Effects of gradual exposure to carbon dioxide gas on the blood pressure status of workers in coal mines of Kerman province, Iran

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Abstract

BACKGROUND: The present study was conducted to investigate the probable changes in blood pressure of workers in coal mines.

METHODS: In this study 91 workers, who worked in forwarding, preparation and exploitation units of coal mines and were in direct contact with carbon dioxide gas (from fireworks), have been selected as the case group, and 70 workers, who did not have direct contact with this gas, from other units were selected as the control group by simple random sampling method. The inclusion criteria were over 10 years of work experience and the age range of 30 to 45 years. The blood pressure values and their classification were determined based on the Seventh Report of the Joint National Committee on Prevention of Hypertension. Statistical analysis was performed using t-test.

RESULTS: The results of this study showed that mean systolic and diastolic blood pressures in the case group were significantly lower than the control group ($P < 0.001$).

CONCLUSION: The mean diastolic blood pressure of workers in coal mines is less than other people due to the CO_2 gas. A greater control of the existing gas in mines by relevant factors is required. Necessary medical care and support measures should also be considered.

Keywords: Blood Pressure Changes, Workers, Coal Mine

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Introduction

Coal is considered to be a valuable exporting product. Despite the importance of this product in the economic development of countries, health problems related to its production, in miners, is one of the major concerns of those involved in this profession.[1] Mining, among other professions, has the highest rate of accidents, particularly accidents resulting in death.[2] The relationship between the mining industry and various illnesses is well known.[3] Studies show that the life of miners is significantly shorter than other people.[2] Therefore, chronic exposure to and inhalation of gas and dust deposits found in mines, and long-term employment in mines have resulted in professional illnesses (particularly in the lung and heart) in miners.[4] The statistics show that about 10% of workers are suffering from various degrees of lung disease from working in mines.[5] Along with lung, and cardiovascular problems the explosion of gas and dust in coal mines, which are the cause of CO_2 gas production, will also cause vascular disorders in the workers.[6,7] The study of Stec et al. indicated that workers, who were exposed to coal dust emissions, were more affected by changes in systolic and diastolic blood pressures than the other workers.[8] The Mine Safety and Health Administration [MSHA] has proposed 2 mg/m^3 of dust and 0.5% of CO_2 gas per shift as the safe amount in the mines. These amounts are declared as 1 mg/m^3 and 0.75% by the National Institute for Occupational Safety and Health (NIOSH).[9] Chronic exposure to CO_2 and other gases emitted in the coal mines can cause changes in blood pressure, in addition to the predicted respiratory changes. The largest amount of gas and dust is caused by explosion.[5] The purpose of this study was to investigate the effect of long-term employment in forwarding and exploitation units of coal mines on changes in blood pressure. This group has the highest rate of exposure to dust and gas in the coal mines of Kerman. Therefore, it was proposed to perform this study in order to control the toxic gas levels in the mines and help improve the existing situation.

Materials and Methods

This case control study was conducted among 91 workers, as the case group. They were employed in

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forwarding, preparation and exploitation units of coal mines and were exposed to emitted fumes and dust, and were chosen by simple random sampling method. The inclusion criteria were over ten years of work experience and age between 30 to 45 years. 70 employees with no history of occupational exposure to dust and gas causing respiratory diseases and disorders of blood pressure were selected for the control group. The two groups were similar in terms of age, gender, work experience, socio-economic status, residence status, and smoking and opium addiction. A questionnaire containing demographic information (such as age, height, and weight) was completed for each person. Blood pressure was measured with automatic oscillometric pressure gauges attached to the right arm (resting position) of the workers while sitting for at least 5 minutes. The time of measurement was between 9 am and 3 pm. Moreover, measurement was not performed 30 minutes after the meals and heavy physical activities. The pressure gauges were examined for calibration once a week. The blood pressure values and their classification were determined based on the Seventh Report of the Joint National Committee on Prevention of Hypertension. None of the workers (in the case and control groups) had a history of respiratory and blood pressure changes at the beginning of the employment. In the case of red blood cells' oxygen saturation of less than 90%, which was measured by pulse oximetry, the patient was excluded from the study. The concentration of CO2 (measured by an interferometer, with two sensors), which is a heavy gas, was measured at the bottom of the mine by safety experts twice a day in the beginning and middle of the shift Interferometer. Sampling was performed with the standard method recommended by the National Institute of Occupational Health and Safety of America. The collected data was analyzed by the Student's t-test. In addition, multiple linear regressions were performed for controlling the confounding effects. Data analysis was performed by using SPSS software version 11.5.

Results

This study comprised 91 workers in the case group and 70 works in the control group. Comparison of the demographic characteristics of the case and control groups is presented in table 1. The mean age of the case group was significantly lower than the control group ($P \leq 0.0001$). The mean height of the case group was less than the control group, but the difference was not significant. The mean weight of the case group was significantly lower than the control group ($P \leq 0.0001$). There was no significant difference in the mean systolic blood pressure of the two groups. The mean diastolic pressure in the case group was significantly lower than the control group ($P \leq 0.01$). The coefficient of smoking and opium addiction (-93%) was not statistically significant and thus was removed from the model ($P = 0.491$). The heart rate showed a significant difference between the two groups.

Discussion

This study showed that because of exposure to CO_2 gas, the mean diastolic blood pressure of the workers in coal mines is less than other people. Several factors can influence the mechanical performance of the heart and change the heart function in the positive or negative direction. The result of these variations will change contractile power, stroke volume, cardiac output and blood pressure. For example, stimulation of the sympathetic system enhances myocardial contractility by increasing the stroke volume and cardiac output.[10]

Previous studies have shown that working in the mines can have several cardiovascular effects. For example, by increasing the mine altitude, sympathetic activity increases, which results in increased blood pressure. This effect will be intensified in workers who have hypertension. It has been reported that workers with a history of ischemic coronary artery disease, or congestive heart failure are more vulnerable to work in the mines.[11]

Table 1. Comparison of mean age, height, weight, systolic blood pressure, diastolic blood pressure and heart rate between the case and control groups

Item	Unit	Case group		Control group		Z	P
		Mean	± SD	Mean	± SD		
Age	year	33.81	2.97	36.85	4.19	5.228	≤ 0.001
Height	cm	166.81	5.84	167.74	6.38	0.949	N.S*
Weight	kg	60.53	8.82	65.32	11.00	2.978	≤ 0.001
Systolic pressure	mmHg	111.43	16.57	114.31	22.11	0.906	N.S
Diastolic pressure	mmHg	77.32	12.56	76.92	12.54	2.303	≤ 0.01
Heart rate	pulse/min	67.90	11.96	90.40	11.65	2.573	≤ 0.01

* Not Significant

On the other hand, it seems that the miners do not have the adequate awareness about cardiovascular diseases.[12] The results of another study showed that there is a possible link between exposure to silica dust, and coronary disease. [13] Although, long-term work in underground mines increases the risk of cardio-pulmonary diseases, such as inflammation of the lungs, because of exposure to dust, environmental factors may also affect the conducting system of the heart in the long term.[8] In general, enhancing cardiac output will increase the systolic pressure, while the increase in peripheral resistance increases the diastolic pressure.[10] Evidences have shown that in apparently normal individuals, the systolic and diastolic pressure increase with age.[14] Reduction in the contribution of PO_2 reduces the contractile apparatus of vascular smooth muscle.[4] In the pulmonary artery, reduction in PO_2 leads to narrowing of blood vessels.[8] Increase in the contribution of PCO_2 often increases the diameter of the vessel; this is caused by the rise in the concentration of hydrogen ions within the cells. Hydrogen ions relax the vascular smooth muscles and cause vasodilatation, reduced peripheral resistance, and relative decrease in blood pressure.[4] The study by Guyton (on the effect of carbon dioxide gas in mines) indicated that increasing of the concentration of Co_2 in the blood would reduce the oxygen pressure in the coronary sinuses, and shift the curve of hemoglobin-O_2 binding to the left; therefore, the tendency of hemoglobin to the CO_2 gas will increase. This also has a significant role in hypoxia. The tendency of hemoglobin to the CO_2 gas added. It also has a significant role in hypoxia.[7]

This study has specifically compared the long-term effects of exposure to dust on blood pressure of the workers in coal mines with the workers who worked in the mine but were not exposed to dust. The workers in the case group were younger than the control group, but it was observed that the workers, who had long-term employment in the mine and were directly exposed to the dust, were still affected. It can be seen that the mean heart rate in the case group was lower than the control group. However, the heart rate should be higher in younger people.[10] These findings indicate that long-term employment in the mine was the cause of this effect. However, it seems that this issue has not been reported yet. The mean systolic and diastolic pressure in the case group was less than the control group. However, there was a significant difference between the mean diastolic pressure of the case and control groups ($P < 0.01$).The main reason for this difference is the increased environmental PCO_2 pressure inside the mine that caused peripheral resistance and decrease in blood pressure in the case group. These results were consistent with previous findings.[2,15] For improving the working conditions and preventing the diseases caused by working in coal mines, it has been proposed to change the mining methods and prevent the employment of people prone to heart and lung diseases. The allowable values for dust in mines should be controlled by providing appropriate ventilation. The workers should be taught the correct use of personal protective equipment during the regular health care programs. Other suggestions can be using the shift work scheduling and changing workplaces.

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Conflict of Interests

Authors have no conflict of interests.

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