ORIGINAL ARTICLE

Tanaffos (2009) 8(3), 10-16

The Relation between Exhaled Carbon Monoxide Level and Smoking Cessation Outcome

Mahshid Aryanpour [1], Majid Tarahomi [2], Gholam Reza Heydari [1], Zahra Hesami [1], Ali Ramezankhani [1]

[1] Tobacco Prevention and Control Research Center NRITLD, Shahid Beheshti University M.C., [2] Avicenna Research Institute, TEHRAN-IRAN.

ABSTRACT

Background: *Smoking is the first preventable cause of mortality in the world. Smoking cessation is affected by various factors like nicotine dependence rate, individual issues and social factors. Measuring the level of exhaled carbon monoxide is a simple noninvasive diagnostic method for determination of smoking status and nicotine dependence; and this study evaluated its correlation with the outcome of smoking cessation.*

Materials and Methods: *In this cross-sectional study, all individuals who had attended the smoking cessation programs in Tehran smoking cessation clinic for 6-sessions during a one- year period were questioned using a questionnaire designed according to the WHO and NRITLD questionnaires. At first, level of exhaled carbon monoxide was measured in all cases and those who quit smoking (no smoking even one puff) after the third treatment session were followed by phone in 1, 3, 6, 12 and 24 month intervals respectively.*

Results: *Three hundred forty- seven cases were questioned in this study out of which, 292 (84.1%) cases were males. At the end of the treatment course, 237 cases (68.3%) successfully quit smoking, 27 cases (7.8%) cut down smoking and 83 cases (23.9%) were excluded from the study due to the exceeded absence from the course. After disregarding the excluded group, the success rate of smoking cessation was calculated to be 89.8%. Measurement of the level of expired carbon monoxide (CO) showed that the exhaled CO level was < 10 parts per million (ppm) in 98 cases (28.2%), between11-20 ppm in 149 cases (42.9%) and > 20 ppm in 100 (28.8%) cases. The highest rate of success in quitting smoking was observed among those with expired CO level < 11-20 ppm and cigarette consumption less than 30 cigarettes per day (p=0.00).*

Conclusion: *Since cases with high concentration of exhaled carbon monoxide showed lower success rates in quitting smoking, more specific treatment courses along with more precise consultation and follow up are recommended for such cases.* ***(Tanaffos 2009; 8(3): 10-16)***

Key words: *Cigarette, Quit, Exhaled carbon monoxide, Nicotine dependence*

INTRODUCTION

Smoking is the first preventable cause of death in the world. Factors affecting smoking cessation comprise a wide variety including social,environmental, family-related and individual issues (1).

Several studies have shown that 70% of smokers are interested in quitting smoking among which 46.4% have attempted to quit smoking during the previous years but only 4-6% of them would be

Correspondence to: Heydari GR

Address: NRITLD, Shaheed Bahonar Ave, Darabad, TEHRAN 19569, P.O:19575/154, IRAN

Email address: ghrheydari@nritld.ac.ir

Received: 6 September 2008

Accepted: 11 February 2009

successful in maintaining the smoking abstinence for one year (2). During the recent years, many efforts have been undertaken to determine the predictive factors for smoking cessation in order to estimate the success rate of smoking cessation and consequently to schedule an efficient program for smokers. In order to offer an appropriate program to a smoker, his/her smoking status, risk factors, nicotine dependence level and causes of failure are important factors that should be evaluated. In this way, the success rate would increase and therapeutic costs would decrease (3).

At present, smoking status and nicotine dependence level are among the predictive factors for smoking cessation which can be evaluated based on the self-reported cigarette consumption (i.e. number of cigarettes smoked per day), Fagerstrom test and some diagnostic tests including the level of exhaled carbon monoxide, urinary and plasma nicotine level, and cotinine and thiocyanate measurements (4,5). Blood tests are invasive and neither blood tests nor urinalysis can offer an early evaluation; whereas, measurement of the exhaled carbon monoxide level has been known as an easy, quick and noninvasive method for evaluation of smoking status (5, 6, 7). Furthermore, this test can be used for detection of nicotine dependence due to its direct relationship with number of cigarettes smoked per day and Fagerstrom test (8). Additionally, the device designed for measuring the exhaled carbon monoxide level is cost effective and portable and therefore can be widely used by smoking cessation clinics (5). This study was conducted to find an appropriate strategy for a more successful smoking cessation process and making necessary changes in current educational and therapeutic smoking cessation programs. For this purpose, we evaluated the correlation between the exhaled carbon monoxide level and successful smoking cessation in smokers referred to smoking cessation clinics. This study also aimed to determine the effect of PICO on successful smoking cessation and to find out if we could use this test as a predictive factor for smoking cessation and recommend a more appropriate smoking cessation method to smokers after determining their smoking status.

MATERIALS AND METHODS

In this cross-sectional study, all smokers who had participated in the educational and therapeutic smoking cessation courses held by the smoking cessation clinic from Mar. 2003 to Feb. 2004, were questioned personally and then followed-up by telephone interviews for two years in 1, 3, 6, 12 and 24- month intervals.

The smoking cessation clinic has been established with the cooperation of NRITLD and the municipality of the 14th district of Tehran since 1998. Monthly treatment courses are held for women and men separately in this clinic.

Treatment and educational courses for smoking cessation include 7 sessions (each takes about 2 hours) in which a physician helps participants (nearly 15-20 cases) to quit smoking after the third session by using educational programs, counseling, behavioral therapy, psychotherapy and drug therapy. In these courses nicotine replacement products such as nicotine chewing gums (made in Iran) are offered to nicotine dependent individuals.

Those who did not attend more than half the sessions were excluded from the study and those who completed the courses with at most 3 absence sessions were considered as course graduates.

Data were collected using a questionnaire including demographic and individual data, information on cigarette smoking and therapeutic interventions. The demographic part of the questionnaire included age, gender, marital status, educational level and occupational status. Information on cigarette smoking was collected by

using the nicotine dependence status based on Fagerstrom test including 6 questions as follows:

- Time of smoking the first cigarette in the morning
- Number of cigarettes smoked per day
- The best cigarette of the day
- Period of time in the day when most cigarettes are smoked
- Tendency to smoke during illnesses
- Having trouble in no smoking areas

The above-mentioned questions were scored from zero to 10.

Nicotine concentration level in the expired air was measured via exhaled carbon monoxide test (PICO) by (Micro Medical Smoke Check Limited, Rochester, Kent ME_1 2AZ, England) at initiation of therapy. Subjects were divided into the three following groups based on measured carbon monoxide level:

1- Low PICO (1-10 ppm)
2- Moderate PICO (11-20 ppm)
3- High PICO (≥21).

Other questions included reasons of smoking, pack/year (P/Y=the number of cigarette packs smoked per day during the smoking years), type and administration of drug, the number of absences from sessions and outcome of the course.

Smoking cessation was determined based on self-reporting on quit smoking after the third session and also exhaled carbon monoxide measurement. The participants were followed-up by telephone interviews at 1, 3, 6, 12 and 24- month intervals after quitting smoking.

Exhaled carbon monoxide concentration index in the three groups of smoking cessation, failure and exclusion was analyzed by using chi-square test. By disregarding the excluded group, chi-square test was used for evaluation of the correlation between the nicotine dependence index and cessation outcome in success and failure groups.

The relation between exhaled carbon monoxide concentration and the mean number of cigarettes smoked per day, mean number of packs/year, age and gender of participants in cessation and failure groups was evaluated by using chi-square test. In addition, exhaled carbon monoxide concentration, nicotine dependence, age and gender of the excluded group were compared with those who completed the course by using chi-square test.

RESULTS

In this study, 347 cases were studied, out of which 292 (84.1%) were men. The mean age was 38.4±1.10 yrs (range 17-87 yrs). Most cases (57.7%) were in the age range of 21-40 yrs and had an educational level below high school diploma (37.2%); 95.2% of subjects were businessmen, 23.6% were employees and 3.2% were students (Table 1).

Regarding the number of cigarettes smoked per day, 18 (13.2%) cases smoked <10, 94 (25.8%) cases smoked between 11-20, 166 (45.6%) cases smoked between 21-30 and, 56 (15.4%) cases smoked >30 cigarettes a day.

Table 1. Frequency distribution of smokers based on gender, age, level of education and occupation

Participants		Number	Percent
Gender	Male	292	84.1
	Female	55	15.9
Age (yr)	<20	6	1.7
	21-40	199	57.7
	41-60	130	37.7
	≥61	10	2.9
Level of education	Illiterate	12	3.5
	Below diploma	128	37.2
	Diploma	118	34.3
	Higher than diploma	86	25
Occupation	Unemployed	31	9
	Employee	81	23.6
	Businessman	155	45.2
	House keeper	34	9.9
	Retired	24	7
	Student	11	3.2
	Other	7	2

Measurement of the level of exhaled carbon monoxide showed that 98 cases (28.2%) had PICO<10 ppm, 149 (42.9%) had PICO between 11-20 ppm and 100 (28.8%) cases had PICO> 20 ppm measured at the beginning of the course. The mean exhaled PICO in the first day of the course was 16.7±9.7 ppm (range 1-80 ppm) in the under study population.

Evaluation of the nicotine dependence status showed that most participants had moderate nicotine dependence. One hundred thirty seven cases (39.6%) showed high dependence (scores 8, 9, 10), 147 (42.5%) cases showed moderate dependence (scores 4, 5, 6, 7) and 62 cases (17.9%) showed low dependence (scores 1, 2, 3). Regarding the number of cigarettes smoked per day, 54 (15.6%) cases smoked <10, 93 (26.9%) cases smoked between 11-20, 149 (43.1%) cases smoked 21-30 and 50 (14.5%) cases smoked >30 cigarettes a day.

Regarding the history of previous smoking cessation, 57.5% of cases had a history of smoking cessation lasting from one to 6 years (mean 4.3±8.7 months).

Two hundred thirty-seven cases (68.3%) successfully quit smoking (no smoking even one puff after the third session), 27 (7.8%) cases cut down smoking and 83 cases (23.9%) were excluded from the study by the end of the course (Table 2).

Table 2. Frequency distribution of smokers based on treatment outcome

Treatment outcome	Number	Percent	Valid percentage
Successful	237	68.3	89.8%
Failure	27	7.8	10.2%
Exclusion	83	23.9	----
Total	347	100.0	100%

As shown in Fig.1, there was a successful and sustained abstinence in 125 cases (53.9%) for 6 months, in 107 (46.1%) for one year and in 75 cases (42.4%) for 2 years.

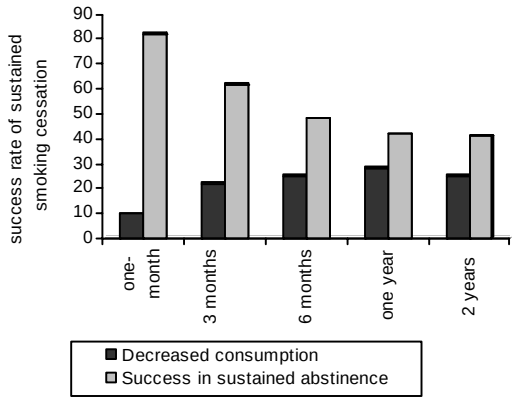

Figure 1. Frequency distribution of the success rate in smokers with sustained smoking cessation based on the period of abstinence

Evaluation of the correlation between the cessation success at the end of the course and exhaled carbon monoxide level showed that the highest success rate was 73.8% (n=110) in those with moderate PICO between 11 and 20 ppm and the lowest rate was 56% (n=56) in those with PICO> 20 ppm (p=0.03, Table 3). There was a significant inverse correlation between the exhaled carbon monoxide level and successful smoking cessation (p=0.01).

Table 3. Frequency distribution of treatment outcome in smokers based on exhaled carbon monoxide level

Outcome Exhaled PICO	Cessation	Failure	Exclusion	Total
<10 ppm	71 (72.4%)	7 (7.1%)	20 (20.4%)	98 (100%)
11-20 ppm	110 (73.8%)	8 (5.4%)	31 (20.8%)	149 (100%)
>20 ppm	56 (56%)	12 (12%)	32 (32%)	100 (100%)
Total	237 (68.3%)	27 (7.8%)	83 (23.9%)	347 (100%)

Cases with lower PICO were more successful in sustained smoking cessation at the end of the first month (91.4% in those with PICO≤ 10 ppm vs. 88.7% and 69.6% in cases with 10< PICO≤ 20 and PICO>20, respectively, p=0.001) but there was no significant correlation between success in maintaining smoking cessation and PICO in the next follow-ups.

In this study, the prevalence of high levels of exhaled carbon monoxide was greater in men compared to women (p=0.03). The mean exhaled carbon monoxide level was 2±0.75 in men and 1.79±0.72 in women; but no significant correlation was found between the exhaled carbon monoxide level and age.

Nicotine dependence measurement based on Fagerstrom test was shown to have a significant inverse correlation with successful cessation In addition, exhaled carbon monoxide level was significantly higher in participants with high nicotine dependence (p=0.00, Figure 2).

Those who consumed less than 30 cigarettes a day were significantly more successful in quitting smoking in comparison with those who smoked more than 30 cigarettes per day (210 cases,71.9% vs. 25 cases, 50%, respectively, p=0.00).

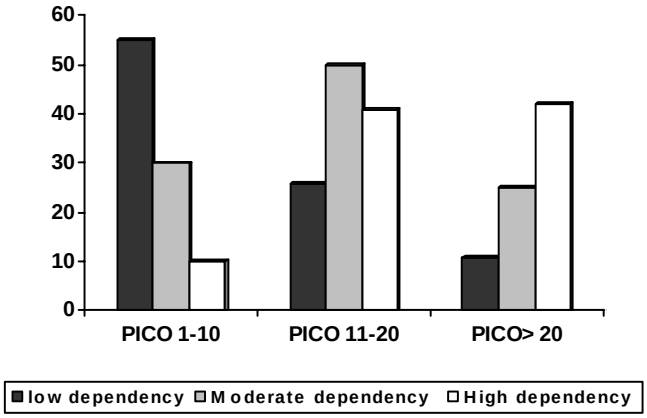

Figure 2. Frequency distribution of nicotine dependence according to exhaled carbon monoxide level in smokers

DISCUSSION

Most smokers are interested in quitting smoking and 46.4% of them try to quit annually (2) but 57% of those attempts result in abstinence for only one month and just 2.5% of the population can sustain their abstinence due to the existing problems in regard to smoking cessation (9).

Smoking cessation is related to a wide range of factors. We can increase the success rate by determining the major factors involved and focusing on them. By doing so, costs of treatment imposed on the health system of our country can be prevented and health level of our community will increase in the future.

Smoking status and nicotine dependence are among the major predictive factors for smoking cessation that can be evaluated by self reporting like the number of cigarettes smoked per day, Fagerstrom test, measuring the exhaled carbon monoxide level, and concentration of nicotine, cotinine and thiocyanate in urine and plasma (4, 5). Numerous studies have suggested the evaluation of exhaled carbon monoxide level as a proper and non-invasive method for determination of the success rate of smoking cessation in smokers (7) and can be a good substitute for interventional paraclinical diagnostic tools (8).

One of the most important findings in this study was the significant correlation between the outcome of treatment courses and exhaled carbon monoxide level which had not been evaluated in Iranian studies. In the present study, we found an inverse correlation between successful smoking cessation and exhaled carbon monoxide level (measured by PICO test). For instance, the lowest rate of success was reported in those with PICO> 20 ppm and even after disregarding the exclusion group, this finding did not change and was consistent with that of Haison et al.(8). Monso and colleagues have also shown a significant correlation between successful smoking cessation and lower level of carbon monoxide. They suggested the lower level of exhaled carbon monoxide measured at the beginning of the course as a powerful predictive factor for smoking cessation outcome (10).

High levels of exhaled carbon monoxide can play

an important role in diagnosis, prognosis and cessation outcome in smokers. Programs designed based on the level of exhaled carbon monoxide i.e. different educational patterns, especial classes designed for those with high levels of exhaled carbon monoxide and high nicotine dependence, extending the duration of treatment courses, adding other interventions to the treatment course like psychiatry counseling and using multi-drug regimens for smokers who have high levels of exhaled carbon monoxide can positively affect the attendance of smokers in educational courses and increase the success rate of smoking cessation program. R.jas et al. also emphasized the necessity of a especial scheduling for subjects with high nicotine dependence level to help them quit smoking (5). Based on a study by God et al., the combination of psychotherapy and drug therapy is necessary to encourage smokers with high and low nicotine dependence level quit smoking and to increase their chance of success (11).

Masjedi and colleagues reported the effective factors on smoking cessation outcome to be the smoker's attendance in each course and number of cigarettes smoked per day (12).

Also, in a study conducted by Gorini et al. on 693 smokers with high nicotine dependence level who had participated in smoking cessation courses for 8 to 9 sessions, two important predictive factors for smoking cessation were determined as follows:

1- Attending the smoking cessation course for at least 7 sessions (OR=4.26)

2- Cigarette consumption less than 30 cigarettes a day (OR=1.56) (13). This study showed that smokers with lesser consumption of cigarette (<30 cigarettes a day) were more successful in quitting smoking. In conclusion, exhaled carbon monoxide level measured at the beginning of the course can be considered as a major paraclinical factor indicating the number of cigarettes smoked per day and level of nicotine dependence.

Complementary evaluations are recommended for designing different educational patterns and assessing other effective factors on smoking cessation. Also, especial courses are required for smokers with high concentration of exhaled carbon monoxide and nicotine dependence.

Acknowledgement

We wish to thank the municipality of the 14th district of Tehran, our colleagues in the smoking cessation clinic and all the personnel in Masih Daneshvari Hospital/NRITLD for their cooperation in this study.

REFERENCES

1. Sylvia May, Robert West. Do social support interventions ("buddy systems") aid smoking cessation? A review. ***Tob Control*** 2000; 9: 415- 422.
2. Centers for Disease Control and Prevention (CDC). Cigarette smoking among adults--United States, 1994. ***MMWR Morb Mortal Wkly Rep*** 1996; 45 (27): 588- 90.
3. Heydari GR, Ariyanpour M, Sharif Kashani B, Ramezankhani A, Fallah Tafti S, Hosseini M, et al. Tobacco dependency evaluation with fagershtrom test among the entrants of smoking cessation clinic. ***Tanaffos*** 2007; 6 (4): 47- 52
4. Berny C, Boyer JC, Capolaghi B, De L'Homme G, Desch G, Garelik D, et al. Biomarkers of tobacco smoke exposure. ***Ann Biol Clin (Paris)*** 2002; 60 (3): 263- 72.
5. Rojas NL, Killen JD, Haydel KF, Robinson TN. Nicotine dependence among adolescent smokers. ***Arch Pediatr Adolesc Med*** 1998; 152 (2): 151- 6.
6. Hurt RD, Croghan GA, Beede SD, Wolter TD, Croghan IT, Patten CA. Nicotine patch therapy in 101 adolescent smokers: efficacy, withdrawal symptom relief, and carbon monoxide and plasma cotinine levels. ***Arch Pediatr Adolesc Med*** 2000; 154 (1): 31- 7.
7. Hung J, Lin CH, Wang JD, Chan CC. Exhaled carbon monoxide level as an indicator of cigarette consumption in a

workplace cessation program in Taiwan. ***J Formos Med Assoc*** 2006; 105 (3): 210- 3.

8. Haramaki Hisano, Terao Yoko, Kondo Toshimi, Kamimoto Sadako, Maeda Hitoshi. Effected of the personal education for smoking cessation in out patient clinic with nicotine patches and measurement of exhaled carbon monoxide (co) concentration. ***Japanese Journal of Occupational Medicine and Traumatology*** 2001; 49 (4): 347-50.
9. Centers for Disease Control and Prevention (CDC). Smoking cessation during previous year among adults--United States, 1990 and 1991. ***MMWR Morb Mortal Wkly Rep*** 1993; 42 (26): 504- 7.
10. Monsó E, Campbell J, Tønnesen P, Gustavsson G, Morera J. Sociodemographic predictors of success in smoking intervention. ***Tob Control*** 2001; 10 (2): 165- 9.
11. Gad RR, El-Setouhy M, Haroun A, Gadalla S, Abdel-Aziz F, Aboul-Fotouh A, et al. Nicotine dependance among adult male smokers in rural Egypt. ***J Egypt Soc Parasitol*** 2003; 33 (3 Suppl): 1019- 30.
12. Masjedi MR, Azaripour Masooleh H, Hosseini M, Heydari GR. Effective factors on smoking cessation among the smoker in the first smoking cessation clinic in Iran. ***Tanaffoss*** 2002; 1(4): 61-7.
13. Gorini G, Chellini E, Terrone R, Ciraolo F, Di Renzo L, Comodo N. Course on smoking cessation organized by the Italian League against Cancer in Florence: determinants of cessation at the end of the course and after 1 year. ***Epidemiol Prev*** 1998; 22 (3): 165- 70.