RESEARCH ARTICLE

Pulmonary Function Tests and their Reversibility in Saudi Arabian Smokers

Suchitra Parkhad, Sachin Palve

King Abdullah Hospital, Bisha, Saudi Arabia

Correspondence to:
Suchitra Parkhad
(drsuchitrapalve11@gmail.com)

Received: 12.06.2013
Accepted: 20.06.2013

DOI: 10.5455/njppp.2014.4.200620132

ABSTRACT

Background: Smoking is known as the major cause of chronic obstructive pulmonary disease (COPD). In COPD, most of pulmonary function tests (PFTs) those indicating the diameter of airways are reduced. There are reports that bronchodilator drugs have no or a very little effect on PFT of COPD patients.

Aims & Objective: PFTs of smokers were compared with those of non-smokers and the effect of bronchodilator inhaler (salbutamol) on PFTs of smokers was also examined.

Materials and Methods: Pulmonary function tests were measured in 100 male smokers (height 171.71 ± 6.68 cm, age 36.49 ± 13.06 years old) and compared with 100 male nonsmokers (height 171.79 ± 8.81 cm, age 35.56 ± 12.83 years old). The subjects underwent measurement of spirometric flow and volume. The following variables were measured: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximal mid-expiratory flow (MMEF), peak expiratory flow (PEF), maximal expiratory flow at 75%, 50%, and 25% of the FVC (MEF75, MEF50, and MEF25 respectively). In addition, pulmonary function tests of 33 male smokers (height 172.79 ± 11.94 cm, age 38.30 ± 6.65 years old) before and 10 minutes after administration of 200 μg salbutamol inhaler were measured.

Results: Most values of PFTs in smokers were significantly lower than those of non-smokers ($p<0.001$ for FVC, FEV1, PEF, MEF75, $p<0.01$ for MMEF, and $p<0.02$ for MEF50). However, there were not significant differences in MEF25 of smokers and non-smokers. There were significant correlations between the smoking duration and FEV1, PEF, MEF75, and MEF50 ($p<0.05$ to $p<0.01$), but correlations between smoking quantity and values of PFTs were not significant. The results also showed that all values of PFTs were significantly increased after salbutamol administration ($p<0.05$ to $p<0.01$). The enhancement in PEF, MEF75, and MEF50 was around 12% and that of MEF25 was 17%.

Conclusion: The effect of smoking on PFT showed that smoking leads to constriction of large and medium sized airways which is mostly due to duration not to quantity of smoking. The airway constriction in smokers was reversible which, was mostly seen for medium sized airways.

Key Words: Pulmonary Function Test; Reversibility; Smoking

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major cause of chronic morbidity throughout the world. Many people suffer from this disease for years and die prematurely from it or its complications. COPD is currently the fourth leading cause of death in the world[1], and further increases in its prevalence and mortality can be predicted in the coming decades[2]. Cigarette smoking is by far the most important risk factor for COPD and the most important way that tobacco contributes to the risk of COPD.[3] Cigarette smokers have a higher prevalence of respiratory symptoms, pulmonary function abnormalities, greater annual rate of decline in FEV1, and a greater COPD mortality rate than those of non-smokers.[4] These differences between cigarette smokers and non-smokers increase in direct proportion to the quantity of smoking. Smoking leads to rapid decline in pulmonary function tests (PFTs) specially those indicating diameter of airways such as forced expiratory flow in one second (FEV1).[5] Even in teenagers who have smoked only a few years, maximum expiratory flow volume curves demonstrate decreases in flow rates at small lung volumes[6] yet another expression of small airway obstruction. If smoking causes changes in small airway calibre at such an early age, one might expect that smoking also causes acute changes in these small airways. Until now, the only well documented acute effect of smoking on the airways was the decrease of airway conductance demonstrated by Nadel and Comroe.[7] The obstruction to airflow that develops in 15 to 20% of heavy smokers is thought to be due to abnormalities in airways with less than 2 mm internal diameter.[8] Previous studies from several laboratories have shown that this airway obstruction is associated with chronic inflammatory process in the membranous and respiratory bronchioles.[9,10] It is believed that the airway constriction in COPD and decline in PFT are not reversible. Therefore, in the present study the pulmonary function tests of smokers were compared with those of non-smokers. The effect of quantity and duration of smoking on PFT and the reversibility of PFT were also evaluated in the present study.

MATERIALS AND METHODS

Expiratory flow-volume curves were recorded by a spirometer with a pneumotachograph sensor (Model ST90, Fukuda Sangyo Co. Ltd. Japan). The spirometer was calibrated daily for few days at the beginning, end and, a few intervals during the middle of the study with a three- litre calibrating syringe. However, because there were almost no differences in daily calibrations, calibration of the spirometer was carried out weekly in the rest of the study. Prior to testing, the required maneuver was demonstrated by the operator, and subjects were encouraged and supervised throughout the test performance. Studies were performed using the acceptability standards outlined by the "American Thoracic Society" (ATS) with subjects in a standing position and wearing nose clips.[11] In 30 smokers, PFTs were repeated 10 min after 200 μg inhaled salbutamol. Pulmonary function tests were performed three times in each subject with an acceptable technique. The highest levels for forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximal mid-expiratory flow (MMEF), peak expiratory flow (PEF), and maximal expiratory flow at 75%, 50%, and 25% of the FVC (MEF75, MEF50, and MEF25 respectively) were taken independently from the three curves.

Data Analysis

The data of height, age, and pulmonary function parameters were expressed as mean ± SD. PFTs of smokers were compared with those of nonsmokers using unpaired t-test. PFTs obtained after inhaled salbutamol were compared with the baseline values using paired t-test. The duration and quantity of smoking were related to decrease in their PFT values, using the least square regression. The criterion of significance was $p<0.05$.

RESULTS

Duration and Quantity of Smoking

Mean duration of smoking was 17.41 ± 4.68 years (range 2-50 years) and mean quantity of smoking was 12.09 ± 9.68 Cigarettes per day (range 0.25-50).

Table-1: Characteristics of Studied Population

Variables	Nonsmokers (N=100)		Smokers (N=100)	
	Range	Mean ± SD	Range	Mean ± SD
Height (cm)	154-194	171.79 ± 8.81	158-190	171.71 ± 6.68
Age (year)	18-65	35.56 ± 12.83	19-71	36.49 ± 13.06
Amount			0.25-50	12.09 ± 9.68
Duration			2-50	17.41 ± 9.68
FVC	71.36-134.50	95.71 ± 12.22	24-126	83.78 ± 16.83
FEV1	80.90-184.40	102.04 ± 17.29	15-130	89.80 ± 16.80
MMEF	69.70-239.60	104.15 ± 20.33	8-158	92.51 ± 27.19
PEF	61.50-150.90	100.13 ± 16.84	5-151	85.88 ± 24.72
MEF75	51.50-170.50	105.62 ± 21.65	6-170	90.01 ± 29.07
MEF50	52.10-213.30	104.28 ± 28.89	12-196	94.70 ± 30.36
MEF25	68.50-223.80	110.48 ± 27.58	36-257	110.84 ± 42.42

Table-2: Pulmonary Function Tests (PFTs) among Smoker and Nonsmoker Subjects and Statistical Differences between Two Groups

PFTs	Nonsmokers Mean ± SD	Smokers Mean ± SD	Statistical Differences
FVC	95.71±12.22	83.78±16.83	P<0.001
FEV1	102.04±17.29	89.80±16.80	P<0.001
MMEF	104.15±20.33	92.51±27.19	P<0.01
PEF	100.13±16.84	85.88±24.72	P<0.001
MEF75	105.62±21.65	90.01±29.07	P<0.001
MEF50	104.28±28.89	94.70±30.36	P<0.02
MEF25	110.48±27.58	110.84±42.42	NS

Pulmonary Function Tests

All values of pulmonary function tests in smokers were significantly lower than those of nonsmoker subjects (p<0.02 to P<0.001) except MEF25. There was significant negative correlation between duration of smoking and decrease in FEV1, PEF, MEF75, and MEF50 (p<0.05 to p<0.01). However, the correlations between the quantity of smoking and values of PFT were not significant.

Low PFTs among Smoker and Nonsmoker Subjects

The percentage of low values of most PFTs (lower than 80% predictive values) among smoker was significantly more than those of normal subjects (Table 3). Only 0-10.6% of non-smokers had low PFT values while in 21.6-42.3% of smokers PFT values were lower than normal range.

Effect of Salbutamol on PFTs of Smokers

Pulmonary function tests of 33 male smokers (height 172.79±11.94 cm, age 38.30±6.65 years) before and 10 min. after administration of 200 µg salbutamol inhaler were measured. All values of PFT in smokers significantly increased 10 min. after 200 µg inhaled salbutamol (p= 0.005 to p<0.001). The enhancement in PEF, MEF75, and MEF50, was around 12% and that of MEF25 was 17%.

Table 4: Pulmonary Function Tests (PFTs) of Smoker Subjects Before and 10 Min. after Inhalation of 200 µg Salbutamol

PFTs	Before	After	Statistical Differences
FVC	76.76 ± 13.23	81.68 ± 16.32	P<0.001
FEV1	82.79 ± 12.79	90.62 ± 14.74	P<0.001
MMEF	80.74 ± 19.07	90.03 ± 24.09	P=0.002
PEF	76.63 ± 19.00	86.91 ± 18.13	P<0.001
MEF75	79.79 ± 20.43	93.47 ± 18.40	P<0.001
MEF50	81.15 ± 19.60	93.32 ± 21.40	P<0.001
MEF25	97.25 ± 36.03	114.09 ± 45.65	P=0.005

Table-3: Percentage and Range of Low PFTs (Lower than 80% Predicted Values) among Smoker and Nonsmoker Subjects

PFTs	Nonsmokers				Smokers				Statistical Differences
	Mean ± SD	Range	Age	No.	Mean ± SD	Range	Age	No.	
FVC	74.00 ± 2.4	71-79	19-44	10	69.39 ± 10.2	24-79	20-71	41	p<0.05
FEV1	-	-	-	-	68.27 ± 14.4	15-79	21-71	22	-
MMEF	73.75 ± 3.3	69-76	29-45	4	68.06 ± 15.0	8-78	21-68	33	NS
PEF	72.20 ± 5.9	61-78	22-64	11	61.14 ± 17.2	5-79	19-68	36	P<0.01
MEF75	65.38 ± 11.2	51-78	22-64	8	60.69 ± 18.7	6-79	19-71	32	NS
MEF50	68.11 ± 10.0	52-79	22-49	9	64.48 ± 14.5	12-79	21-68	31	NS
MEF25	72.56 ± 3.2	68-78	23-63	8	64.71 ± 10.7	36-79	21-53	24	P<0.05

DISCUSSION

This study has shown reduction of all values of pulmonary function tests in smokers compared to those of nonsmoker subjects. Although the mean values of PFTs in smokers was in normal range (83.78 ± 16.83 to 110.84 ± 42.42), they were significantly lower than PFT values in normal subjects. However, in 21.6-42.3 % of smokers, the values of PFT were lower than normal range, while only 0-10.6% of normal subjects had low values of PFT. In addition, relatively younger smoker subjects had low values of PFT comparing to normal subjects. Previous studies[12-20] also showed reduction of different values of PFT among smokers comparing to normal subjects. The result of the present study showed the reduction in PEF and MEF75 among smoker subjects was significantly more than other values of PFT. These results may indicate that in smoker subjects medium and large airways are affected more than other airways. The results of our study were supported by previous studies indicating reduction of PFTs in smokers.[17,18] However, there is some evidence that small airways are affected more by smoking.[14] The results of the present study also showed negative correlation between decrease in most values of PFT and duration of smoking. However, the relationships between decrease in PFTs and quantities of smoking were not significant. These results showed that duration of smoking has more profound effect on airways than quantity of smoking. The studies of Sherrill et al.[21] and Verschakelen et al.[22] also showed correlation between smoking and reduction in most values of PFT which support the results of the present study. In addition, Burrows et al. also showed quantitative relationship between cigarette smoking and reduction in values of PFT.[5] Furthermore, the results of the present study showed that the values of PFT of smokers were significantly increased due to 200 μg inhaled salbutamol indicating some degree of reversibility of the airway constriction in smokers. Although the mean value of MEF25 among smokers was normal, increase in this value of PFT due to salbutamol administration was more than other values of PFT. This may indicate that in smokers small airways are more liable to reversible constriction. It is believed that airway constriction of COPD patients is not reversible, or there is very small reversibility of airways in these patients.

CONCLUSION

The results of our study demonstrated a relatively large component of reversibility of airways in smokers, which is a novel finding of the present study. In conclusion, the results of the present study demonstrated the profound effect of smoking on PFT and, therefore, indicated that smoking leads to constriction of large and medium airways, which is mostly due to duration, not to quantity of smoking. The airway constriction in smokers was reversible which was mostly seen for medium and small sized airways.

REFERENCES

1. World Health Organization. World health report. Geneva: WHO; 2000.
2. Murray CJ, Lopez AD. Evidence-based health policy--lessons from the Global Burden of Disease Study. Science 1996; 274(5288):740-3.
3. Auerbach O, Hammond EC, Garfinkel L, Benante C. Relation of smoking and age to emphysema,whole-lung section study. N Engl J Med 1972;286(16):853-7.
4. Lebowitz MD, Burrows B. Quantitative relationships between cigarette smoking and chronic productive cough. Int J Epidemiol 1977;6(2):107-13.
5. Burrows B, Knudson RJ, Cline MG, Lebowitz MD, Quantitative relationships between cigarette smoking and ventilatory function. Am Rev Respir Dis 1977;115(2):195- 205.
6. Seely JE, Zuskin E, Bouhuys A. Cigarette smoking: objective evidence for lung damage in teen-agers. Science 1971;172(984):741-3.
7. Nadel JA, Comroe JH Jr. Acute effects of inhibition of cigarette smoke on airway conduction. J Appl Physiol 1961;16:713-6.
8. Hogg JC, Macklem PT, Thurlbeck MW, Site and nature of airway obstruction in chronic obstructive lung disease. N Engl J Med 1968;278(25):1355-60.
9. Berend N, Wright JL, Thurlbeck MW, Marlin GE, Woolcock AJ. Small airways disease: reproducibility of measurements and correlation with lung function. Chest 1981;79(3):263-8.
10. Wright JL, Lawson LM, Pare PD, Kennedy S, Wiggs B, Hogg JC.The detection of small airways disease. Am Rev Respir Dis 1984;129(6):989-94.
11. Standardization of spirometry, 1994 update American Thoracic Society. Am J Respir Crit Car Med 1995;152(3):1107-36.

12. Zuskin E, Mitchell CA, Bouhuys A. Interaction between effects of beta blockade and cigarette smoke on airways. J Appl physiol 1974;36(4):449-52.
13. Lange P, Groth S, Nyboe GJ, Mortensen J, Appleyard M, Jensen G, Schnohr P. Effects of smoking and changes in\ smoking habits on the decline of FEV1. Eur Respir J 1989;2(9):811-6.
14. Bosken CH, Wiggs BR, Pare PD, Hogg JC. Small airway dimensions in smokers with obstruction to airflow. Am Rev Respir Dis 1990;142(3):563-70.
15. Eidelman DH, Ghezzo H, Kim WD, Hyatt RE, Cosio MG. Pressure-volume curves in smokers. Comparison with alpha- 1-antitrypsin deficiency. Am Rev Respir Dis 1989;139(6):1452-8.
16. Aparici M, Fernandez Gonzalez AL, Alegria E. Respiratory function tests. Differences between smokers and nonsmokers. Effects of withdrawal. Rev clin Esp 1993;192(4):169-72.
17. Nemery B, Moavero NE, Brasseur L, Stanescu DC. Changes in lung function after smoking cessation: an assessment from a cross -sectional survey. Am Rev Respir Dis 1982;125(1):122-4.
18. Lubinski W, Targowski T, Frank-Piskorska A. Evaluation of the influence of tobacco smoking on pulmonary function in young men. Pneumonol Alergol pol 2000;68(5-6):226- 31.
19. Goodman RM, Yergin BM, Landa JF, Golivanux MH, Sackner MA. Relationship of smoking history and pulmonary function tests to tracheal mucous velocity in nonsmokers, young smokers, ex-smokers, and patients with chronic bronchitis. Am Rev Respir Dis 1978;117(2):205- 14.
20. Welty C, Weiss ST, Tager IB, Munoz A, Becker C, Speizer FE, Ingram RH Jr. The relationship of airways responsiveness to cold air, cigarette smoking, and atopy to respiratory symptoms and pulmonary function in adults. Am Rev Respir Dis 1984;130(2):198-203.
21. Sherrill DL, Lebowitz MD, Knudson RJ, Burrows B. Longitudinal methods for describing the relationship between pulmonary function, respiratory symptoms and smoking in elderly subjects: the Tucson Study. Eur Respir J 1993;6(3):342-8.
22. Verschakelen JA, Scheinbaum K, Bogaert J, Demedts M, Lacquet LL, Baert AL. Expiratory CT in cigarette smokers: correlation between areas of decreased lung attenuation, pulmonary function tests and smoking history. Eur Radiol1998;8(8):1391-9.

Cite this article as: Parkhad SB, Palve SB. Pulmonary function tests and their reversibility in saudi arabian smokers. Natl J Physiol Pharm Pharmacol 2014; 4:29-33.
Source of Support: **Nil**
Conflict of interest: **None declared**