Research Article

The health effects of carbon monoxide in chronic exposure to low concentrations

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ABSTRACT

Background: Acute exposure to carbon monoxide could be caused poisoning but in chronic exposure might be caused some symptoms and signs. **Objective:** The objective of this study was to determine the health effects of carbon monoxide in low concentration. **Materials and Methods:** It was a cohort study with >10 years follow-up. The people who were employed in different industries were participated in this study. Groups were followed for cardiovascular and neurological symptoms and signs. These groups were exposed to low concentrations of carbon monoxide; according to exposure levels, working sections were divided to five groups: Working section A, working section B, working section C, working section D, and working section E. Carbon monoxide concentrations, symptoms, and signs were determined. Data were analyzed with SPSS 16 Analysis of variance, Chi-square, Exact test, and relative risks with considering $P < 0.05$ as significant level. **Results:** Working section B had the most carbon monoxide concentration; 9.01 ± 0.62 part per million. Cardiovascular and neurological symptoms and sign were determined. Chronic fatigue, palpitation of heartbeat, loss of memory, and impaired decision-making were the most in Group B and relative risks were 1.62 (1.07–2.43), 1.60 (1.09–2.33), 1.50 (1.07–2.82), and 1.46 (1.08–2.72). **Conclusions:** Carbon monoxide had health effects in low concentration and might be caused, chronic fatigue, palpitation of heartbeat, loss of memory, and impaired decision-making.

KEY WORDS: Carbon Monoxide; Concentration; Exposure

INTRODUCTION

Acute exposure to carbon monoxide could be caused poisoning but in chronic exposure might be caused some symptoms and signs. Occupational exposures must be controlled and occupational health centers did this task.[1]

One of the most effective exposures was chemical especially asphyxiant gases.[1] The most prevalent asphyxiant gas was carbon monoxide.[1]

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The main etiology for many disorders symptoms and signs in the workplaces was chemical exposures.[2,3] Asphyxiant gases were important harmful agents.[1] The occupational health system tried to control it in factories and industrial workplaces.[4] If it was more than standards, 35 part per million (PPM), the health team had controlled.[5-7] However, in recent years, researchers studied the probability of injury with lower concentrations.[8,9]

Exposure to high concentrations could be caused an acute poisonous case with acute symptoms and signs such as headaches, nausea, vomiting, high pulse rate, respiratory rate, and blood pressure then low consciousness and lowering of all vital signs.[10] However, in a long time exposure, unknown symptoms and signs might be seen.[11-14]

Zdrenghea *et al*. demonstrated the cardiovascular risk factors and behaviors in railway workers.[15] Bryla *et al*. showed the

job risk factors for cardiovascular diseases in the prevention program participants.[16]

Cho *et al*. demonstrated the effect of job stress and lifestyle on cardiovascular risk factors in personnel.[17] Tsai did the study of the health-related quality of life and work-related stress of workers.[18]

Scientists researched about pollution and vascular accidents.[19] Their study showed the effects of exposures to cause disorders and admission to hospital.[20] Researchers showed the relationship between pollution exposure and inflammation.[21] Other study worked on ways of control of pollution.[22]

There were also some studies about the exposure to carbon monoxide and health effects.[23]

Shiozaki *et al*. had studied about the risk of ischemic heart disease and its relevant factors.[23] Other research showed the prevalence and risk factors of hypertension among male occupational bus drivers.[24] Researcher studied about the health status of firefighters.[25]

Some studies worked on the health of the employee and found the important factors for having healthy workers.[26] Health programs for workplace modifications were necessary and the occupational health team should be done. Assessing and measuring the risk factors was an important subject in this situation. According to air pollution in indoor and outdoor, some hazards need to study more than previous. The objective of this study was to determine the health effects of carbon monoxide in low concentration.

MATERIALS AND METHODS

Study Setting Different Industries

Study design and study population; it was a cohort study with >10 years follow-up. The people who were employed in different industries were participated in this study. Groups were followed for symptoms and signs. These groups were exposed to low concentrations of carbon monoxide; according to exposure levels, the working sections were divided to five groups: Working section A, working section B, working section C, working section D, and working section E. Symptoms and signs were determined.

Sampling method was used with $\alpha = 0.05$, power = 90, P1 = 30% and P2 = 50%, the calculated study population was 200 for each group (five groups), and 1000 in total.

These groups were exposed to the low concentration of carbon monoxide; symptoms and signs were determined using questionnaire and physical examinations.

Symptoms and sign were cardiovascular and neurologic; palpitation of heartbeat, arrhythmia, prehypertension, chronic fatigue, slowed reaction time, disturbed dexterity, mood changes, decision-making, and memory.

The inclusion criteria were people who worked in different industries with at least 4 years of work experience in the same work. The exclusion criteria were having related diseases in cardiovascular and neurological systems before beginning this job and having a positive family history of cardiovascular and neurological disorders.

Exposure assessment; all exposures assessed and calculated the risks. Other work exposures were kept in the standard levels. Carbon monoxide measured and calculated according to standards of occupational safety and health administration using a Draeger model 190 CO Datalogger and CO-specific filter. Data were transferred to computer; computer program (National Draeger Inc. Enhanced Graphic Software 2.0 part number 4510259) on a 32-in. (720K byte) micro diskette or a 5¼-in. (360K byte) disk.[27]

The questionnaire was checked with specialists and also with performing a correlation coefficient of 93%. The participants were examined by the author using a questionnaire, physical exams, and tests. Data were analyzed with SPSS; Chi-square, Exact test, Analysis of variance, $P < 0.05$ was considered for significant levels. Ethical consideration; the study was implemented with the consent that was obtained from all the participants and confident of the data.

RESULTS

The study participants were divided into five groups based on exposure level.

Working section B had the most carbon monoxide concentration; 9.01 ± 0.62 PPM. Cardiovascular and neurological symptoms and sign were determined. Chronic fatigue, palpitation of heartbeat, loss of memory, and impaired decision-making were the most in Group B, and relative risks were 1.62 (1.07–2.43), 1.60 (1.09–2.33), 1.50 (1.07–2.82), and 1.46 (1.08–2.72).

All of the symptoms and signs were the most in Group B.

Table 1 showed the minimum, maximum, and means of carbon monoxide concentration in five groups. Group B had the highest concentration and Group A had the lowest concentration of carbon monoxide. There were significant differences between the five groups ($P < 0.05$).

The highest number of symptoms and signs was in Group B: Palpitation of heartbeat, arrhythmia, prehypertension, chronic fatigue, slowed reaction time, disturbed dexterity, mood changes, decision-making, and memory. The lowest number of symptoms and signs was from Group A. There were significant differences. These items are demonstrated in Table 2 ($P < 0.05$).

The relative risks for symptoms and signs were determined, Group B had the highest risks. The relative risk in Group B for palpitation was 1.60 (1.09–2.33) and for chronic fatigue was 1.62 (1.09–2.33). The relative risk in Groups E and D, for palpitation was 1.55 (1.08–2.32) and 1.50 (1.01–2.20) and for chronic fatigue was 1.56 (1.07–2.22) and 1.51 (1.01–2.32). Table 3 shows the relative risks in different groups. Using the logistic regression, there were significant differences.

DISCUSSION

According to our findings, working section B had the most carbon monoxide concentration; 9.01 ± 0.62 PPM. Cardiovascular and neurological symptoms and sign were determined. All of the symptoms and signs were the most in Group B with the highest carbon monoxide concentration.

According to the finding; Group B had the highest number of symptoms and signs for cardiovascular and neurological systems: Palpitation of heartbeat, arrhythmia, prehypertension, chronic fatigue, slowed reaction time, disturbed dexterity, mood changes, decision-making, and memory. The lowest number of symptoms and signs was from Group A. Group A had the lowest concentration of carbon monoxide. There were significant differences. None of the previous articles showed all of the symptoms and signs but few articles

Table 1: Means of carbon monoxide concentration in PPM and comparison between working sections (P<0.05)

Variable	Groups				
	Working section A	Working section B	Working section C	Working section D	Working section E
Concentration - Minimum	5.20±1.03	8.01±1.01	6.20±1.06	5.50±1.16	6.70±1.02
Concentration - Maximum	7.01±0.02	10.01±0.13	7.40±0.12	7.20±1.06	7.10±1.06
Concentration - Mean±SD	6.10±0.52	9.01±0.62	6.30±1.09	6.35±1.12	6.40±1.04
P-value	0.03				

PPM: Part per million

Table 2: Frequencies of symptoms and signs and comparison between working sections (P<0.05)

Symptoms and signs	Groups					
	Working section A *n* (%)	Working section B *n* (%)	Working section C *n* (%)	Working section D *n* (%)	Working section E *n* (%)	*P*-value
Palpitation of heartbeat	5 (0.5)	20 (2.0)	6 (0.6)	11 (1.1)	15 (1.5)	0.01
Arrhythmia	0	5 (0.5)	0	1 (0.1)	3 (0.3)	0.04
Pre hypertension	0	5 (0.5)	2 (0.2)	3 (0.3)	3 (0.3)	0.04
Chronic fatigue	6 (0.6)	22 (2.2)	8 (0.8)	15 (1.5)	20 (2.0)	0.01
Slowed reaction time	3 (0.3)	9 (0.9)	6 (0.6)	6 (0.6)	7 (0.7)	0.03
Disturbed dexterity	3 (0.3)	9 (0.9)	6 (0.6)	6 (0.6)	7 (0.7)	0.03
Mood changes	4 (0.4)	10 (2)	4 (0.4)	8 (0.8)	9 (0.9)	0. 02
Decision-making	4 (0.4)	16 (1.6)	5 (0.5)	12 (1.2)	15 (1.5)	0. 01
Memory	5 (0.5)	18 (1.8)	5 (0.5)	11 (1.1)	15 (1.5)	0.01

Table 3: Relative risk of symptoms and signs between working sections (P<0.05)

Symptoms and signs	Groups				
	Working section A RR (CI)	Working section B RR (CI)	Working section C RR (CI)	Working section D RR (CI)	Working section E RR (CI)
Palpitation of heartbeat	1.10 (0.04–2.21)	1.60 (1.09–2.33)	1.12 (0.08–2.11)	1.50 (1.01–2.20)	1.55 (1.08–2.32)
Arrhythmia	-	1.40 (1.01–3.03)	-	1.30 (1.10–1.43)	1.33 (1.03–3.02)
Prehypertension	-	1.12 (1.01–3.03)	1.05 (0.17–2.34)	1.10 (1.05–2.03)	1.12 (1.10–2.20)
Chronic fatigue	-	1.62 (1.07–2.43)	1.06 (0.16–2.74)	1.51 (1.01–2.32)	1.56 (1.07–2.22)
Slowed reaction time	1.01 (0.15–1.24)	1.38 (1.01–2.03)	1.03 (0.18–2.54)	1.25 (1.10–1.53)	1.30 (1.02–3.12)
Disturbed dexterity	-	1.35 (1.01–3.15)	1.04 (0.14–2.74)	1.22 (1.12–1.55)	1.29 (1.02–2.01)
Mood changes	1.02 (0.17–2.34)	1.38 (1.05–2.13)	1.04 (0.16–2.44)	1.28 (1.12–1.53)	1.30 (1.11–2.03)
Decision-making	1.07 (0.18–2.94)	1.58 (1.10–2.13)	1.08 (0.07–1.24)	1.48 (1.02–4.20)	1.46 (1.08–2.72)
Memory	1.05 (0.07–1.35)	1.60 (1.08–2.13)	1.06 (0.17–2.33)	1.49 (1.01–2.50)	1.50 (1.07–2.82)

CI: Confidence interval

demonstrated some symptoms in low carbon monoxide concentrations.[1-3] The relative risks for symptoms and signs were calculated, Group B had the highest relative risks. Relative risk in Group B for palpitation was 1.60 (1.09–2.33) and for chronic fatigue was 1.62 (1.09–2.33) there was significant. Relative risk in Groups E and D, for palpitation was 1.55 (1.08–2.32) and 1.50 (1.01–2.20) and for chronic fatigue was 1.56 (1.07–2.22) and 1.51 (1.01–2.32). There were significant differences. Using the logistic regression, there were significant differences. It means that symptoms and signs were not related to age, body mass index, other occupational exposure, and environmental exposures.

Other studies showed the same as these results and demonstrated the special effects of carbon monoxide on cardiovascular and neurological systems.[23,24] Carbon monoxide had effects on a different part of the body, we thought it affected all of them from cardiovascular to neurological system.[19]

It seems that carbon monoxide that was emphasized on vital organ systems.[2,3] These were more prominent on neurological and cardiovascular. In this study, the researcher showed that Group B had the most frequency palpitation of heartbeat, arrhythmia, prehypertension, chronic fatigue, slowed reaction time, disturbed dexterity, mood changes, decision-making, and memory. This group had the highest level of carbon monoxide. Other studies had demonstrated the harmful effects of asphyxiant gases on well-being and health.[1,2] The highest numbers of people with palpitation, arrhythmia, and prehypertension were the most in Group B. The effects of this gas on blood pressure had been demonstrated in other researches.[1,24]

After deleting the effects of age, body mass index, and other exposures the risk of diseases had a significant difference. The risk of neurological symptoms and related diseases was demonstrated in other studies too.[2,3] Neurological symptoms and mental disorders could be caused by exposure to carbon monoxide.[2,3] This study showed the effects of low concentration of this gas on neurological symptoms and signs and mental or psychological symptoms disorders.

The physician must not ignore this important item in the occupational health system. Modifying the workplace especially from asphyxiant gases was necessary and the employee could be worked very well.

According to the results of this study, the researcher thought that specific job analysis must be done for all workers and must be measured all of the risk hazards in the workplace. In other studies were worked on determination of risk factors by emphasized control of pollution.[22]

Frequency of symptoms and signs was important and was gathered by reliable and valid questionnaires and checklist. The author found that the carbon monoxide was an important risk factor for cardiovascular and neurological disorders even in low concentrations. Low concentration in a long time might be followed by neurological, mental such as parkinsonism, mood instability, and cardiovascular disorders such as cardiomyopathy, hypertension, and arrhythmia.[2,3]

Examination and tests in occupational medicine had an important situation. Cardiovascular and neurological disorders could be prevented by periodic examinations and assessments. The author of this article recommended to the occupational physicians and occupational health team must be assessed the risk factors in the workplaces especially chemicals and tried to modified the workplaces, they should be examined personnel in periodic examinations and assessed the exposures. Carbon monoxide exposure could be resulted from environmental exposures and air pollution; occupational health team might be paid attention.

CONCLUSIONS

Carbon monoxide had health effects in low concentration and might be caused, chronic fatigue, palpitation of heartbeat, loss of memory, and impaired decision-making.

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