A Study of blood gases (PO_2, PCO_2, HCO_3^-) changes after long exposure to formaldehyde vapor on the respiratory system of rabbits

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Abstract

This study was planned to reveal the changes in blood gases after long exposure to formaldehyde vapor on the respiratory system of rabbits. Treated animals were housed in closed room and exposed to formaldehyde fume using 10% formalin solution for a period of six months. Exposure was twenty-three hours for the whole period of experiment, and one hour a day was left for ventilation. Control group was exposed to distilled water humidity. There were significant differences between PO_2, PCO_2 (Partial Pressure) and HCO_3^- in addition to pH, hemoglobin, packed cell volume and reticulocyte counts.

Introduction

Formaldehyde, as a chemical compound has been known for a long time as a disinfectant and a preservative for biological specimens. It is a gas with high solubility in water and therefore, it is naturally absorbed in the upper part of the respiratory system (4). Formaldehyde is still the principal solution from the content of carcase preservation fluid in the containers of anatomical halls (2). Since then, its usage has been spread in different aspects of chemical industries. It is different from the rest of aldehydes by not having the alkyl group which gives it the importance of increased activity (11).Consideration on the changes in blood gases values, which seems to be the significant statistical correlation, was detected in few instances. Only arterial blood samples are suitable for PO_2 determination. Venous samples are adequate for pH and PCO_2 measurements (5,7).This project was undertaken to determine the changes in blood gases after long exposure to formaldehyde vapor on the respiratory system of rabbits.

Materials & Methods

A total of 40 adult male New Zealand White rabbits, age 4-6 months, weighting 1-2 Kg were used in this experiment. Five groups (n=5 each) were exposed to formaldehyde vapor in a closed room by using open pans contained 10% formalin for 23 hours a day. Control animals (n=3) for each treated group were exposed to distilled water humidity for the same period. One hour was left daily for ventilation during which fresh solution (10% formalin) was used. The first group rabbits were sacrificed after two months of exposure and groups 2, 3 4 and 5 were sacrificed at every month thereafter. Venous and arterial blood were taken from the heart directly and collected from each animal in different assigned group and the blood were evaluated for blood gases (PO_2, PCO_2, HCO_3^-), in addition to pH, hemoglobin, packed cell volume and reticulocyte counts.

Sampling:

5ml of venous and arterial blood was collected by pumping force without any bubble appear in the sample (anaerobically), using a disposable syringe contained heparin. Analysis of venous and arterial blood was carried out within few minutes and were handled in ice water bath and checked in the laboratory (8).The partial pressure of oxygen (PO_2) and carbon dioxide (PCO_2), pH and bicarbonate (HCO_3^-) were determined

using a blood gas analyzer (Acid-base calculator: Inst. Lab. Italy).Hemoglobin was determined by using hemoglobin meter, packed cell volume using the hematocrit tube for determination of the percentage of blood that is composed of erythrocytes. Reticulocyte was demonstrated by using a supravital stain (6).

Statistical Data Analysis

Data were statistically analyzed using one way ANOVA, the level of significance chosen was $P<0.05$. All descriptive and inferential statistical analysis was conducted using SPSS version 14.0, to calculate significance difference between treatment using (Duncan multiple test) (12).

Results

Results of the blood gases (PO_2, PCO_2, HCO_3^-), in addition to pH changes were presented in tables 1 and significant statistical correlation were detected in few instances. There were significant increased ($P<0.05$) in PO_2, PCO_2, HCO_3^- concentration in all rabbits that were exposed to the formaldehyde vapor and (as compared to control). The prominent feature of the cases was respiratory acidosis with some degree of the compensation as indicated by elevation of arterial PCO_2. Respiratory acidosis occurs in condition where there is decreased carbon dioxide elimination and blood carbonic acid and PCO_2 are increased, and the bicarbonate is normal or slightly increased. Blood pH is decreased, as shown in table 1 compared to the control. All rabbits in the five groups show changes in the trachea and the lung. There was congestion of blood vessels and edema, in addition the hemorrhagic exudates were noticed inside the lumen of the trachea. In the lung, hemorrhagic pneumonia and blood filled alveoli were observed in some cases, while the interstitial pneumonia and filtration of inflammatory cells were observed in certain cases. There was also the presence of emphysema with the mast cell aggregation which was quite obvious (Figure 1 and Figure 2). The result of hemoglobin, packed cell volume and reticulocyte are shown in table 2. There were significant statistical reductions ($P<0.05$) in PCV and reticulocyte count during the period of experiment and increased in percentage at the early stage of exposure to formaldehyde vapor. Therefore, further study is very much encouraged in this line providing that longer period of time should be applied to look for significant results in other parameters under investigation.

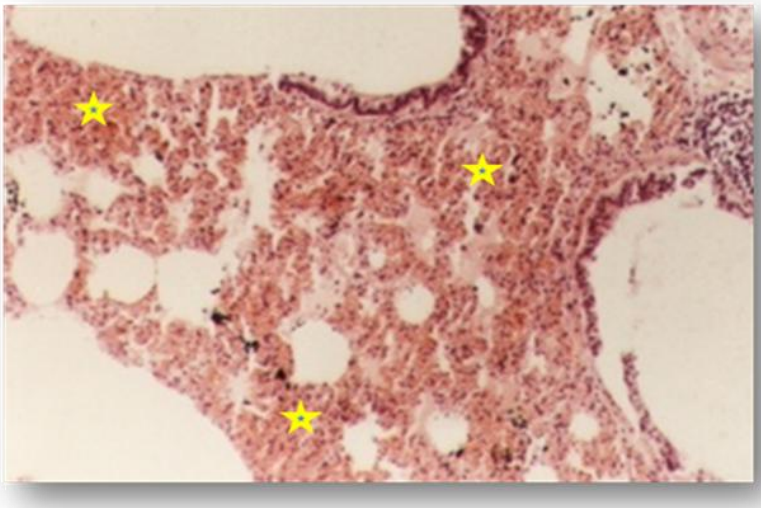

Figure 1: Histopathological section of lung demonstrates the hemorrhagic pneumonia (yellow stars), the blood observed was full all the alveoli. (x 132) H&E.

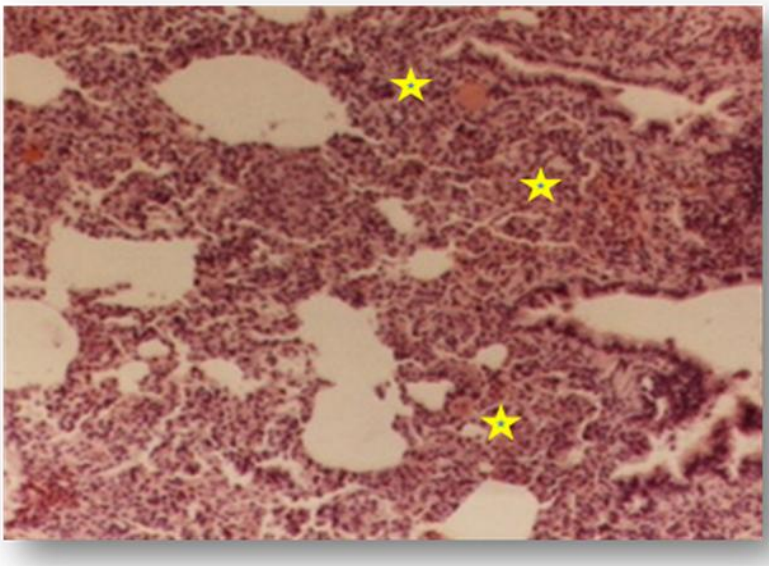

Figure 2: Histopathollogical section of lung demonstrates the interstitial pneumonia, filtration of inflammatory cells was observed in certain cases (yellow stars). (x 132) Attwood's alcian green-phloxine method.

Table 1: Arterial and Venous PO2, PCO2, HCO3- and pH in rabbits exposed to formaldehyde vapor (mean±S.D.)

Animal groups	Exposure to formaldehyde	Parameters							
		Arterial PO_2 mmHg	Venous PO_2 mm Hg	Arterial PCO_2 mmHg	Venous PCO_2 mmHg	Arterial HCO_3^- mEq/L	Venous HCO_3^- mEq/L	Arterial pH	Venous pH
Control		160.9± 9.32^{c}	51.2± 6.77^{c}	57.9± 16.32^{b}	74± 12.2^{c}	24.9± 6.4^{b}	25.3± 7.17^{b}	7.2± 0.25^{a}	7.1± 0.16^{a}
1	2 months	220.4± 2.3^{a}	139.7± 6.84^{a}	70.5± 4.48^{a}	96.7± 30.1^{a}	24.5± 3.23^{b}	31.3± 9.97^{a}	7.2± 0.22^{a}	7.1± 0.18^{a}
2	3 months	186.7± 6.67^{b}	81.54± 10.23^{b}	61.4± 9.4^{b}	81.74± 22.6^{b}	28.3± 7.77^{a}	20.7± 5.6^{c}	7.2± 0.18^{a}	7.02± 0.14^{a}
3	4 months	207.9± 16.09^{a}	59± 5.41^{c}	51.7± 15.11^{b}	97.8± 25.4^{a}	17.4± 4.98^{c}	24.8± 1.32^{c}	7.1± 0.14^{a}	6.96± 0.19^{a}
4	5 months	148.4± 7.94^{c}	48± 6.22^{c}	59± 3.68^{b}	61± 10.8^{d}	14.1± 2.35^{c}	19.7± 2.29^{c}	6.98± 0.15^{a}	6.99± 0.11^{a}
5	6 months	92.4± 11.6^{d}	35± 8.33^{d}	49.3± 8.32^{c}	77.2± 15.5^{b}	22± 3.34^{b}	27.2± 3.25^{b}	7.22± 0.08^{a}	7.2± 0.16^{a}

The different letter denote that significantly different between months (P<0.05)

Table 2: PCV, hemoglobin and reticulocyte count during and after exposure to formaldehyde vapor (mean ± S.D)

Animal groups	Exposure to formaldehyde		Parameters	
		Packed cell volume%	Hemoglobin mg/dl	Reticulocyte counts*
Control		35 ±1.73^{bc}	12±0.84^{ab}	0.8±0.24^{c}
1	2 months	40±5.04^{a}	13.1±0.24^{a}	3.2±0.86^{b}
2	3 months	38±1.94^{ab}	12.5±0.58^{ab}	5.5±2.95^{a}
3	4 months	32±5.78^{c}	10.9±2.18^{c}	2±1.63^{b}
4	5 months	34±3.8^{bc}	11.6±1.25^{bc}	0.7±0.38^{c}
5	6 months	35±2.9^{b}	11.9±2.1^{bc}	1.3±1.03^{c}

The different letter denote that significantly different between months (P<0.05)

Discussion

Changes in blood gases are a state of abnormalities (metabolic acidosis, metabolic alkalosis, respiratory acidosis, respiratory alkalosis) depending primarily upon the ratio between bicarbonate and PCO_2 in blood (14). An increase in PO_2 does not reflect the total O_2 carried in the blood. Most O_2 is combined with hemoglobin and does not contribute to PO_2. Therefore, high PO_2 can occur only when animals are given gases with high O_2 content. Low PO_2 can occur in respiratory disorders or with derangement of respiratory control mechanisms that showing obviously in the last three groups (3,1).While the PCO_2 is proportional to the dissolved CO_2 in the plasma, PCO_2 is a measure of alveolar ventilation. Decreased alveolar ventilation produces high PCO_2, while increased ventilation produces low PCO_2. The obstruction of airways; intrathoracic lesions such as bronchitis, pneumonia and asthma will give the prominent feature of the cases of respiratory acidosis (10). In addition, this will lead to increased in pulmonary rate, this increase in respiratory rate increases carbon dioxide loss intern decreases the carbonic acid level and the ratio of HCO_3^- approaches normal (do not understand). HCO_3^- concentration is calculated from the pH and PCO_2 by the Henderson-Hasselbach equation (14). HCO_3^- concentration ratio is maintained in healthy (rabbits) by conservation and production by the renal tubules. Finally, it seems that formaldehyde has little effect on most parameters used because of its short half-life in the animal body. However, changes in reticulocytes counts may indicate a problem in oxygen transportation or histological changes in the lung tissue, which impede gaseous exchange (13). Congestion of blood vessels and hemorrhagic pneumonia appeared to be dependent on the duration of exposure will causes increased primarily in Hb and PCV (9). The study revealed the exposure to formaldehyde vapor for long time make the adaption of the tissue against to the formalin.

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دراسة التغير في غازات الدم بعد التعريض لفترة طويلة لبخار الفورماليديهايد عن طريق الجهاز التنفسي في الأرانب

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الخلاصة

صممت هذه الدراسة لمعرفة التغيرات في غازات الدم لدى الأرانب بعد تعريضها لفترة طويلة لبخار الفورمالديهايد على الجهاز التنفسي. وضعت الحيوانات في غرفة مغلقة وعرضت لبخار الفورمالديهايد باستعمال ١٠% محلول الفورمالين على مدى ستة أشهر فترة التعريض كانت 23 ساعة يوميا خلال فترة التجربة وساعه واحدة للتهوية في حين عرضت مجموعة السيطرة الى بخار ماء المقطر فقط. كان هناك اختلافات إحصائية بين الضغط الجزيئي لغاز الأوكسجين (PO_2), الضغط الجزيئي لغاز ثاني أوكسيد الكاربون (PCO_2), آيون البيكاربونات (HCO_3^-) بالإضافة الى حامضية الدم, الهيموغلوبين, حجم الخلايا المضغوطة وعدد الخلايا الشبكية.