV1(L)	2.82±0.62	2.67±0.60	0.001**	Significant
3	FEV1/FVC(%)	92.84±11.08	91.33±12.98	0.038*	Significant
4	PEFR(L/S)	6.17±1.95	5.38±1.91	0.000***	Significant
5	FEF_{25-75}(L/S)	4.26±1.53	3.28±1.4	0.001**	Significant

Table 2 shows various parameters of the pulmonary function test of the study participants before and after 2 hours exposure to formalin. This shows that there is decrease in values of FVC, FEV1, FEV1/FVC, PEFR and FEF_{25-75} after 2 hours exposure to formalin and also statistically significant (Fig.1).

Table 3: Pulmonary Function Test Comparison in The male Participants (n=40) before and after 2 hours exposure to formalin (p value < 0.05*, p value <0.001**, p value < 0.0001***)

S.No	Parameters	Before Exposure Mean±S.D	After Exposure Mean±S.D	P value	Significance
1	FVC (L)	3.42±0.53	3.24±0.63	0.015*	Significant
2	FEV1(L)	3.11±0.59	2.85±0.65	0.002*	Significant
3	FEV1/FVC(%)	91.02±13.20	88.10±15.93	0.015*	Significant
4	PEFR(L/S)	6.84±2.11	5.83±2.27	0.000***	Significant
5	FEF_{25-75}(L/S)	4.52±1.64	3.93±1.58	0.001**	Significant

Table 3 shows the values of pulmonary function test of the male participants before and after 2 hours exposure to formalin. This shows that

there is decrease in values of FVC, FEV1, FEV1/FVC, PEFR and FEF_{25-75} in the male participants after 2 hours exposure to formalin. The decrease in values of these parameters after 2 hours exposure to formalin are statistically significant (Fig.2).

Table 4: Pulmonary Function Test Comparison in The female Participants (n=40) before and after 2 hours exposure to formalin(p value < 0.05*, p value <0.001**, p value < 0.0001***).

S.No	Parameters	Before Exposure Mean±S.D	After Exposure Mean±S.D	P value	Significance
1	FVC (L)	2.69±0.55	2.65±0.56	0.44	Not Significant
2	FEV1(L)	2.53±0.51	2.49±0.50	0.301	Not Significant
3	FEV1/FVC(%)	94.66±8.24	94.55±8.15	0.896	Not Significant
4	PEFR(L/S)	5.51±1.54	4.93±1.36	0.003*	Significant
5	FEF_{25-75}(L/S)	3.99±1.39	3.70±1.22	0.145	Not Significant

Table 4 shows the values of pulmonary function test of the female participants before and after 2 hours exposure to formalin. The only parameter which is statistically significant is PEFR in the female participants after expsure to formalin but the values of FVC, FEV1, FEV1/FVC and FEF_{25-75} are not statistically significant(Fig.3).

Table 5: Difference in Pulmonary function test between male (n=40) and female participants (n=40) before exposure to formalin (p value < 0.05*, p value <0.001**, p value < 0.0001***)

S.No	Parameters	Before Exposure Mean±S.D Males	Before Exposure Mean±S.D Feales	P value	Significance
1	FVC (L)	3.42±0.53	2.69±0.55	0.894	Not Significant
2	FEV1(L)	3.11±0.59	2.53±0.51	0.000***	Significant
3	FEV1/FVC(%)	91.02±13.20	94.66±8.24	0.020*	Significant
4	PEFR(L/S)	6.84±2.11	5.51±1.54	0.081	Not Significant
5	FEF_{25-75}(L/S)	4.52±1.64	3.99±1.39	0.141	Not Significant

The above Table 5 shows the comparison of pre exposure values (to formalin vapours) of pulmonary function test between male and female participants. The values of FEV1 and FEV1/FVC are statistically significant but the values of FVC, PEFR and FEF_{25-75} are not statistically significant in male and female participants before exposure to formalin.

Table 6: Difference in effect of formalin on Pulmonary function tests between male (n=40) and female participants(n=40) after 2 hours exposure to formalin (p value < 0.05*, p value <0.001**, p value < 0.0001***)

S.No	Parameters	After Exposure Mean±S.D Males	After Exposure Mean±S.D Females	P value	Significance
1	FVC (L)	3.24±0.63	2.65±0.56	0.596	Not Significant
2	FEV1(L)	2.85±0.65	2.49±0.50	0.245	Not Significant
3	FEV1/FVC(%)	88.10±15.93	94.55±8.15	0.001**	Significant
4	PEFR(L/S)	5.83±2.27	4.93±1.36	0.005*	Significant
5	FEF_{25-75}(L/S)	3.93±1.58	3.70±1.22	0.035*	Significant

Table 6 shows the comparison of pulmonary function test between male and female participants after 2 hours exposure to formalin. The values of FEV1/FVC, PEFR and FEF_{25-75} are statistically significant but the values of FVC and FEV1 are not statistically significant in male and female participants after 2 hours exposure to formalin.

Table 7 shows the results of lung parameters in relation to BMI before and after 2 hours exposure to formalin. The PEFR is statistically significant with BMI <18.5. The FEV1/FVC is statistically significant with BMI 18.6-21.5. The FVC, FEV1, PEFR, FEF_{25-75}(L/S) values are statistically significant with BMI 21.6-25. The PEFR(L/S) is statistically significant with BMI >25. This also clearly shows that lung volume decreases with increase in BMI and effect of formalin is more or less greater in the study participants with a BMI of 21.6-25 and BMI > 25.

Table 7: Pulmonary function test before and after 2 hours exposure to formalin in relation to Body Mass Index(BMI). (p value < 0.05*, p value <0.001**, p value < 0.0001***)

Lung	BMI< 18.5			BMI- 18.6-21.5			BMI- 21.6-25			BMI >25		
Parameters	Pre	Post	Diff	Pre	Post	Diff	Pre	Post	Diff	Pre	Post	Diff
FVC (L)	3.11±0.50	2.96±0.65	0.15	3.03±0.81	2.96±0.71	0.07	3.03±0.60	2.80±0.68*	0.23	3.09±0.71	3.12±0.63	-0.03
FEV1(L)	2.95±0.54	2.73±0.51	0.22	2.81±0.75	2.74±0.67	0.07	2.84±0.57	2.57±0.57*	0.27	2.75±0.67	2.74±0.65	0.01
FEV1 /FVC(%)	95.08±9.08	93.47±10.78	1.61	92.97±8.86	91.6±9.67*	1.37	94.01±8.80	92.23±11.83	1.78	90.27±15.16	89.06±16.84	1.21
PEFR (L/S)	5.98±2.28	4.82±1.68*	1.1	6.36±1.98	5.83±2.11	0.53	6.26±1.81	5.37±1.85*	0.89	6.03±2.09	5.37±2.01*	0.76
FEF_{25-75}(L/S)	4.5±1.71	3.56±1.23	0.94	4.20±1.56	3.97±1.42	0.23	4.35±1.40	3.86±1.45*	0.49	4.07±1.66	3.75±1.47	0.32

Table 8: C reactive Protein(CRP) levels of the study participants on exposure to formalin (n=80).

S.No	Serum CRP Value range(mg/l)	Number of study participants within this range
1	< 6.0	7
2	6.1-10.0	5
3	10.1-20.0	28
4	20.1-30.0	29
5	30.1-40.0	7
6	40.1-80.0	4

Table 8 shows the C reactive protein levels of all the study participants on exposure to formalin The Mean serum CRP level found to be 20.83± 11.55 mg/l. Seven students are within normal range of CRP levels ie >6mg/l (8.75%), five students have slightly increased levels of CRP within the range of 6.1-10.0 (6.25 %), About 64 students have CRP range of 10.1-40.0mg/l (80%). About 4 students have more increased levels of CRP within the range of 40.1-80.0 mg/l (5%)

Table 9: C reactive Protein(CRP) levels of the male participants on exposure to formalin (n=40).

S.No	Serum CRP Value range (mg/l)	Number of male participants within this range
1	< 6.0	4
2	6.1-10.0	0
3	10.1-20.0	17
4	20.1-30.0	14
5	30.1-40.0	13
6	40.1-80.0	2

Table 9 shows the C reactive protein levels of the male participants on exposure to formalin. The Mean Serum CRP level found to be 21.55± 12.49 mg/l. Four students are within normal range of CRP levels (10%) , About 34 students have CRP range of 10.1-40.0mg/l (85%). About 2 students have more increased levels of CRP within the range of 40.1-80.0 mg/l (5%).

Table 10: C reactive Protein(CRP) levels of the female participants on exposure to formalin (n=40).

S.No	Serum CRP Value range (mg/l)	Number of female participants within this range
1	< 6.0	3
2	6.1-10.0	5
3	10.1-20.0	11
4	20.1-30.0	15
5	30.1-40.0	4
6	40.1-80.0	2

Table 10 shows the C reactive protein levels of the female participants (n=40) on exposure to formalin. The Mean Serum CRP level found to be 20.10± 10.63 mg/l.. Three students are within normal range of CRP levels (7.5%) , five students have slightly increased levels of CRP within the range of 6.1-10.0 (12.5 %), About 19 students have CRP range of 10.1-40.0mg/l (80%). About 2 students have more increased levels of CRP within the range of 40.1-80.0 mg/l (5%).

Fig. 1: PFT pre and Post Exposure to Formalin.

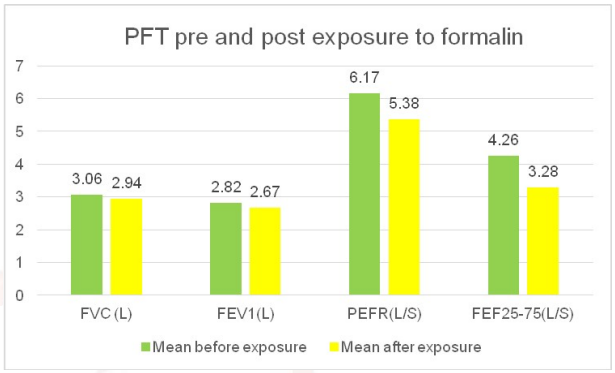


Fig. 2: PFT pre and post exposure to Formalin among males.

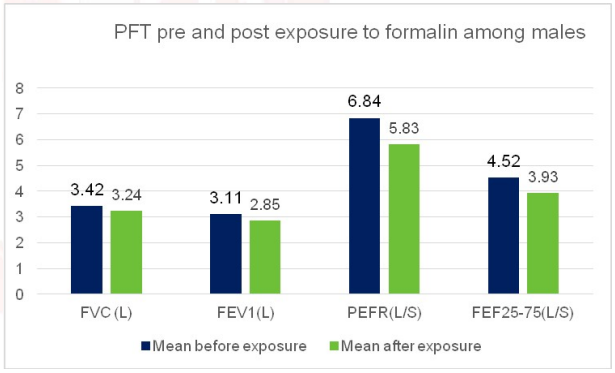
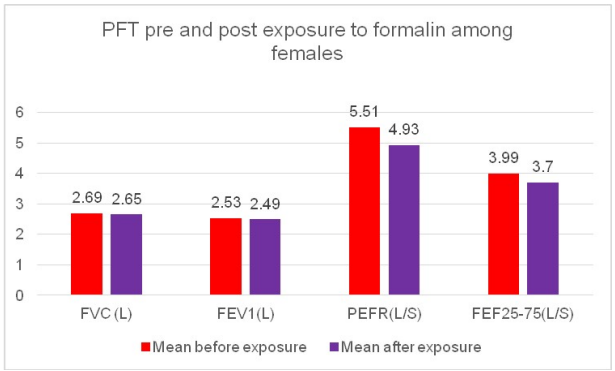


Fig .3: PFT pre and post exposure to Formalin among females



DISCUSSION

Formaldehyde is a readily polymerised, flammable, colourless gas at ambient temperature, and is one of the important pollutants in indoor air. Exposure of medical students to formalin during dissection hour is recently considered to be one of the causes of multiple chemical

sensitivity.The binding of formaldehyde to endogenous proteins creates heptens that can bring out an immune response in the body. Long term exposure to formaldehyde has been associated with immunological hypersensitivity as indicated by elevated circulating IgG and IgE autoantibodies to human serum albumin. Also there was a decrease in the proportion of T-cells indicating altered immunity. The most common symptoms include irritation of the eyes, nose, and throat, along with increased tearing[10]. Wei et al[11] revealed that subjective symptoms were related to the period spent in the anatomy dissection hall. 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 symptom[10].

The increased formaldehyde fumes in the dissection rooms and embalming rooms are due to:

1) poor working practices leading to spillages of fluid during embalming,

2) poor condition of cadavers causing embalming fluid to leak out of the cadaver,

3) using high concentrations of formaldehyde in the embalming fluid, and

4) poor ventilation of dissection rooms[12]

In a study by Shrivastava A and Saxena Y[13], the mean age was 18.32 years, the mean height was 166.8 cm, mean weight was 65.63 kg and mean BMI was 23.45 kg/m2.In the present study, the mean age, height, weight and BMI of the study participants (n=80) are 18.40 years, 166.65 cm, 64.16 kg and 23.15kg/m^2 respectively and the age, weight and height of the participants in our study is similar to that reported by Shrivastava A and Saxena Y[13] but our findings of lung parameters are slightly greater than those reported by Shrivastava A and Saxena [13]. Relatively higher values of lung parameters were reported by Khaliq F and Tripathi P [14] where the average height was 177.63 cm and weight was 68.38 kg. Neginhal et al[15] have reported a men height of 158.08 cm and mean weight of 56.5 kg which is lower than the present study. The variation in the lung paramaters could be due to the relatively lower average height of our study participants as compared to them. Therefore, this shows that the lung parameters recorded are appropriate for the anthropometric parameters.

In the study done by Shrivastava A and Saxena[13] et al on 100 medical students acute exposure to formalin for 2 hrs/day for 6 days/ week resulted in decrease in FVC, FEV1%, FEF25-75, PEFR which were statistically significant and also observed decease in FEV1 on acute exposure to formalin but it was not statistically significant. Akbar- Khanzadeh et al[16] also studied acute pulmonary response in group of 34 workers exposed to formalin in gross anatomy dissection hall, also reported decrease in FVC but FEV1/FVC ratio increased during exposure . Farah Khaliq et al[14] reported decrease in FVC immediately after 2 hours exposure to formalin. and decrease in values of FEV1 immediately after exposure was not statistically significant. .Chia et al[17] observed that no significant difference in the pre and post exposure in mean values of FVC and FEV1 . Alexanders and Hedenstierna[18], evaluated lung function tests and immunoglogulin levels in 34 wood workers who were exposed to formaldehyde and there is a significant decrease in FVC, FEV1, FEF25-75 and the effect of formaldehyde exposure in plywood workers resulted in significantly reduced FEV1, FEV1/ FVC ratio, FEF25-75 but not FVC.

Banoo et al [6] reflected that the pulmonary function test values after 1 month of formalin exposure showed statistically significant decrease as compared to the basal levels recorded before the exposure. Binawara et al[19] observed that all the five lung parameters were reduced except FEV1/FVC ratio and FEF25–75% that was normal and indicated obstructive lung impairment. In the study done by Hemalatha[20], decrease in values of FVC, FEV1 and PEFR and increase in lung age were statistically significant after exposure. However, the FEV /FVC % ratio did not show any significant change . In the present study,. the decrease in values of all the lung parameters like FVC, FEV1, FEV1/FVC, PEFR and FEF_{25-7}after 2 hours exposure to formalin are statistically significant . These findings are same as that reported by Banoo et al. Among the male students, Narendra Gupta et al[21] observed the mean FVC at

baseline was 3.30 ± 0.42 which decreased after 1st month to3.05 ± 0.30, the FEV1 at baseline was 91.75 ± 9.36% which decreased after 1st month to85.83 ± 7.46%, the FEV1/FVC ratio at baseline was 110.33 ± 5.30% which successively decreased to 109.53 ± 8.98%. The values of FVC and FEV1 were statistically significant but FEV1/FVC was not significant. Shital et al [22] observed the mean FVC (L) at baseline was 3.31±0.43 which is increased to 3.33±0.65 after 2 hours exposure to formalin which was not statistically significant but all other parameters like FEV1 (L), FEV1/FVC and PEFR (L/S) showed decreased values after 2 hours exposure to fiormalin among the male participants and also statistically significant. In the study done by Hema et al[20], there were significant decrease in FVC, FEV1 and PEFR after 2 hours exposure to formalin among the male students. In the present study,. the decrease in values of all the lung parameters after 2 hours exposure to formalin are also statistically significant among the male students.

Among the female students, Narendra Gupta et al[21] observed the mean FVC at baseline was 2.60 ± 0.17 which decreased after 1st month to 2.49± 0.21, FEV1 at baseline was 103.75 ± 14.02% which decreased after 1st month to 98.65 ± 17.33% , he FEV1/FVC ratio at baseline was 110.92 ± 7.97% which decreased after 1st month to 106.98 ± 12.70% among the female students. The values of FVC and FEV1 were statistically significant but FEV1/FVC was not significant. Shital et al[22] observed the all the lung parametere were statistically significant among the female participants after 2 hours exposure to formalin. In the study done by Hema et al[20], there were significant decrease in FVC, FEV1 and PEFR after 2 hours exposure to formalin among the female students. In the present study, the value of PEFR is statistically significant but the values of FVC, FEV1, FEV1/FVC and FEF_{25-75} are not statistically significant in the female participants.

Comparing the pre exposure values of lung parameters between male and female participants there is significant difference in the values of FEV1 and FEV1/FVC but all other lung parameters like FVC, PEFR and FEF_{25-}75 are not statistically different.

In the study done by Narendra Gupta et al[21] the post exposure values of PFT between male and female participants FVC is statistically significant but FEV1 and FEV1/FVC did not show any significant change. In the present study, Comparing the post exposure values of lung parameters between male and female participants, there is significant difference in the values of FEV1/FVC, PEFR and FEF_{25-75} but other parameters like FVC and FEV1 are not statistically significant.

In the study by Mitsumune et al[23]. pulmonary aging related to obesity was also observed 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 greater than 25 kg/m2, according to the classification of obesity by the Japanese Respiratory Society, which differs from that of the World Health Organization..Richard L[24] et al 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 change in FRC and ERV occurred in the overweight condition and in mild obesity. At a BMI of 30 kg/m2FRC and ERV were only 75% and 47%, respectively, of the values for a lean person with a BMI of 20 kg/m2.

Hemalatha et al [20] showed 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 and also showed that the decrease in values of lung parameters like FVC, FEV1 and PEFR and increase in lung age were statistically significant after exposure. However, the FEV / FVC % ratio did not show any significant change Several previous studies2have reported that increased body weight decreases lung volumes. Others 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. In the present study , the PEFR is statistically

significant with BMI <18.5. The FEV1/FVC is statistically significant with BMI 18.6-21.5. The FVC, FEV1, PEFR, FEF_{25-75}(L/S) values are statistically significant with BMI 21.6-25. The PEFR(L/S) is statistically significant with BMI >25. This also clearly shows that lung volume decreases with increase in BMI and effect of formalin is more or less greater in the study participants with a BMI of 21.6-25 and BMI > 25.

Wie et al [9] aimed to evaluate whether circulating immune/inflammation markers were altered in workers occupationally exposed to formaldehyde. They measured serum levels of 38 immune/inflammation markers in a cross-sectional study of 43 formaldehyde-exposed and 51 unexposed factory workers in China. CRP levels found to be increased in exposed workers than unexposed workers. Kodama et al[25] studied the changes of serum C-reactive protein (CRP) levels in rainbow trout (Oncorhynchus mykiss after exposure to formalin, which are used in aquaculture as anti-ectoparasitic chemicals. The CRP level in normal trout sera is 88+/-5 microg ml(-1) according to sandwich enzyme-linked immunosorbent assay. CRP levels increased to a maximum at six or nine days after exposure to formalin for 3.5 h at 300 ppm or 9.5 h at 30 ppm, respectively; these levels are 4.3 and 18 times higher than normal.

In the present study, the overall mean serum CRP level found to be 20.83± 11.55 mg/l. The mean Serum CRP level of the male students found to be 21.55± 12.49 mg/l and the mean Serum CRP level of the female students found to be 20.10± 10.63 mg/l which shows that effect of formalin on CRP is more in males than females..This clearly shows that exposure to formalin has some role to increase the levels of CRP in blood plasma. Hence necessary measures should be taken to replace some other chemical instead of formalin.

CONCLUSION

Since the numerous health challenges that formaldehyde causes on the medical students in anatomy dissection laboratory, it cannot be considered as an ideal chemical for embalming of cadaver. Also teachers and laboratory technicians who are exposed to formaldehyde fumes on regular basis during the daily dissection schedules, they should be informed of potential health hazards of formalin. Attempts should be taken to reduce the concentration of formaldehyde by using other chemicals like glutaraldehyde, which can serve a good substitute for formaldehyde . Glutaraldehyde is an aldehyde related to formaldehyde, with similar fixation qualities. And would be a feasible alternative, but because of the volumes that would be required, it is little bit expensive. Frolich *et al*[26] in 1984 tried using phenoxyethanol as its non-toxic substitute and it sounded to be impractical as the amount required was large because about 600 litres for each cadaver needing continuous emersion to prevent mould formation and the fixation process taking 5 to 10 months. Whitehead MC[27] et al found that InfuTrace and Perfect Solution, substituted for standard formaldehyde embalming, and InfuTrace solution infused through the vasculature after formaldehyde embalming, resulted in lower concentrations . Moreover the use of cadavers should be complemented with the use of computer assisted Virtual dissection learning methods to avoid continuous exposure to formalin and to promote student comprehension in the practical hours.

Formaldehyde remains the popular choice as a tissue fixative because of its undoubted efficiency, and consistency of results that are obtained for somany years despite its toxix effects.. Thus by decreasing the concentration of formalin in standardised cadaver embalming fluid and improving the ventilation of our dissection laboratories we can eliminate about 90% of the ill effects of formalin, As quoted by BS Mitchell[28] “Reduction in formaldehyde concentration is not deleterious to specimen preservation, but leads to a safer working environment”. In conclusion, there is great impact of formalin on CRP and Pulmonary function tests in first year undergraduate medical students who are constantly exposed to formalin in Anatomy dissection laboratory. To avoid this, either protective measures or alternative measures should be taken.

Conflicts of Interests: **None**

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