Original Article

Breath Carbon Monoxide Level of Non-Smokers Exposed to Environmental Tobacco Smoke

Raj Kumar, Gopal C. Mahakud, Jitendra K. Nagar, S.P. Singh, N. Raj, K. Gopal and V.K. Vijayan

Department of Respiratory Medicine, Vallabhbhai Patel Chest Institute, University of Delhi, Delhi, India

ABSTRACT

Background. Environmental tobacco smoke (ETS) exposure is a health hazard for non-smokers.

Objective. To measure breath carbon monoxide (CO) levels of non-smoking subjects exposed to ETS and of non-smoking subjects not exposed to ETS.

Results. The study was conducted with the help of a pre-designed questionnaire. One hundred male subjects were selected for the study; group I consisted of 50 non-smokers (waiters in hotels/restaurants/bars) exposed to ETS and group II consisted of 50 non-smokers not exposed to ETS. All subjects underwent clinical examination. Breath CO levels of both the groups were measured by the Mini Smoklyzer. The mean breath CO level (ppm) was higher in group I compared to group II (9.18±2.84 *versus* 4.56 ±1.62; $p<0.001$). The mean breath CO level was also significantly higher in ETS exposed subjects who worked for more than nine hours a day in bars, restaurants and hotels ($p=0.018$) and in subjects suffering from respiratory diseases ($p<0.001$) compared to normal subjects.

Conclusion. The abnormally high level of breath CO observed in passive smokers exposed to ETS may suggest that these subjects may be prone to develop the tobacco related diseases. **[Indian J Chest Dis Allied Sci 2011;53:215-219]**

Key words: Carbon monoxide, Passive smoking, Non-smoker, Environmental tobacco smoke.

INTRODUCTION

Smoking or use of tobacco may be considered a curse to a healthy society. People who are in the viscinity with smokers inhale the smoke emitted by the smokers and are considered to be "secondary smokers" or "passive smokers". The passive smokers also suffer from diseases related to smoking similar to active smokers. Tobacco smoking by patrons is common in hotels and restaurants in metropolitan cities like Delhi. The waiters serving in such hotels and restaurants work for 8 to 10 hours a day, inhale the smoke emitted by active smokers in closed environment of the establishment and suffer harmful effects of smoking.

Smoking is considered a prime cause of carbon monoxide (CO) exposure, though small amount of exposure can also occur due to vehicular smoke emission, occupational exposure, etc.[1] Various studies[2-4] have been done to correlate the number of cigarettes smoked per day and levels of CO in breath. The CO when inhaled from tobacco smoke is absorbed through lungs and enters into the blood stream and combines with haemoglobin to form carboxyhaemoglobin (COHb), which can be measured in the blood and is a useful marker of tobacco smoke absorption.[5-10] The CO remains in the blood for about 24 hours after inhalation of tobacco smoke depending on various factors such as gender, physical activity, and ventilation rate.[11-13] It then re-enters the alveoli because of concentration gradient at the alveoli. This CO that is present in expired air can be measured using portable CO analysers. The breath CO concentration has been found to be a reliable indicator of COHb level in the blood.[1,14] Therefore, indirect measurement of COHb through breath analysis is preferred over direct measuring of blood COHb levels because of its non-invasive nature, easy procedure and better compliance.[1,15]

Most of the studies based on smoking and its relation with CO levels were done on normal people and active smokers. This study is focused on passive smokers working in the hotels, bars and restaurants.

MATERIAL AND METHODS

This study was sponsored by Ministry of Health and Family Welfare, Government of India and World

[Received: September 9, 2010; accepted after revision: May 25, 2011]

Correspondence and reprint requests: Dr Raj Kumar, Professor and Head, Department of Respiratory Allergy and Applied Immunology, Vallabhbhai Patel Chest Institute, University of Delhi, Delhi-110 007, India; Phone: 91-11-27667102, 27667667, Extn 144; Fax: 91-11-27667420; E-mail: rajkumar_27563@yahoo.co.in

Health Organization. Informed consent was obtained from all participants of the study. A questionnaire was prepared which consisted general profile of smokers, duration of work, exposure to passive smoking, respiratory problems etc. A total of 100 male subjects were studied. This included passive smokers exposed to environmental tobacco smoke (ETS) working as waiters in hotels, restaurants and bars (n=50; group I); and 50 age-matched non-smokers not exposed to ETS (n=50; group II), were studied. Group II subjects were selected from the caretakers and relatives of the patients visiting the V.P. Chest Institute, University of Delhi, Delhi. All subjects underwent clinical examination. Exhaled CO levels were measured using a portable CO monitor (Mini-Smokerlyzer, Bedfont, England) in both the groups. The smokerlyzer measures breath CO levels in parts per million (ppm) based on the conversion of CO to carbon dioxide (CO_2) over a catalytically active electrode. Exhaled CO levels were measured following the method described by Jervis and Co-workers,[15] according to which, the participants were asked to exhale fully, inhale deeply and hold their breath for 20 seconds before exhaling rapidly into a disposable mouth-piece. During the procedure, the nose of the subjects was clamped. This was done to remove any contribution from the paranasal sinuses to the exhaled CO levels. The procedure was repeated for three times with one minute of normal breathing between each repetition, and the mean value was considered for analysis.

RESULTS

Comparison of Demographic Parameters, Type and Duration of Occupation, Smoke-less Tobacco Use, Knowledge Regarding Smoking and Other Parameters Between Passive Smokers and Non-smokers

Comparison of demographic parameters, type and duration of occupation, smoke-less tobacco (SLT) use, knowledge regarding smoking and other parameters between passive smokers and non-smokers is shown in table 1.

Table 1: Comparison of demographic parameters, type and duration of occupation, smoke-less tobacco use, knowledge regarding smoking and other parameters between passive smokers and non-smokers*

Characteristic	Passive Smokers (n=50)	Non-smokers (n=50)
Age (years) (mean±SD)		
Age group (years)	38.56±8.65	32.36±9.25
22-30 [No. (%)]	10 (20)	26 (52)
31-40 [No. (%)]	15 (30)	14 (28)
41-50 [No. (%)]	25 (50)	10 (20)
Sex [No.(%)]		
Male	50 (100)	50 (100)
Occupation	All are hotel, restaurant and bar waiters	Professionals (n=4, 8%); business (n=16, 32%); student (n=5, 10%); skilled (n=23, 46%); unemployed (n=2, 4%)
SLT user [No. (%)]	**15 (30)**	**15 (30)**
Khaini	7 (14)	10 (20)
Gutka	1 (2)	4 (8)
Pan	7 (14)	1 (2)
Hours of working [No. (%)]		
8	5 (10)	
9	24 (48)	
10	16 (32)	_____
11	4 (8)	
12	1(2)	
Years of working [No. (%)]		
≤5	12 (24)	
5-10	19 (38)	
10-20	8 (16)	_____
20-25	7 (14)	
>25	4 (8)	

Cont.

Table 1 Cont.

Feeling of change in outer and inner environment due to ETS [No. (%)]		
Yes	41 (82)	_____
No	9 (18)	
Serving smoker customer [No. (%)]		
<10	41 (82)	_____
>10	9 (18)	
Liking of the work place [No. (%)]		
Yes	44 (88)	_____
No	6 (12)	
Knowledge of harmful effect of passive smoking [No. (%)]		
Yes	47 (94)	_____
No	3 (6)	
Respiratory problems [No. (%)]		
Yes	8 (16) [rhinits (n=6), asthma (n=2)]	_____
No	42 (84)	
Smokers in family [No. (%)]		
Yes	3 (6)	_____
No	47 (94)	
Respiratory patients in family [No. (%)]		
Yes	3 (6)	_____
No	47 (94)	
Feeling of health problem before and after joining [No. (%)]		
Yes	2 (4)	_____
No	48 (96)	
Job satisfaction [No. (%)]		
Yes	44 (88)	_____
No	6 (12)	
Support laws to ban smoking in hotels, restaurants and bars [No. (%)]		
Yes	3 (6)	
No	47 (94)	_____
CO level (ppm) [No. (%)]		
0-6	1 (2)	46 (92)
7-10	37 (74)	4 (8)
>10	12 (24)	0 (0)

*All the parameters of the passive smokers exposed to ETS were not taken in non-smokers, (not exposed to ETS) as the aim of this study was to compare the breath CO level of passive smokers, exposed to ETS and non-smokers not exposed to ETS

SLT=Smoke-less tobacco; ETS=Environmental tobacco smoke; CO=Carbon monoxide; ppm=parts per million.

Passive Smokers (Non-smokers Exposed to ETS)

The average age of passive smokers (non-smokers exposed to ETS) was 38.6 years (range 22 to 50 years). All subjects, by nature of their work, were exposed to ETS for 8 to 12 hours daily. Majority (n=25, 50%) of subjects were between 41 to 50 years of age. Of these, 15 (30%) subjects used smoke-less type of tobacco. Maximum number of subjects (n=19, 38%) had worked in that environment for 5 to 10 years. The mean breath CO levels were higher in passive smokers who had worked for more than six years compared to those who worked for less than six years in the same environment (Table 2).

Most of the subjects (n=24, 48%) used to work for nine hours daily. The breath CO level was significantly higher (p=0.018) in subjects working for more than nine hour a day (Table 2). Forty-nine (98%) of the subjects were working in the evening or night shift. Forty-two (84%) subjects, who were exposed to

Table 2: Significance of breath carbon monoxide (CO) level in passive smokers

Category		No. of Subjects	Mean Level of CO (ppm)	p-Value
Hours of working	≥9 hours	21	10.38±3.39	p=0.018
	<9 hours	29	8.31±2.00	
Years of working	≥6	38	9.26±2.63	p=0.758
	<6	12	8.91±3.52	
Serving smoker customer daily	≥10	23	10.17±3.51	p=0.030
	<10	27	8.33±1.77	
Respiratory diseases	Yes	2	11.00±0.00	p<0.001
	No	48	9.10±2.87	

ppm=parts per million

ETS used to feel stuffy in front of the smoking customer or in the smokey environment. Forty-one (82%) of the subjects felt drastic change in the environment outside and inside their working place due to ETS, while other (9, 18%) of subjects did not complain; 41 (82%) subjects were serving 5 to 10 smoker customers daily whereas the rest of the subjects (n=9, 18%) were serving 10 to 20 smoker customers daily. Breath CO level was significantly high (p=0.030) in subjects who served 10 or more smoker customers daily compared to the subjects those used to serve less than 10 smoker customers daily (Table 2). Only six (12%) subjects detested the location of their hotel, restaurant and bars while the remaining 44 (88%) liked their working place. Forty-seven (94%) subjects had no knowledge about the harmful effects produced by passive smoking or ETS and even they did not know that they are inhaling the smoke indirectly. Among the passive smokers it was found that 16% of subjects had respiratory problems (Table 1) .

During the study, two (4%) subjects reported that they experienced cough, sneezes and breathlessness during the time they were serving the smoker customer. Only two (4%) of subjects stated that their health has deteriorated physically after joining the job. Only three (6%) subjects had family history smoking. When enquired whether smoking should be banned in restaurants, hotels and bars, 47 (94%) of subjects did not agree for the same while three (6%) of subjects agreed.

In most of the subjects (74%), breath CO levels ranged from 7-10 parts per million (ppm). In 12 of them (24%) breath CO levels ranged from 10-20 ppm which could be considered as the dangerous levels (Table 1).

Non-smokers (Not Exposed to ETS)

Their mean age was 32.4 years (range 22 to 50 years); most of them (n=26, 52%) were between 22 to 30 years of age. These subjects were from different occupations. Maximum number of subjects (n=16, 32%) were from businessmen group (Table 1). Maximum number of the subjects (n=46, 92%) had breath CO levels between 0-6 ppm. In four subjects (8%), breath CO levels between 7 and 10 ppm were observed. Of four subjects, one was the worker of polymer company, two were drivers and one was working in Delhi Transport Corporation.

Comparison of Breath Carbon Monoxide Between the Passive Smokers and the Non-smokers

The mean breath CO levels were significantly high in the passive smokers who worked more than nine hours per day (p=0.018) (Table 2). The mean breath CO levels were also higher in the subjects working for a period of more than six years but this difference was not statistically significant (p=0.758). The breath CO level was significantly (p=0.030) high in the waiters who were serving more than 10 smoker customers daily and spending more time with the smokers (Table 2). Breath CO was significantly higher in the subjects who were suffering from respiratory diseases compared to normal subjects (p<0.001). There was no significant correlation between CO level in passive smokers and ventilation system in bars, restaurants and hotels. The mean breath CO level of 9.18±2.84 ppm was significantly higher in the passive smokers who were exposed to ETS compared to non-smokers (4.56±1.62 ppm) who were not exposed to ETS (p<0.001).

DISCUSSION

Smoking is not injurious only for the smoker himself but for his family members and the society also. This study was conducted in Delhi city, India where many of the small restaurants and hotels are starved of space and located in congested and suffocating market places with poor ventilation facilities. Most of

the waiters worked 8 to 10 hours in that environment and inhale the smoke; hence they are a vulnerable group. In this study, the mean breath CO level of passive smokers and non-smokers was 9.18±2.84 ppm and 4.56±1.62 ppm, respectively. These findings are similar to the observations reported by Devecia *et al*,[16] where the mean exhaled CO level was 17.13±8.50 ppm for healthy smokers, 3.61±2.15 ppm in healthy non-smokers and 5.20±3.38 ppm in passive smokers.

In the present study, breath CO levels among passive smokers who serve 10 or more smoker customers daily was significantly higher (p=0.030). Passive smokers who worked for more than nine hours a day had a breath CO levels that were significantly higher (p=0.018). Breath CO level was higher in passive smokers working for more than six years compared to the passive smokers working less than six year although the difference was not statistically significant (p=0.758). Passive smokers having respiratory diseases had breath CO level significantly high (p<0.001) compared to the passive smokers who did not have any respiratory diseases. In another study,[17] it was found that 74% and 77% of the workers in taverns and bars reported respiratory symptoms and mucosa irritation symptoms, respectively due to the effect of ETS exposure. In this study[17] spirometric assessment included measurement of forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC). After prohibition of work place smoking they observed improvement in mean FVC and to a lesser extent in mean FEV_1 (0.039). Complete cessation of workplace ETS exposure was also associated with improved mean FVC and mean FEV_1. From these findings it is clear that the respiratory symptoms and sensory irritation symptoms (eye, nose, and throat) occur more frequently due to the ETS exposure in the work place. It was also found in a study[18] that passive smoking airborne nicotine level was high compared to the non-smoking areas. Few studies have[17,18] compared breath CO levels between smokers and passive smokers but sparse published literature is available regarding the comparison of the breath CO level between passive smokers and non-smokers. More studies are required in this area.

In conclusion, compared to non-smokers passive smokers are more prone to respiratory diseases and other harmful effect of smoking. Smokers should be conscious about the harmful effect of smoking not only for themselves but for others and should stop smoking in public places, hotels, restaurant and bars.

ACKNOWLEDGEMENT

Authors are thankful to the Ministry of Health and Family Welfare, Government of India and World Health Organization (WHO) for providing the financial assistance for the successful completion of the project.

REFERENCES

1. Jarvis M, Tunstall-Pedoe H, Feyerabend C, Vesey C, Salloojee Y. Biochemical markers of smoke absorption and self reported exposure topassive smoking. *J Epidemiol Community Health* 1984;38:335-9.
2. Wald N, Idle M, Bailey A. Carboxyhaemoglobin levels and inhaling habits in cigarette smokers. *Thorax* 1978;33:201-6.
3. Middleton ET, Morice AH. Breath carbon monoxide as and indication of smoking habit. *Chest* 2000;117:758-63.
4. Jarvis MJ, Tunstall-Pedoe H, Feyerabend C, Vesey C, Saloojee Y. Comparison of tests used to distinguish smokers from nonsmokers. *Am J Public Health* 1987;77: 1435-8.
5. Ohlin P, Lundh B, Westling H. Carbon monoxide blood levels and reported cessation of smoking. *Psychopharmacology* 1976;46:263-5.
6. Jamrozik K, Vessey M, Fowler G, Wald N, Parker G, Van Vunakis H. Controlled trial of three different antismoking interventions in general practice. *Br Med J* 1984;288:1499-502.
7. Ringold A, Goldsmith JR, Helwig HI, Finn R, Schuette F. Estimating recent carbon monoxide exposures. *Arch Environ Hlth* 1962;5:308-18.
8. Cohen SI, Perkins NM, Ury HK, Goldsmith JH. Carbon monoxide uptake in cigarette smoking. *Arch Environ Hlth* 1971;22:55-60.
9. Rea JN, Tyrer PJ, Kasap HS, Beresford SAA. Expired air carbon monoxide, smoking, and other variables. *Br J Prev Soc Med* 1973;27:114-20.
10. Goldsmith JR, Aronow WS. Carbon monoxide and coronary heart disease: a review. *Environ Res* 1975;10:236-48.
11. Wald N, Howard S, Smith PG, Bailey A. Use of carboxyhaemoglobin levels to predict the development of diseases associated with cigarette smoking. *Thorax* 1975;30:133-40.
12. Mellvaine PM, Nelson WC, Bartlett D. Temporal variation of carboxyhaemoglobin concentrations. *Arch Environ Hlth* 1969;19:83-91.
13. Deller A, Stenz R, Forstner K, Konrad F. The elimination of carboxyhaemoglobin: gender specific and circadian effects. *Infusther Transfusmed* 1992;19:121-6.
14. Joumard R, Chiron M, Vidon R, Maurin M, Rouzioux JM. Mathematical models of the uptake of carbon monoxide on haemoglobin at low carbon monoxide levels. *Environ Health Perspect* 1981;41:277-89.
15. Jarvis MJ, Russel MAH, Saloojee Y. Expired air carbon monoxide: a sample Breathe test of tobacco smoke intake. *BMJ* 1980;281:484-5.
16. Devecia SE, Devecib F, Acika Y, Ozana AT. Measurement of exhaled carbon monoxide in healthy smokers and non-smokers. *J Respir Med* 2004;98:551-6.
17. Eisner MD, Smith AK, Blanc PD. Bartenders' respiratory health after establishment of smoke-free bars and taverns. *JAMA* 1998;280:1909-14.
18. Cenko C, Pisaniello D, Esterman A. A study of environmental tobacco smoke in South Australian pubs, clubs and cafes. *Int J Environ Health Res* 2004;14:3-11.

RADIOLOGY FORUM

It is proposed to extend the scope of the Radiology Forum of our Journal by inviting our readers as well as other workers in the field of Respiratory Medicine to submit brief report of patints with interesting clinical and radiological features for publication. These will be published, provided that:

1. The condition is of sufficient clinical and radiological interest;
2. Photographs (10cm×8cm) are of excellent quality for printing (Maximum: 4 photographs);
3. The diagnosis in each case has been confirmed; and
4. The chest radiograph is accompanied by brief clinical account, not exceeding two page typescript (with sub-head: Clinical Summary, Investigations, Diagnosis, Discussion and References)

All the material received for publication under the Radiology Forum section will be evaluated to judge the suitability for publication by our peer-review experts panel.

Editor-in-Chief