Int J Pharm Bio Sci 2015 April; 6(2): (B) 410 - 416

Research Article **Medicine**

International Journal of Pharma and Bio Sciences **ISSN 0975-6299**

THE DIFFUSING LUNG CAPACITY IN FORMALIN EXPOSED AND NON EXPOSED SUBJECTS - A COMPARATIVE STUDY

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ABSTRACT

The thoracic and abdominal muscle strength plays an important role in pulmonary function and diffusing lung capacity. The main function of the lung is gas exchange, which can be assessed in several ways. A Spirometer measures the flow and the volumes of the inspired and expired air .The aim of the study was to assess Diffusing Lung Capacity of formalin exposure and to compare with healthy individuals. To assess the chronic effects of formalin exposure on Diffusing lung capacity in the faculties, lab technicians and attender of the department of anatomy and pathology of SRM Medical Hospital and Research Centre, Kattankulathur. This prospective study was carried out in 50 healthy formalin exposed subjects (atleast 5 years exposure) from department of anatomy and pathology of SRM medical college hospital and research centre, Kattankulathur and 50 healthy controls of same age group of this study were included after obtaining ethical clearance and consent ' Easy One Pro Spirometer was used to find out the Diffusing Lung Capacity .Student t-test was applied to compare the PFT parameters between formalin exposed and formalin non exposed group. There was a significant difference in mean and standard deviation of pulmonary parameters with the p – value < 0.005 in formalin exposed which shows that they have lesser ventilatory drive.

KEY WORDS: Formalin, Spirometer, Diffusing Lung Capacity (DLCO)

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INTRODUCTION

The main function of the lung is gas exchange, which can be assessed in several ways. A Spirometer measures the flow and the volumes of the inspired and expired air. The thoracic and abdominal muscle strength plays an important role in pulmonary function and diffusing lung capacity. 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]. 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.[2]. 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)[3]. Formaldehyde enters in body by breath or when it comes in contact with our skin. Formaldehyde is quickly observed into the nose and the upper part of the lungs. Once observed, 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-di-oxide and breathed out of the body. But formaldehyde can be toxic and allergenic, and carcinogenic[4].Formaldehyde has been reported to cause an assortment of acute and chronic health effects. It has been suggested that formaldehyde may produce physiological alterations of respiratory system. Due its high water solubility, more than 95% of inhaled formaldehyde is absorbed in the upper respiratory tract and a very little formaldehyde, if any, will reach the alveolar membranes of the lung. The toxic effects of formaldehyde on the upper respiratory tract are described as an irritant and sensitizer[5]. Occupational data suggests that small but significant changes may occur in lung functions following prolonged exposure in the work place[6-8]. Upper airway irritation is the most common respiratory effect reported by the workers and occurs over a wide range of concentrations most frequently above 1ppm. However airway irritation has occurred in some workers with exposures to formaldehyde as low as 0.1ppm.The annual production of formaldehyde (around 2005) was 21 million tons (46 billion pounds). In view of its wide spread use, toxicity and volatility, exposure to formaldehyde is a significant consideration for human health hazards[3]. Several European countries restrict the use of formaldehyde, including the import of formaldehyde-treated products and embalming. Various studies have revealed the effect of formalin by artificial exposures of volunteers under controlled environmental condition[9-13]. Symptoms of upper airway irritation include dry or sore throat, itching and burning sensations of the nose and nasal congestion. Tolerance to this level of exposure may develop within 1-2 hours. This tolerance can permit workers remaining in an environment of gradually increasing formaldehyde concentrations to be unaware of their increasingly hazardous exposure.Formaldehyde has also been reported to produce allergic contact dermatitis[14] neurobehavioral changes[15] and carcinogenesis[16]. Formaldehyde may on rare occasions induce bronchial asthma at relatively high exposure doses. The approach to formaldehyde-induced symptoms should be one of careful documentations of objective physiologic changes[17]. 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)[18,19]. A few studies have characterised formaldehyde emission rates in gross anatomy laboratory.[20]

The General Aspect of the Gas Exchange [21,22,23,24]

The main function of the lung is to establish gas exchange between the body tissues and the surrounding air. O_2 is taken up and CO_2 is eliminated. This process of gas exchange can be subdivided into three stages.

1. Ventilation, which is the mechanism by which the alveolar gas is intermittently refreshed with ambient air. As a result, the O_2 is Concentration in the alveolar gas is kept high and the CO_2 concentration is kept low.
2. Alveolar – capillary diffusion, which is the passage of gases across the blood – gas barrier by passive diffusion.
3. Perfusion, which involves the distribution of blood in the lungs and its removal from the lungs by the blood circulation process

FICK'S LAW

A diffusion process in one medium by which molecules are transferred from a place with a high concentration to a place with a low concentration.

HENRY'S LAW

In the lungs, diffusion occurs between a gas and a liquid phase. The concentration in a liquid is a function of the solubility of the gas exchange in the liquid and the pressure of the gas. Since the quantity of the dissolved gas is proportional to the pressure.

Diffusion Capacity (DLCO)

Diffusing Capacity (DLCO) is the carbon monoxide uptake from a single inspiration in a standard time (usually 10 sec). Since air consists of very minute or traces quantities of CO, 10 seconds is considered to be the standard time for inhalation, and then rapidly blow it out (exhale). The exhaled gas is tested to determine how much of the tracer gas was absorbed during the breath. This will pick up diffusion impairments, for instance in pulmonary fibrosis. This must be corrected for anaemia (because rapid CO diffusion is dependent on hemoglobin in RBC's; a low hemoglobin concentration, anaemia, will reduce DLCO) and pulmonary haemorrhage (excess RBC's in the interstitium or alveoli can absorb CO and artificially increase the DLCO capacity). Atmospheric pressure and/or altitude will also affect measured DLCO, and so a correction factor is needed to adjust for standard pressure. Online calculators are available to correct for hemoglobin levels and altitude and/or pressure where the measurement was taken.The carbon monoxide diffusing capacity (DLCO) is the rate of the uptake of carbon monoxide (CO) per driving pressure of the alveolar CO. The simplified equation is:

DLCO = VCO / PACO
VCO = Uptake of CO (ml/min)
PACO = the mean alveolar pressure of CO (ml of Hg)

This test can be used for a wide variety of diseases, because it is relatively easy to measure or estimate the two determinants. The component resistances to DLCO include: Pulmonary membrane and Red cell resistance.

MATERIALS AND METHODS

This comparative study was carried out in 50 healthy formalin exposed subjects from department of anatomy and pathology of SRM medical college hospital and research centre, Kattankulathur and 50 healthy controls of same age group.The study was approved by the institutional ethical committee and a written consent form from the subjects was obtained for carrying out the study after explaining to them the protocol of the study and the benefits of the study.

Project Instruments

Questionnaire and examination proforma for obtaining medical history and for recording clinical examination. Portable weighing machine was used to record the weight in Kg**.** Measuring tape was used to measure the standing and sitting height in centimetres**.** The EasyOne Pro (Computerized Spirometer) respiratory analysis system available in the research lab of department of physiology, SRM Medical College Hospital and Research Centre was used to perform the pulmonary function tests.

History and clinical examination

A thorough history was collected from all the participants including personal history like name, age, sex, ethnicity, address, habit of smoking and medical history including history of any respiratory and cardiac diseases. All the subjects underwent an anthropometrical assessment including standing height and weight.The subjects for the study were recruited based on the following criteria: Formalin exposed subjects (at least five years in their field).were included, Asthmatic and COPD subjects were excluded.

Manoeuvre for DLCO

The subjects nostrils were closed using a nose clip and asked to hold the sensor straight in front of his or her mouth without taking the mouth piece into the mouth yet. Then the subjects were asked to do tidal breathing, after 3 or 4 breaths the subjects were instructed to fully exhale, during which the Activate button (the valve will automatically close at the end of exhalation) was pressed. Now the subjects were asked to fully inhale the gas and then hold their breath for 10 seconds. After 10 seconds, the valve opens and the subjects were asked to exhale quickly and continue tidal breathing till end of the test. The parameters were statistically analyzed by using the paired 't' test.

RESULTS

The mean and standard deviation of DLCO was significantly lower in the formalin exposed group when compared to the non-exposed group with a p value of 0.000 (Table I). There was less significant in BMI between the formalin exposed and non exposed group (Table II)

Table 1
Comparison of DLCO variables between the formalin exposed and formalin non-exposed individuals.

Variables	Group	No	Mean & Std Deviation	P value
DLCO[ml/min/mmhg]	Formalin Non Exposed	50	28.54±6.18	.000
	Formalin Exposed	50	15.88±2.85	

CHART NO 1
COMPARISON OF DLCO BETWEEN FORMALIN EXPOSED AND FORMALIN NON-EXPOSED GROUP

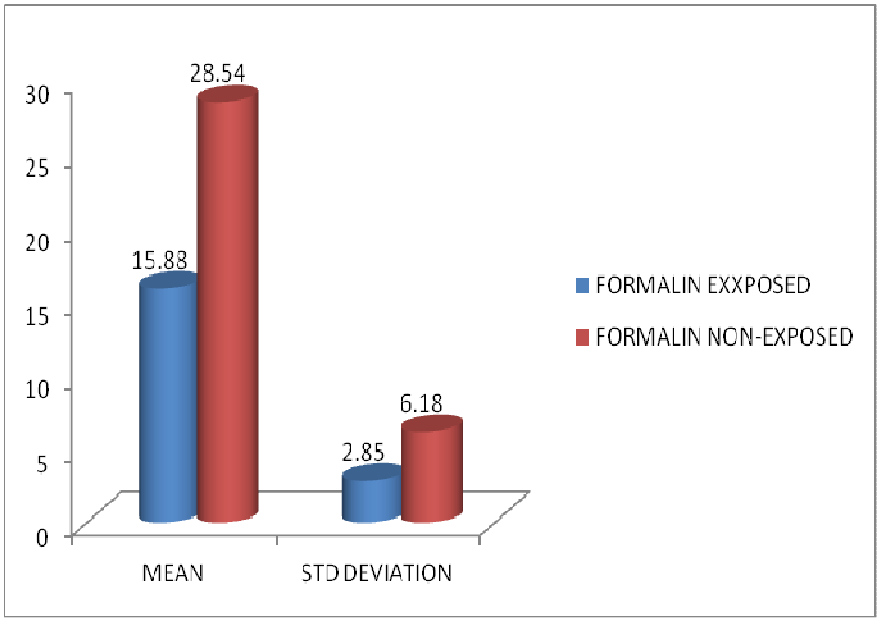

Table 2

PARAMETERS BMI	<18.5-22.9 (Mean±SD)	18.6-22.9 (Mean±SD)	23-24.9 (Mean±SD)	>25 (Mean±SD)	P value
DLCO	16.70±3.46	19.16±6.74	24.54±6.81	23.13±9.31	**0.025**

DISCUSSION

In our study, we found that the DLCO was significantly lower in formalin exposed subjects compared to that in the non exposed group. Our results were similar to the results of few other studies, through only few studies has assessed the DLCO in formalin exposed subjects.Most studies suggest that lung CO-diffusing capacity (DLCO) is normal[25-27], even in morbid obesity[28] however we found a significant correlation between BMI and DLCO. Some studies suggest DLCO may be increased in extremely obese subjects probably as a result of the increase in blood volume[29,30]. Most of the studies have not taken DLCO parameter[31,32] but since exposure of formalin is through inhalation, in our study we had taken DLCO into account. The mean and standard deviation of DLCO was significantly lower in the formalin exposed group when compared to the non-exposed group with a 'p' value of [0.000]. this result is in concordance with the results of few other studies[33,34] compared to unexposed controls the only lung function parameter significantly differing in exposed group was the blood volume of pulmonary capillaries, which was significantly higher in exposed group. The increase of the blood volume of pulmonary capillaries in persons exposed to formaldehyde is also radiologically confirmed. One of the explanatory hypothesis includes the hyperemic lung reaction as the consequence of the exposure to environmental irritants including formaldehyde.Although mean values of all other parameters were within normal ranges it should be mentioned that the lungs' diffusion capacities in 16 examinees professionally exposed to formaldehyde showed to be rather divergent. Increased diffusion capacity has been recorded in eight examinees (50%), a decrease of diffusion capacity has been recorded in three examinees, whereas only in five examinees the recorded values fall within normal range. The diffusion capacity of the lungs showed a tendency to be related with the years of exposure. Exposure to formaldehyde fume inhalation upto 10 years causes an increase of the diffusion capacity of the lungs. Exposure to formaldehyde fumes inhalation more than 10 years causes a decrease of the diffusion capacity of the lungs. A larger sample is needed to provide sufficient evidences to confirm above findings. This study was done in SRM Medical college among 50 individual of the anatomy and pathology department faculties technicians and attenders and 50 non-exposed individuals. With the limited sample size, the interpretation of results with other study makes it difficult. It may be overcome if we have taken a large sample size from institution using formaldehyde and manufacturing industries.

CONCLUSION

In India, very few studies were conducted and documented between the formalin exposed and non exposed by using different methods and standardized criteria. In our study, especially medical college faculties, technician and attenders (at least five years exposure of formalin) in their field. Statistically, the parameter (DLCO) was analyzed, So, we conclude that the formalin exposed persons had lesser diffusing ling capacities as compared to the non exposed subjects because, formalin exposure has been found to have a deleterious effect on pulmonary function. The formalin exposed subjects in our study presented with a mixed disorder of both obstructive and restrictive type. More information can be obtained if this study is continued for a longer duration.

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