Research Journal of Biological Sciences 10 (4-5): 66-71, 2015
ISSN: 1815-8846

Kinetic Changes of Carbon Monoxide and Carboxyhemoglobin Levels among Various Smoking Models

[1]Ali Shotar, [1]Ahed Al Khatib, [2]Ahmad Boran, [1]Hatem Al Mansouri and [3]Virginia Rice
[1]Department of Legal Medicine, Toxicology of Forensic Science and Toxicology,
School of Medicine, [2]Department of Public Health, School of Medicine,
Jordan University of Science and Technology (JUST), P.O. Box 3030, Irbid, Jordan
[3]College of Nursing, Wayne State University, Detroit, USA

Abstract: The main objective of this study was to show the kinetic changes of carbon monoxide and its equivalent carboxyhaemoglobin in the blood during smoking models. This is an experimental descriptive cross sectional study. This study was performed in Irbid cafes using a special instrument called carbon monoxide monitor (piCO+™ Smokerlyzer). A previously prepared questionnaire was used to collect personal and smoking related data. A total of 437 participants were involved in this study and divided into 4 groups: passive smokers, cigarette smokers, waterpipe smokers and waterpipe and cigarette smokers. The results showed that age, sex, job, nationality, type of smoking and smoking inhaling frequency were associated significantly with both readings of carbon monoxide and carboxyhaemoglobin ($p \leq 0.05$). The results also showed that after 1 h of smoking, all smokers had dangerous amounts of carbon monoxide and its equivalent carboxyhaemoglobin in the blood. In all cases, passive smokers had profound impacts of carbon monoxide compared with smokers. The results showed that breath carbon monoxide and blood carboxyhaemoglobin resulting from smoking exceed the normal levels into dangerous levels and breath carbon monoxide and blood carboxyhaemoglobin resulting from cigarettes is higher than that from waterpipe.

Key words: Smoking, waterpipe, cigarette smoking, passive smoking, blood

INTRODUCTION

Tobacco smoke is a source of carbon monoxide for smokers as well as non-smokers and other chemicals with which environmental carbon monoxide could interact. Available data strongly suggest that acute and chronic carbon monoxide exposure attributed to tobacco smoke can affect the cardiopulmonary system but the potential interaction of carbon monoxide with other products of tobacco smoke confounds the results (McNicoll, 2002).

The >4800 compounds including 69 carcinogens have been identified in waterpipe smoking machine studies that span a period of >40 years (Hoffmann *et al*., 2001). Few studies have investigated the chemistry of narghile smoke in which a comparatively small range of chemical compounds were investigated (Rakower and Fatal, 1962; Hoffman *et al*., 1963; Sajid *et al*., 1993; Shihadeh, 2003). In none of these studies, CO or Polycyclic Aromatic Hydrocarbon (PAH), two major toxic agents in tobacco smoke were quantified using relevant narghile smoking parameters (Shihadeh, 2003).

A previous work on the mainstream narghile smoke chemistry showed that it contains significant amounts of “tar” and nicotine. It was found that while the “tar” of a single narghile smoking session was startlingly high typically two orders of magnitude greater than that produced from a single cigarette it was likely to have a different composition due to the much lower temperature of the tobacco in the narghile. It was anticipated therefore that the proportion of pyrosynthesized 4 and 5 ring PAHs responsible for much of the carcinogenicity of “tar” should be considerably lower than for cigarettes. It was also found that approximately, 5 g of charcoal were consumed in the course of a single smoking session, suggesting the possibility of large quantities of carbon monoxide being delivered to the smoker (Shihadeh, 2003).

The tobacco used in WPS typically weighs 10-20 g and has 3 main forms. “Mu’essel” or “maasel” (literally, “honeyed”) contains 30% tobacco and 70% honey or molasses (treacle). “Tumbak” or “ajami” is a pure, dark paste of tobacco. “Jurak”, mainly of Indian origin is an intermediate form that often contains fruits or oils but that

Corresponding Author: Ali Shotar, Department of Legal Medicine, Toxicology of Forensic Science and Toxicology, Jordan University of Science and Technology (JUST), P.O. Box 3030, Irbid , Jordan

may also be treacled and unflavored. "Muessel" is usually flavored with apple, mango, banana, strawberry, orange, grape, mint, cappuccino or other additives. It is generally sold in cardboard boxes or plastic jars decorated with fruit illustrations. Drugs or alcohol is often added to the tobacco.

Despite its widespread use, few studies have documented the adverse health consequences of WPS. This lack of data may due to the observation that WPS is mostly a non-Western habit, the high prevalence of smoking is a relatively recent phenomenon, lack of standardization of narghile content and the difficulty in studying the isolated effects of narghile because most of the smokers are also current or past cigarette smokers (Hoffmann *et al*., 2001).

Existing studies suggest pathologic consequences for the most part similar to those induced by cigarettes and additional risks of infection related to smoking practice. Because the smoke passes through the water before the smoker inhales it, there is a common misconception that the smoke "filters out" the harmful substances in tobacco smoke. Also the use of herbs or fruits as flavorings masks the harshness of the tobacco, leading some users to believe that they are smoking a herbal product that appears less hazardous than conventionally smoked tobacco products. However, waterpipe tobacco smoking delivers nicotine and as is common with other tobacco products, frequent use is associated with users reporting that they are addicted (Hoffmann *et al*., 1963).

Indeed, a waterpipe smoking session may expose the smoker to more smoke over a longer period of time than occurs when smoking a cigarette. According to the WHO, a waterpipe smoker may typically inhale as much smoke during one session as a cigarette smoker would inhale by smoking 100 or more cigarettes. Furthermore, even after it has been passed through water, the smoke from a waterpipe contains high levels of toxic compounds including carbon monoxide, heavy metals and cancer-causing chemicals (Memon *et al*., 2000).

WPS was associated with esophageal and gastric carcinoma in a preliminary survey from Yemen (Sajid *et al*., 1993). A case-control study of bladder cancer patients in Egypt showed no difference in rates between waterpipe smokers and non-smokers (Memon *et al*., 2000). Two cases of squamous cell carcinoma and 1 of keratoacanthoma of the lower lip have been reported among Egyptian narghile smokers (El-Hakim and Uthman, 1999). These reports suggest that WPS has a carcinogenic role in a number of body systems.

WPS has been associated with non-carcinogenic morbidity and pathophysiologic effects in the respiratory system. In a study of 595 smokers in Saudi Arabia, the mean vital capacity, forced expiratory volume in 1 sec and the forced vital capacity were lower among waterpipe smokers than among non-smokers and these values declined with age. Waterpipe smokers were at greater risk than cigarette smokers for decreased pulmonary function.

In addition to its intrinsic pathogenic ability, WPS has the potential for spreading infectious diseases given that smokers often share the same mouthpiece and pipe. The spread of infectious diseases could also result from the uncontrolled, manual preparation of narghile in contrast to tobacco marketed by the cigarette industry (Maziak *et al*., 2004a, b).

In a group of Egyptian patients with Helicobacter pylori, waterpipe smokers who smoked in groups had increased rates of infection when compared with non-smokers, similar to the rates among moderate to mild cigarette smokers (Rastam *et al*., 2004). Pulmonary aspergillosis has been reported in a leukemia patient as a result of smoking contaminated tobacco and marijuana in a waterpipe. Sharing a marijuana waterpipe has been associated with the transmission of tuberculosis. Other pathogens that could potentially be transmitted include hepatitis C, herpes simplex, Epstein-Barr virus, respiratory viruses and HIV (Wolfram *et al*., 2003). A case-control study of 100 Egyptian infertile women found that WPS of the husband was associated with infertility of the couple.

Low birth weight was reported to be approximately, twice as common among the newborns of Lebanese women who smoked narghile (approximately, the same as for cigarette smokers) and nearly 3 times as common among those who began smoking narghile in the first trimester than among non-smokers (Maziak *et al*., 2004a, b).

Elevations in heart rate and systolic, diastolic and mean arterial blood pressure were found after smoking in a group of 18 healthy Jordanian waterpipe smokers (Kiter *et al*., 2000). A case-control study of patients with recently diagnosed coronary heart disease found higher rates among those who had ever engaged in WPS. Egyptian patients who underwent oral surgery were more likely to develop postextraction dry socket when they were waterpipe or cigarette smokers (Maziak *et al*., 2004a, b).

Study objective: The main objective of this study was to show the kinetic changes of carbon monoxide and its equivalent carboxyhaemoglobin in the blood during smoking models.

MATERIALS AND METHODS

This is a cross sectional study. A questionnaire was used as a tool to collect the data from waterpipe smokers, passive smokers, cigarette smokers and both waterpipe and cigarette smokers. A total of 437 individuals were randomly chosen to form the sample population. The questionnaire concentrated on personal information such as sex and age. Carbon monoxide and carboxyhaemoglobin were measured in breathing by a device designed to measure both of carbon monoxide and carboxyhaemoglobin called carbon monoxide monitor (piCO+™ Smokerlyzer).

This study was conducted in several coffee shops in Irbid city. The coffee shops in Irbid city were randomly selected.

RESULTS

The participants of this study included different types of smokers: waterpipe smokers, cigarette smokers, waterpipe and cigarette smokers and passive smokers. This study was conducted in several coffee shops in Irbid city. The coffee shops in Irbid city were selected randomly. There were 437 participants involved in this study and were divided into the following groups as shown in Table 1.

Demographic characteristics of participants: In this study, 437 participants were involved among which were 93.1% males. The age group interval was divided into 14-22 years (50.8%) and 23-73 years (49.2%). The majority of participants were Jordanians (96.8%). Approximately, half of the participants were students (50.1%) (Table 2).

Table 1: Frequency of smokers

Type of smoking	No. of cases	Percentage
Passive	102	23.3
Cigarette	134	30.7
Waterpipe	100	22.9
Cigarette and waterpipe	101	23.1
Total	437	100.0

Table 2: Demographic characteristics of Irbid cafe smokers (n = 437)

Variables	Number	Percentage
Sex		
Male	407	93.1
Female	30	6.9
Age		
14-22 years old	222	50.8
23-73 years old	215	49.2
Nationality		
Jordanian	423	96.8
Non-Jordanian	14	3.2
Job		
Student	219	50.1
Non-student	218	49.9

The frequency and statistical significance of first readings of carbon monoxide (CO1) and Carboxyhaemoglobin (CO-HB1) with among study participants: As shown in Table 3, the readings for carbon monoxide and carboxyhaemoglobin, the prevalence of each variable is indicated as dangerous levels above 10 ppm for carbon monoxide and above 3% for carboxyhaemoglobin are reported in relation to prevalence and significance.

Age: In this study, there were 40.1% of participants within the age group 14-22 years and 59.9% in the age group 23-73 years. The results showed that there is a significant correlation between age and the prevalence of (CO1, p = 0.000, CO-HB1, p = 0.000).

Sex: This study comprised 95.0% male participants and 5% female participants. Both of CO1 and CO-HB1 were correlated significantly with sex (CO1, p = 0.010, CO-HB1, p = 0.008).

Job: The prevalence of CO1 was 40.4% among students and 59.6% among non-students. The prevalence of CO-HB1 was 41.5% among students and 58.5% among non-students. Both of CO1 and CO-HB1 were correlated significantly with job (CO1, p = 0.000, CO-HB1, p = 0.000).

Nationality: In this study most of the participants were Jordanians with a prevalence of 95.7% for CO1 among Jordanians and 4.3% among non-Jordanians. The prevalence for CO-HB1 was 95.8% among Jordanians and

Table 3: The prevalence of CO1 and CO-HB1 and their statistical significance by personal related factors

	CO1		COHB1	
Variables	Prevalence (n)	p-values	Prevalence (n)	p-values
Age				
14-22 years old	40.1 (129)	0.000	40.9 (128)	0.000
23-73 years old	59.9 (193)		59.1 (185)	
Sex				
Male	95.0 (306)	0.010	95.2 (298)	0.008
Female	5.0 (16)		4.8 (15)	
Job				
Student	40.4 (130)	0.000	41.5 (130)	0.000
Non student	59.6 (192)		58.5 (183)	
Nationality				
Jordanian	95.7 (308)	0.013	95.8 (300)	0.050
Non Jordanian	4.3 (14)		4.2 (13)	
Type of smoking				
Passive	2.8 (9)	0.000	2.9 (9)	0.000
Cigarette	38.2 (123)		39.0 (122)	
Waterpipe	28.3 (91)		27.2 (85)	
Cigarette and waterpipe	30.7 (99)		31.0 (97)	
Smoking inhaling frequencies				
Yes	91.7 (287)	0.000	91.5 (279)	0.007
No	8.3 (26)		8.5 (26)	

Table 4: The prevalence of CO2 and CO-HB2 and their statistical significance by personal related factors

	CO2		COHB2	
Variables	Prevalence (n)	p-values	Prevalence (n)	p-values
Age				
14-22 years old	45.0 (165)	0.000	44.8 (163)	0.000
23-73 years old	55.0 (202)		55.2 (201)	
Sex				
Male	94.8 (348)	0.004	94.8 (345)	0.005
Female	5.2 (19)		5.2 (19)	
Job				
Student	43.9 (161)	0.000	43.4 (158)	0.000
Non student	56.1 (206)		56.6 (206)	
Nationality				
Jordanian	96.2 (353)	NS	96.2 (350)	NS
Non Jordanian	3.8 (14)		3.8 (14)	
Type of smoking				
Passive	10.1 (37)	0.000	9.6 (35)	0.000
Cigarette	35.4 (130)		35.7 (130)	
Waterpipe	27.0 (99)		26.9 (98)	
Cigarette and waterpipe	27.5 (101)		27.7 (101)	
Smoking inhaling frequencies				
Yes	90.9 (301)	0.000	90.9 (300)	0.001
No	9.1 (30)		9.1 (30)	

4.2% among non-Jordanians. Both of CO1 and CO-HB1 were correlated significantly with job (CO1, p = 0.013, CO-HB1, p = 0.050).

Type of smoking: Type of smoking was correlated significantly with both of CO1 and CO-HB1 (CO1, p = 0.000, CO-HB1, p = 0.000).

Smoking inhaling frequency: The results interestingly showed that for those who inhaled smoking frequently, the prevalence was 91.7, 91.5% for both of CO1 and CO-HB1. The prevalence of CO1 and CO-HB1 among the persons who did not inhale smoking frequently was 8.3, 8.5% for CO1 and CO-HB1, respectively. The prevalence of both of CO1 and CO-HB1 was correlated significantly with smoking inhaling frequency (CO1, p = 0.000, CO-HB1, p = 0.007).

The second readings of Carbon monoxide (CO2) and Carboxyhaemoglobin (CO-HB2): As shown in Table 4, the readings for carbon monoxide and carboxyhaemoglobin, the prevalence of each variable is indicated as dangerous levels above 10 for carbon monoxide and above 3 for carboxyhaemoglobin are reported in relation to prevalence and significance.

Age: In this study, the prevalence of CO2 was 45% within the age group 14-22 years old and 55% in the age group 23-73 years old. The results showed that there is a significant correlation between the prevalence of (CO2, p = 0.000, CO-HB2, p = 0.000).

Table 5: The first and second readings of CO1 and CO2 among smokers

	Before CO1		After CO2	
Type of smoking	Normal ≤10 ppm (n)	Danger >10 ppm (n)	Normal ≤10 ppm (n)	Danger >10 ppm (n)
Passive	93	9	65	37
Cigarette	11	123	4	130
Waterpipe	9	91	1	99
Cigarette and waterpipe	2	99	0	101

Sex: Both of CO2 and CO-HB2 were correlated significantly with sex (CO2, p = 0.004, CO-HB1, p = 0.005).

Job: The prevalence of CO1 was 43.9% among students and 56.1% among non-students. The prevalence of CO-HB1 was 43.4% among students and 56.6% among non-students. Both of CO1 and CO-HB1 were correlated significantly with job (CO1, p = 0.000, CO-HB1, p = 0.000).

Nationality: In this study, most of the participants were Jordanians with a prevalence of 96.2% for CO2 among Jordanians and 3.8% among non-Jordanians. The prevalence for CO-HB1 was 96.2% among Jordanians and 3.8% among non-Jordanians. Both of CO2 and CO-HB2 were correlated significantly with job (CO2, p = 0.013, CO-HB2, p = 0.050).

Type of smoking: Type of smoking was correlated significantly with both of CO2 and CO-HB2 (CO2, p = 0.000, CO-HB1, p = 0.000).

Smoking inhaling frequency: The results interestingly showed that for those who inhaled smoking frequently, the prevalence was 90.9, 90.9% for both of CO2 and CO-HB2. The prevalence of CO2 and CO-HB2 among the persons who did not inhale smoking frequently was 9.1% for CO2 and CO-HB2, respectively. The prevalence of both of CO2 and CO-HB2 were correlated significantly with smoking inhaling frequency (CO2, p = 0.000, CO-HB2, p = 0.001).

The first and second readings of CO1 and CO2 among smokers: As shown in Table 5 for passive smokers, there were 93 participants within the normal level and 9 persons within the danger level. While for the second reading, the number within the normal level becomes 65 participants and the number of danger levels increased to 37. For cigarette smokers, the number of normal decreases from 11-4 participants. The number of danger increased from 123-130 persons. For waterpipe smokers, the number of normal level decreases from 9-1 and there was an increase in danger level from 91-99. For cigarette and waterpipe smokers, the normal level decreases from 2-0 and the danger level increased from 99-101.

Table 6: The first and second readings of CO-HB1 and CO-HB2 among smokers

	Before CO-HB1		After CO-HB2	
Type of smoking	Normal ≤3 ppm (n)	Danger >3 ppm (n)	Normal ≤3 ppm (n)	Danger >3 ppm (n)
Passive	93	9	67	35
Cigarette	12	122	4	130
Water pipe	15	85	2	98
Cigarette and Waterpipe	4	97	0	101

The first and second readings of CO-HB1 and CO-HB2 among smokers: As shown in Table 6 for passive smokers, the normal level decreases from 93-67 and the danger level increases from 9-35. For cigarette smokers, the normal level decreases from 12-4 and the danger level increases from 122-130. For waterpipe smokers, the normal level decreases from 15-2 and the danger level increases from 85-98. For waterpipe and cigarette smokers, the normal level decreases from 4-0 and the danger level increases from 97-101.

DISCUSSION

Breath carbon monoxide levels and its equivalent carboxyhaemoglobin percentage in blood were studied in Irbid cafes. No previous studies had been conducted to address this problem in these areas. Furthermore, little information is available in regard to dynamic changes of carbon monoxide and carboxyhaemoglobin levels during smoking. As shown in the results, the first and second readings for both of carbon monoxide and carboxyhaemoglobin levels were associated significantly with age, sex, job and nationality. For age, the adverse effects of smoking seem to accumulate over the time and both of readings were statistically important. This finding is in agreement with other reported studies on literature in which the mean vital capacity, forced expiratory capacity decline with age. Because the majority of participants were males and Jordanians, the obtained results do not form a good statistical indicator to generalize related findings. The job was associated significantly with both of the first and second readings for both of carbon monoxide and carboxyhaemoglobin. Non-students may be more affected by other sources for carbon monoxide exposure.

Type of smoking was correlated significantly with both of the first and second readings for both of carbon monoxide and carboxyhaemoglobin. Cigarette smokers scored highest prevalence for all readings. This can be explained by taking into consideration the following facts: the way by which tobacco burned is directly compared with waterpipe in which mu'assel is burned and the inhaled air passes through water where it will be cooled and condensated.

Smoking inhaling frequency was shown to be associated significantly with both of the first and second readings for both of carbon monoxide and carboxyhaemoglobin. The results showed that it is more dangerous to inhale smoking than smoking itself. This can be explained by the fact that inhaling smoking brings carbon monoxide to lungs which impact carboxyhaemoglobin levels and the overall lung function.

The results showed that the passive smokers are more affected by carbon monoxide than the other groups of smokers and that may due to the ability of their lungs to absorb more carbon monoxide from breath. This is also true for carboxyhaemoglobin. Carboxyhaemoglobin which is considered the real biological indicator for the real exposure to carbon monoxide, seems to be completely resulted from conversion of carbon monoxide.

CONCLUSION

The results showed that breath carbon monoxide and blood carboxyhaemoglobin resulting from smoking exceed the normal levels into dangerous levels.

It was also shown that breath carbon monoxide and blood carboxyhaemoglobin resulting from cigarettes is higher than that from waterpipe.

ACKNOWLEDGEMENT

Researchers would like to acknowledge the Deanship of Research at Jordan University of Science and Technology for funding for the present study.

REFERENCES

El-Hakim, I.E. and M.A. Uthman, 1999. Squamous cell carcinoma and keratoacanthoma of the lower lip associated with goza and shisha smoking. Int. J. Dermatol., 38: 108-110.

Hoffmann, D., G. Rathkamp and E.L. Wynder, 1963. Comparison of the yields of several selected components in the smoke from different tobacco products. J. National Cancer Inst., 31: 627-635.

Hoffmann, D., I. Hoffmann and K. El-Bayoumy, 2001. The less harmful cigarette: a controversial issue. a tribute to Ernst L. Wynder. Chem. Res. Toxicoi., 14: 767-790.

Kiter, G., E.S. Ucan, E. Ceylan and O. Kilinc, 2000. Water-pipe smoking and pulmonary functions. Respir. Med., 94: 891-894.

Maziak W., K.D. Ward, R.A. AfifiSoweid and T. Eissenberg, 2004a. Tobacco smoking using a waterpipe: A re-emerging strain in a global epidemic. Tobacco Control, 13: 327-333.

Maziak, W., T. Eissenberg, S. Rastam, F. Hammal and T. Asfar *et al*., 2004b. Beliefs and attitudes related to narghile (waterpipe) smoking among university students in Syria. Ann. Epidemiol., 14: 646-654.

McNicoll, T., 2002. Hooked on hookas. Newsweek International, November 4, 2002.

Memon, A., P. Moody and T. Sugathan, N. El-Gerges and M. Al-Bustan *et al*., 2000. Epidemiology of smoking among Kuwaiti adults: prevalence, characteristics and attitudes. Bull. World Health Organiz., 78: 1306-1315.

Rakower, J. and B. Fatal, 1962. Study of narghile smoking in relation to cancer of the lung. Br. J. Cancer, 16: 1-6.

Rastam, S., K.D. Ward, T. Eissenberg and W. Maziak, 2004. Estimating the beginning of the waterpipe epidemic in Syria. BMC Public Health, Vol. 4 10.1186/1471-2458-4-32.

Sajid, K.M., M. Akhter and C.Q. Malik, 1993. Carbon monoxide fractions in cigarette and hookah (hubblebubble) smoke. J. Pak. Med. Assoc., 43: 179-182.

Shihadeh, A., 2003. Investigation of mainstream smoke aerosol of the argileh waterpipe. Food Chem. Toxicol., 41: 143-152.

Wolfram, R.M., F. Chehne, A. Oguogho and H. Sinzinger, 2003. Narghile (waterpipe) smoking influences platelet function and (iso-) eicosanoids. Life Sci., 74: 47-53.