ACUTE EFFECT OF FORMALIN ON PULMONARY FUNCTION TESTS IN MEDICAL STUDENTS

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Background and Methods: The incessant complaints from medical students during and after gross anatomy dissections led to this study. The present study was carried out on 80 healthy (male) first year medical student's between the age of 18–23 years. The pulmonary function tests included were FVC, FEV_1, FEV_1/FVC, $FEF_{25–75\%}$ and PEFR carried out by computerised spirometer. All these parameters helped in evaluating pulmonary functions among medical students exposed to formaldehyde for two hours during their Anatomy dissection. **Result:** The study revealed statistically highly significant (p<0.0001) decrease in values of FVC, FEV_1 and PEFR after exposure but reverted back to normal within 24 hrs. But FEV_1/FVC ratio and $FEF_{25–75\%}$ did not show any significant change. **Conclusion:** Medical students' exposure to formalin during anatomy dissection is indeed hazardous to their health. Medical colleges should take more concrete measures to reduce students' exposure to formalin.

Keyword: Pulmonary function test, Formaldehyde, Anatomy dissection

INTRODUCTION

Formaldehyde is the simplest aldehyde, that can be obtained from its cyclic trimer trioxane and the polymer paraformaldehyde. Aqueous solutions of formaldehyde are referred to as formalin. In 1867, the German chemist August Wilhelm von Hofmann discovered formaldehyde.[1] Occupational exposure to formaldehyde by inhalation is mainly from three types of sources: thermal or chemical decomposition of formaldehyde-based resins, formaldehyde emission from aqueous solutions (for example, embalming fluids), and the production of formaldehyde resulting from the combustion of a variety of organic compounds (for example, exhaust gases).[2]

Formaldehyde solutions are used as a fixative for microscopy and histology. Formaldehyde-based solutions are also used in embalming to disinfect and temporarily preserve human and animal remains. This is prepared by mixing the commercially available formalin solution with tap water in the proportion of 3:1.[3] Formaldehyde enters in body by breath or when it comes in contact with your skin. Formaldehyde is quickly absorbed from the nose and the upper part of lungs. Once absorbed, formaldehyde is very quickly broken down. Almost every tissue in the body has the ability to break down formaldehyde. It is usually 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. But formaldehyde can be toxic, allergenic, and carcinogenic.[4]

Formaldehyde may on rare occasions induce bronchial asthma at relatively high exposure doses. The approach to formaldehyde-induced symptoms should be one of careful documentation of objective physiologic changes.[5] The annual world production of formaldehyde (around 2005) was 21 million tons (46 billion pounds). In view of its widespread use, toxicity, and volatility, exposure to formaldehyde is a significant consideration for human health.[2] Several European countries restrict the use of formaldehyde, including the import of formaldehyde-treated products and embalming. From September 2007, the European Union banned the use of formaldehyde due to its carcinogenic properties as a biocide (including embalming) under the Biocidal Products Directive (98/8/EC).[6–7]

We have evaluated pulmonary functions among medical students exposed to formaldehyde for two hours during their Anatomy dissection, and have investigated the relation between exposure to formaldehyde and acute changes in respiratory function.

MATERIAL AND METHODS

The present study was carried out on 80 healthy first year medical students (male) between 18–23 years age after informed consent. Prior to starting this project we had obtained approval from ethical and research board of Sardar Patel Medical College Bikaner. The relationship between exposure to formalin (10%) and change in pulmonary function tests was compared prior to exposure and after two hours of dissection class in Department of Anatomy. Exclusion criteria were related symptoms, stress, type-I allergy, respiratory diseases, and smoking habits.

Computerised Spirometer (RMS-Helio 401, Transducer No. 400-666) was used to measure respiratory function tests. This is solid state electronic equipment. The subject had to respire into a sophisticated transducer, which is connected to the instrument by means of a cable. 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, Forced Expiratory Flow between 25% and 75% of vital capacity ($FEF_{25–75\%}$), and Peak Expiratory Flow Rate (PEFR) with graphic curves were obtained. For Statistical analysis Student's *t*-test was applied to determine the significance of values.

RESULT

The mean age of the all the male subjects in the present study was 20±1.02 years. The mean height of the subjects was 169.59±9.85 Cm and weight was 56.95±8.99 Kg. Almost all subjects complained about mild irritation in the nose and eyes. As shown in table, the decrease in values of FVC, FEV_1 and PEFR were statistically highly significant (p<0.0001) after exposure. The FEV_1/FVC ratio and $FEF_{25–75\%}$ did not show any significant change. Table-1 shows values of Pulmonary Function Tests in our subjects.

Table-1: The percentage predicted values of pulmonary function tests (%Predicted)

	Pre-exposure (Mean±SD)	After exposure (Mean±SD)
FVC	91.62±8.63	75.45±14.2*
FEV_1	103.79±9.79	84.01±17.41*
FEV_1/FVC	113.26±5.83	111.83±12.46
$FEF_{25–75\%}$	109.77±26.11	107.283±29.7
PEFR	86.73±12.88	74.32±12.72*

*p<0.0001

DISCUSSION

Formaldehyde is a flammable, colourless and readily polymerised gas at ambient temperature, and is one of the major pollutants in indoor air. 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 binding of formaldehyde to endogenous proteins creates heptens that can elicit an immune 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-cells was observed, indicating altered immunity.[8] The most common symptoms include irritation of the eyes, nose, and throat, along with increased tearing.

In the present study, when all the above five parameters were taken together they all were reduced except FEV_1/FVC ratio and $FEF_{25–75\%}$ that was normal and indicated obstructive lung impairment. These can be attributed to the adverse effect of formalin on respiratory system. Various studies done earlier revealed that FVC decreased in subjects immediately after their first exposure. While all other lung function parameters remained unchanged, indicating some mild transient bronchoconstriction on acute exposure to formalin.[9] Akbar-Khanzadeh, *et al* reported that formaldehyde exposure, acute pulmonary response, and exposure control options were evaluated in a group of 34 workers in a gross anatomy laboratory and noted that Forced vital capacity (FVC) decreased, but FEV_1/FVC ratio increased during the exposure.[10] Similarly, histology technicians (280 subjects) were shown to have reduced pulmonary function, as measured by FVC, FEV_1 and $FEF_{25–75\%}$ compared with 486 controls.[11]

Alexandersson and Hedenstierna, evaluated symptoms of irritation, spirometry, and immunoglobulin levels in 34 wood workers exposed to formaldehyde over a 4-year period. Exposure to 0.4–0.5 ppm formaldehyde resulted in significant decreases in FVC, FEV_1, and $FEF_{25–75\%}$.[12] Meanwhile, the effects of formaldehyde exposure in plywood workers resulted in significantly reduced FEV_1, FEV_1/FVC ratio, and $FEF_{25–75\%}$ compared with controls but Forced vital capacity was not significantly reduced.[13]

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 FEV_1 and FVC.[14]

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 symptoms.[15]

The present study was conducted to evaluate the acute symptoms caused by formaldehyde fumes that were experienced by the medical students in the dissection rooms. The probable measures which can be taken will be the lesser concentration of formaldehyde as it will reduce the toxic effects and the other chemicals like surgical spirit, glycerine and carbolic acid will help in maintaining a good preservation of the cadavers. As is quoted by BS Mitchell "reduction in formaldehyde concentration is not deleterious to specimen preservation, but leads to a safer working environment.[16]

As for the other alternative chemicals in place of formaldehyde, Frolich *et al* in 1984 tried using phenoxyethanol as its non-toxic substitute. It proved to be impractical as the amount required was large, i.e., about 600 litres for each cadaver needing continuous emersion to prevent mould formation and the fixation process taking 5 to 10 months.[17] Similarly, Glutaraldehyde is an aldehyde related to formaldehyde, with similar fixation qualities. It would be a feasible alternative, but because of the volumes that would be required, it is prohibitively expensive. Also Reinhard Pabst in his follow up study has advocated the use of glutaraldehyde as a good substitute for formaldehyde.[18]

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