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ESTIMATION OF "LUNG-AGE" OF FIRST YEAR MEDICAL STUDENTS TO DETERMINE THE EFFECT OF EXPOSURE TO FORMALDEHYDE DURING GROSS ANATOMY DISSECTION ON THEIR PULMONARY FUNCTIONS.

MEDICAL PHYSIOLOGY

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ABSTRACT

Exposure to formaldehyde is one of the occupational hazards experienced by medical students during their education, which has detrimental effects on the pulmonary functions. The concept of lung age was introduced to give a simplified and consolidated impression of the different spirometric parameters of an individual. An increased lung age implies a functionally older lung, underlining a premature decline in pulmonary efficiency when an exposure to a toxic substance is present. The present study was done to estimate the lung age of first year medical students over six months of exposure to formaldehyde. Computerized spirometer was used to record the lung age. Descriptive statistics and repeated measures ANOVA were applied for analysis. A p-value < 0.05 was considered statistically significant. An increased mean lung age was observed after first month, which was nearly restored to baseline values by the sixth month. Increased lung age reaffirms the adverse effects of formaldehyde on the respiratory system. However, the body adapts to it over a period of time. We need to promote steps to reduce exposure by various means like use of masks, specially-engineered ventilation systems, and prevention of unnecessary spillage of formalin in dissection hall or find an alternative embalming fluid.

KEYWORDS

Lung age, Medical students, Formaldehyde

INTRODUCTION

Health and well-being has always been the epicentre of human civilization. Therefore, doctors play a significant role in the society. However, medical education and training brings within its domains various types of occupational hazards. Formaldehyde is one of these substances. Chemically, it is an aldehyde and at room temperature, it exists as a gas which has noxious and irritating properties. The existing medical literature shows that formaldehyde can be toxic, allergenic and carcinogenic [1,2].

Formalin is 37% aqueous solution of formaldehyde [3] which is used in embalming of cadavers. Study of human cadaver is one of the cornerstones of medical science. A medical student learns about anatomy by scrupulous dissection of these formalin-embalmed cadavers. Formalin on vapourization yields formaldehyde. Therefore, medical students during the first year of medical course are regularly exposed to formaldehyde in the gross anatomy dissection classes. And often, the exposure-rates are high [4,5]. The respiratory system is therefore a critical target of formaldehyde toxicity[6,7,8,9]. Studies conducted on occupational exposure of formaldehyde suggest that small but significant changes occur in lung functions of exposed subjects following prolonged exposure [10]. In fact, concentration more than 0.5 ppm in the ambient atmosphere results in altered pulmonary functions [11].

Lung age was a new concept introduced in 1985 by Morris and Temple to give a single, composite and consolidated impression of the measurements of different spirometric lung volumes and capacities. The basic premise of lung age is a comparison of the expected effect of ageing on the pulmonary function vis-à-vis the presumed additional damage from any noxious substance [12]. From the measured FEV_1 of an individual, the age of the lung that would produce this value of FEV_1 is estimated using linear regression equations and reference values of the population. This is then compared with the actual chronological age of the subject. It is well known that lung function varies with age. It has been documented that Forced Vital Capacity and FEV_1 typically increase upto 18 to 20 years of age and then maintain a plateau till about 40 years of age followed by a steady decline thereafter due to progressive loss of elastic recoil [13]. This conforms to the general pattern of growth followed by senescence in physiology. It can be logically reasoned that factors such as smoking and various occupationally-exposed harmful substances like formaldehyde would further add to the effect of normal ageing on lung function. Therefore an abnormal lung age would imply an accelerated decline of lung functions than what would normally happen due to aging [12]. Studies assessing changes in this novel parameter in occupationally-exposed population groups is however very scarce. The present study was therefore carried out to observe and understand whether formaldehyde causes any premature decline in lung function among first year medical students by measuring their lung age at different intervals of time.

MATERIALS AND METHODS

A longitudinal, descriptive study was conducted in the Department of Physiology, Rohilkhand Medical College and Hospital, Bareilly among first year MBBS students in the academic year 2015-16. Approval was obtained from the Institutional Ethics Committee (vide document IEC/IRB No. IEC/27/2015). Students having no history of previous exposure to formalin were considered as subjects. The exclusion criteria comprised of presence of any pre-existing chronic respiratory diseases like bronchial asthma, any acute or chronic inflammatory state, altered baseline pulmonary function test, deformities of the thoracic cage or spine, extremes of height & weight and those who were not willing to participate in the study. Eighty (80) medical students (40 male and 40 female students) out of the total 150 students, who suitably fulfilled these criteria, were selected using simple random sampling technique. Informed consent was taken from every participant after explaining the nature of the study. Lung age was recorded using computerized spirometer RMS Helios 401 (ISO 9001:2008) available in the research lab of the department of Physiology. The FVC maneuver of the software was used and lung age was recorded in sitting posture [14]. Best of three such values was recorded as per the guidelines of the American Thoracic Society [14]. The baseline values were recorded at the beginning of the academic calendar and follow-up values at the end of 1st and 6th month. It is now recommended to use percent-predicted values of the lung functions instead of absolute values, which expresses the recorded lung functions as a percentage of the predicted normal values for a subject's age, height, weight and ethnicity [13,15,16]. Therefore in the present study, percent-predicted values were used for analysis to eliminate the confounding effect of various anthropometric and other factors. Descriptive statistics and tests like repeated measures ANOVA was used for analysis of the data. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean chronological age of the participants was 18.59 ± 0.96 years. The lung age at baseline and follow-up occasions are shown in Table No. 1. An increase in lung age was observed after the 1st month of exposure, which reverted back towards the pre-exposure values by 6th month.

Table 1: Percent-predicted Lung age values of students over the study period

Parameters	Baseline	After 1st month	After 6th month
Male	102.03 ± 15.02	113.63 ± 9.86	109.35 ± 8.33
Female	102.50 ± 14.36	97.43 ± 20.05	96.15 ± 17.01
Total	102.26 ± 14.60	105.53 ± 17.69	102.75 ± 14.87

When the overall statistical significance of change in lung age at different points of time was analysed by repeated measures ANOVA, it was not found to be statistically significant. But, significant increase in

lung age was observed after the first month of exposure among males (P-value =0.001), which was markedly different from the females. The values are depicted in Table No. 2.

Table 2: Significance of change in lung age on exposure over different spans of time

Exposure Duration	P-value (Level of significance)	
	Overall effect on all students	Differences in effect on male and female students
Effect over entire study period	**0.140**	**0.003**
Effect between Baseline & 1st month	0.174	0.001
Effect between 1st & 6th month	0.060	0.306

DISCUSSION

The respiratory system undergoes various anatomical, physiological and immunological changes with age. Physiologically, the lungs undergo a phase of growth and maturation during the first two decades of life and achieve maximal lung function around age 20 years in females and 25 years in males. Lung function remains steady with very minimal change from age 20 to 35 years and starts declining thereafter [17]. In clinical and occupational settings, it is vital to differentiate these "normal" aging changes from a decline caused either due to a disease or some form of occupational or environmental exposure. Otherwise, aging itself would have a confounding effect on interpreation of pulmonary functions. The concept of lung age addresses this issue. Estimated lung age is calculated from the FEV_1 of an individual using linear regression equations and reference values of the population. This is then compared with the actual chronological age of the subject to provide the final index of lung age. It was initially devised to encourage smokers to quit smoking by communicating the spirometric pulmonary functions tests in a manner that was easily understood and profound enough to make an impact on their mind [18]. An increased lung age of a person implied that his lungs were aging faster than what is expected at that particular age.

In context of formaldehyde exposure, an increased lung age as observed after the first month in the present study would imply a premature decline in overall efficiency of lung function due to exposure. Toxic substances like formaldehyde have the potential of causing chemical inflammation in tissues of body. Since formaldehyde fumes vapourize from the formalin-embalmed cadavers during dissection, respiratory system is the critical target of its action. Upon contact, this would incite inflammatory cells and release mediators like serotonin, histamine, etc. Consequently, in the airways there would be a variable state of constriction. In the lung parenchyma, effects like acute interstitial inflammation (pneumonitis) have been observed in animal models upon exposure to formaldehyde [19]. A consistent exposure has the propensity of setting up recurrent cycles of inflammation and epithelial injury followed by healing which could herald a process similar to fibrosis [20]. In fact, a type of interstitial lung disease called extrinsic allergic alveolitis has been described in medical literature that occurs on exposure to environmental antigens. Occupationally exposed chemicals and pharmaceuticals are proposed to be important etiological agents of this entity [20]. All these changes point towards a deleterious effect on pulmonary functions. The brunt of these changes would be additional to the changes expected because of normal aging of body, resulting in a lung that is functionally older than the rest of the body. However, the near restoration of the lung age at the end of 6 months in the study, underlines the fact that the lung recovers substantially from the functional derangement with time. The mechanisms behind this adaptation however remain to be unveiled.

CONCLUSION

Formaldehyde has a detrimental effect on the mechanics and functioning of the respiratory system. This leads to an additional attenuation in the efficiency of lung over and above the effect of normal aging on body's physiology. We should therefore institute steps to reduce exposure like use of masks, improvement in the ventilation system across the dissection hall and avoiding unnecessary spillage of formalin within the dissection hall. Other available avenues are use of specially-engineered dissection beds and modifications in the conventional process of embalming by use of accessory chemicals or alternative embalming fluids.

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