Eur Respir J
1990, 3, 752–759

Short-term smoking reduction is associated with reduction in measures of lower respiratory tract inflammation in heavy smokers

S.I. Rennard, D. Daughton, J. Fujita, M.B. Oehlerking, J.R. Dobson, M.G. Stahl, R.A. Robbins, A.B. Thompson

Short-term smoking reduction is associated with reduction in measures of lower respiratory tract inflammation in heavy smokers. S.I. Rennard, D. Daughton, J. Fujita, M.B. Oehlerking, J.R. Dobson, M.G. Stahl, R.A. Robbins, A.B. Thompson.
ABSTRACT: **The beneficial effect of short-term smoking reduction in reducing lower respiratory tract inflammation was assessed in 15 healthy heavy smokers. All underwent fibreoptic bronchoscopy and bronchoalveolar lavage and were then treated with at least 20 mg of nicotine gum daily. Self-reported cigarette consumption decreased from 50.7±2.3 to 18.8±1.5 ($p<0.001$) cigarettes daily, and expired CO decreased from 48.5±2.5 to 27.3±2.5 ppm ($p<0.001$). After two months, repeat bronchoscopy and bronchoalveolar lavage revealed that bronchial inflammation, as assessed by direct inspection, neutrophilia of bronchial lavage fluid, and the number of alveolar macrophages, the number of alveolar neutrophils and the concentration of neutrophil elastase alpha$_1$-antiprotease complex in alveolar lavage fluid, had improved significantly. The present study suggests that smoking reduction may be associated with an improvement in lower respiratory tract inflammation in heavy smokers and may, if persistent, be an alternative for smokers who cannot, or do not wish, to quit.**
Eur Respir J., 1990, 3, 752–759.

University of Nebraska Medical Center, Dept of Internal Medicine, Division of Pulmonary and Critical Care Medicine, 600 South 42nd Street, Omaha, Nebraska 68198-2465, USA.

Correspondence: Dr S.I. Rennard, University of Nebraska Medical Center, Dept of Internal Medicine, Division of Pulmonary and Critical Care Medicine, 600 South 42nd Street, Omaha, Nebraska 68198-2465, USA.

Keywords: Airway inflammation; bronchoalveolar lavage; smoking reduction.

Received: June 21, 1989; accepted after revision February 13, 1990.

This work was supported, in part, by a grant from the Merrell Dow Pharmaceutical Corporation.

Cigarette smoking continues to be an extremely tenacious addiction. Current evidence indicates that nicotine, like alcohol and opiates, is a potent psychoactive, dependence-producing drug [1, 2]. Most smokers state that they want to quit, but only one in three stops permanently before the age of 60 yrs [3]. While smoking cessation is unquestionably the most important therapeutic goal of intervention, there are many smokers who never achieve permanent abstinence. For them, reducing the degree of lifetime cigarette exposure may be a therapeutic alternative. In support of this, there is cross-sectional data demonstrating a relationship between dose of smoking and smoke-related bronchial carcinoma [4]. This makes it reasonable to explore possible health benefits of reducing smoking in a defined population.

The present study was designed to assess whether smoking reduction would be associated with evaluable benefits that might be a reasonable therapeutic goal. We specifically sought to determine whether smoking reduction in a group of heavy smokers would be associated with measurable improvement in abnormalities which are present in the lower respiratory tract of smokers, including increased macrophages, increased neutrophils, and increased levels of the neutrophil derived protease, elastase. Reduction was achieved in the study group, and it was associated with improvements in lower respiratory tract inflammation. These results suggest that smoking reduction may be a reasonable therapeutic goal in heavy smokers who cannot or do not wish to quit.

Methods

Patients

Fifteen healthy volunteers (aged 21–44 yrs), who consumed a minimum of two packs of cigarettes daily, were studied under a University of Nebraska Medical Center Institutional Review Board approved protocol, after informed consent had been obtained. Heavy smokers were chosen for two reasons. Firstly, as observed by JAFFE and KANZLER [2], they tend to be the most sensitive to elevated plasma nicotine levels. Such smokers reduce their cigarette intake when the plasma nicotine levels become unusually high. This made it seem more likely that the smokers could achieve reduction when exogenous nicotine was administered (see below). Secondly, it was expected that the measurable effects of

smoking would be easier to observe in heavy smokers. Because this was to be a smoking reduction study, all volunteers who expressed a current interest in quitting were encouraged to do so and were excluded from the investigation. All participants (9 males, 6 females) had normal results on physical examination, ECG, chest radiograph, and blood chemistries. Spirometry, except for reduced flows at low lung volumes, was also normal. All subjects completed all phases of the study.

For comparison purposes, a group of 15 normal, nonsmoking volunteers (aged 18–36 yrs) were also studied. All had normal physical examinations, pulmonary function tests, chest radiographs and no history of any lung disease. All underwent bronchoscopy and bronchoalveolar lavage under a University of Nebraska Institutional Review Board approved protocol after informed consent had been obtained. One subject who had obvious evidence of bronchitis at the time of bronchoscopy was questioned again after the study and admitted to smoking marijuana cigarettes. This subject was an "outlier" for several of the parameters assessed. As "exit interviews" were not routine and as the subject met all "entry" criteria, it was felt to be most valid to include this subject in the normal group for statistical purposes. Exclusion of this subject only increases the differences observed.

Procedures

Smoking reduction. All smokers agreed to reduce their cigarette consumption by 50%. Several lines of evidence suggested that nicotine replacement therapy may be a reasonable aid to achieve smoking reduction. Firstly, smokers tend to adjust their nicotine intake to their individually preferred levels [5, 6]. Secondly, smokers reduce their smoking when nicotine is administered by aerosol or intravenously [7, 8]. Thirdly, smokers significantly reduce their cigarette consumption following treatment with gum delivering 4 or 8 mg nicotine [8]. Therefore, all subjects in the current investigation were instructed to use at least ten 2 mg nicotine-polacrilex gum (Nicorette, Merrell Dow) daily. By administering nicotine through the gum, it was hoped that desire to smoke would decrease making reduction easier to achieve. The effectiveness of this intervention as a strategy for smoking reduction was not compared with other interventions, although the smoking behaviour and the subjective responses of the subjects were recorded. Participants were given forms on which to record daily cigarette and nicotine gum consumption. To confirm smoking history, expired carbon monoxide (CO) was measured (Interscan Model No. 1146, Interscan Corp., Chatsworth, CA) at entry and at one and two months [9]. The time of day of the testing was controlled by scheduling the two month CO assessment at roughly the same time as the entry meeting. Expired CO was also measured at one month, but the time of testing was arranged for patient convenience, generally late afternoon or early evening.

Bronchoscopy

To determine whether a reduction in cigarette consumption would result in reduced lower respiratory tract inflammation, participants underwent a bronchoscopy and bronchoalveolar lavage (BAL) [10, 11] prior to starting their smoking reduction programme. In all cases, smokers were given topical anaesthesia to permit the flexible fibreoptic bronchoscope to be passed transorally. This procedure was repeated at the conclusion of the two month smoking reduction trial. For baseline comparisons only, 15 normal nonsmoking volunteers were evaluated once.

Bronchitis index

During bronchoscopy, two physicians independently rated bronchial inflammation by visual examination. Four characteristics, friability, erythema, oedema and secretions were rated on a four point scale; 0–3 in each of the five lobes and lingula [11]. Normal = a score of 0; mild = I; moderate = 2; severe = 3. The sum of each of the four rated characteristics was totalled from all six lung sites, and the two independent observations were averaged to develop a final bronchitis index. The correlation between the two scorers was excellent, $r=0.92$, $p<0.001$.

Bronchoalveolar lavage

Bronchoalveolar lavage was performed after gently wedging the bronchoscope in a segmental or subsegmental bronchus [10, 11]. Five 20 ml aliquots of sterile saline were infused into each of three lobes. The fluid from the first aliquot in each lobe, enriched for bronchial material, was collected and analysed separately [11, 12]. The remaining four aliquots from each lobe, which were enriched for alveolar material, were pooled.

Cytological examination and elastase determination

To prepare samples for cytological examination, BAL fluid was filtered through a nylon gauze to remove excess mucus. Total cell numbers were counted prior to further processing using a haematocytometer. One hundred thousand cells were centrifuged at 165 g on a cytocentrifuge (Shandon) for 10 min and stained using Diff-Quik (American Scientific). Cell differentials were counted twice on 200 cells and averaged in both the bronchial and alveolar samples. Blood and lavage samples were stored for later analysis of urea and albumin concentrations [13, 14] at -80°C. To evaluate elastase burden, elastase activity was assayed using a synthetic substrate [15] and elastase alpha$_1$-antitrypsin complex in the alveolar samples was assayed with a sandwich method enzyme-linked immunosorbent assay (ELISA) [16]. Both urea, measured enzymatically, and albumin,

measured by ELISA, were determined and used to correct for variable dilution of the lung epithelial lining fluid by the saline during the BAL [13].

Statistics

Comparisons between smokers and normals were made with the unpaired Wilcoxon test. Student's paired T-test was utilized to assess the two month changes in CO values and average cigarette consumption. The paired Wilcoxon test was used to assess changes in all BAL parameters.

Results

Smoking reduction assessment

All participants reported a consistent decrease in cigarette consumption (fig. 1A). Overall, self-reported cigarette consumption fell from 50.7±2.3 at entry to 18.8±1.5 cigarettes a day after two months ($p<0.001$). Reduction was confirmed by expired CO which decreased from 48.5±2.5 ppm to 27.3±2.5 ppm at two months ($p<0.001$) (fig. 1B). The mean expiratory CO concentration at one month seems lower than at two months, suggesting some increase in smoking during the second month. As the measurements at the beginning and end were controlled for time of day and that at one month was not, however, this inference is not definitive.

Even though smokers achieved smoking reduction, all but two reported that the task was difficult. Fourteen participants reported symptoms which may have been secondary to nicotine withdrawal: craving for cigarettes (n=14), irritability (n=12), anxiety (n=10), restlessness (n=10), difficulty concentrating (n=8), headache (n=6), and drowsiness (n=3).

Bronchitis index

Despite the fact that all study subjects were selected to be asymptomatic and have normal pulmonary functions, abnormally appearing airways consistent with mild bronchitis was regularly observed (fig. 2). The mean bronchitis index of smokers was 8.5±0.9, significantly increased compared to the normal nonsmokers, 1.9±0.8 ($p<0.01$). Smoking reduction was associated with a significant reduction in the visible evidence for bronchitis as the mean bronchitis index fell to 6.5±0.6 ($p<0.05$).

Cell recovery by bronchoalveolar lavage

As expected, increased numbers of cells were recovered from the BAL of smokers. This was entirely due to an increased recovery of cells in the alveolar sample (fig. 3) and not to an increase in cells recovered in the bronchial sample which were no different among the three study groups. The mean recovery of cells in the alveolar lavage of smokers prior to reduction was $104.3\pm9.4 \times 10^6$, approximately fourfold greater than that

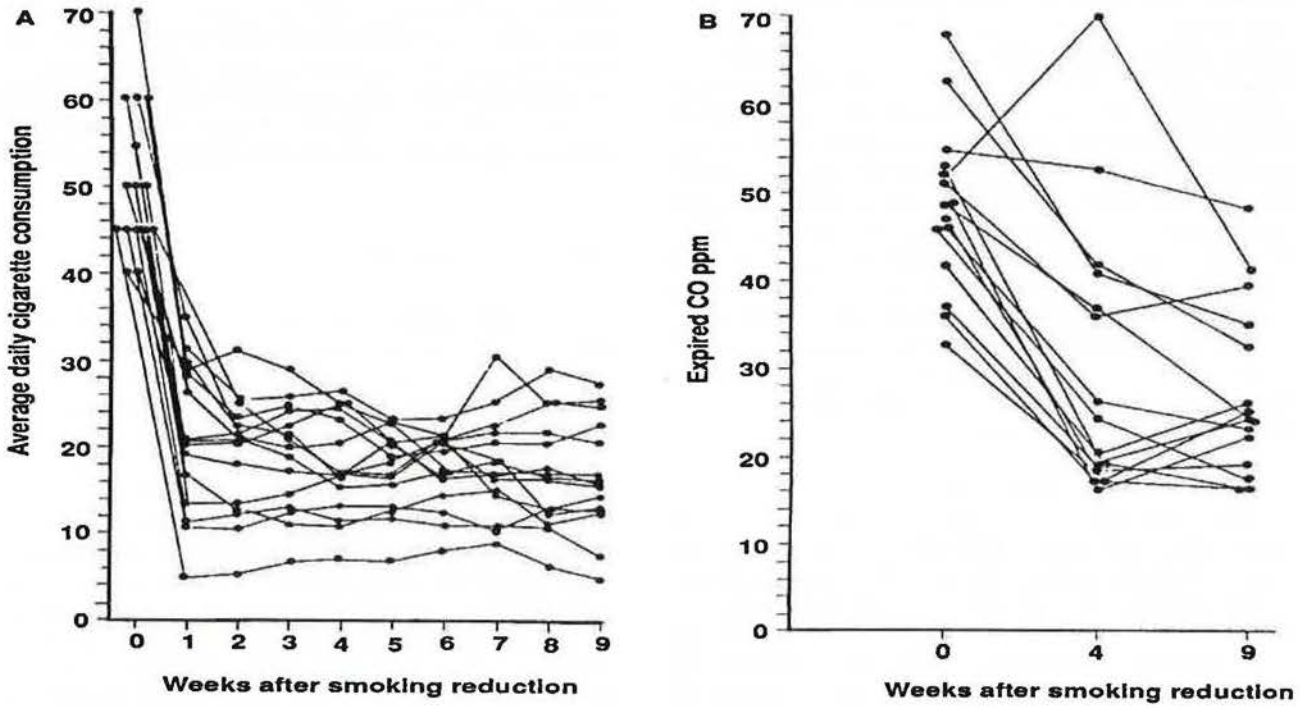

Fig. 1. – Smoking status. A: Smoking status as determined by self-report. Vertical axis: cigarettes per day; horizontal axis: weeks of cessation. B: Smoking status as assessed by expired CO. Vertical axis: expired CO (ppm); horizontal axis: weeks of study.

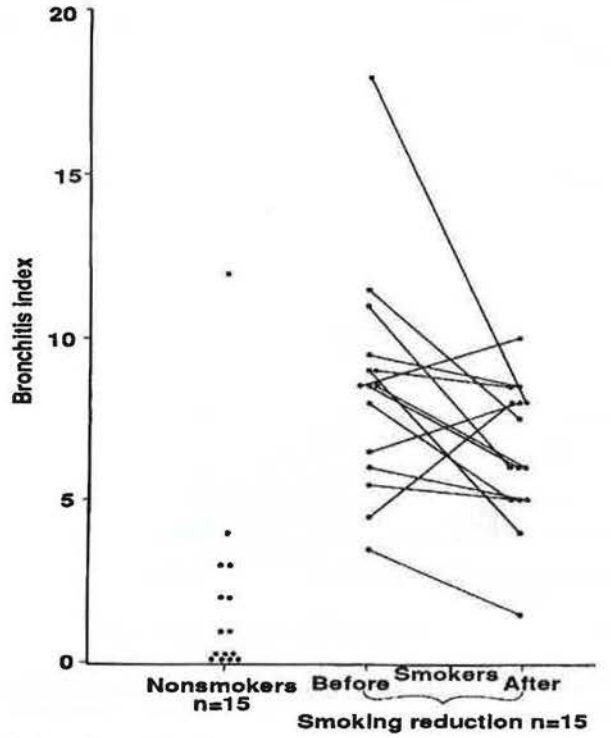

Fig. 2. – Bronchitis index. The severity of airways inflammation was assessed by two observers at the time of bronchoscopy (see Methods). Vertical axis: bronchitis index; horizontal axis: study group before and after reduction; normal nonsmokers are included for comparison.

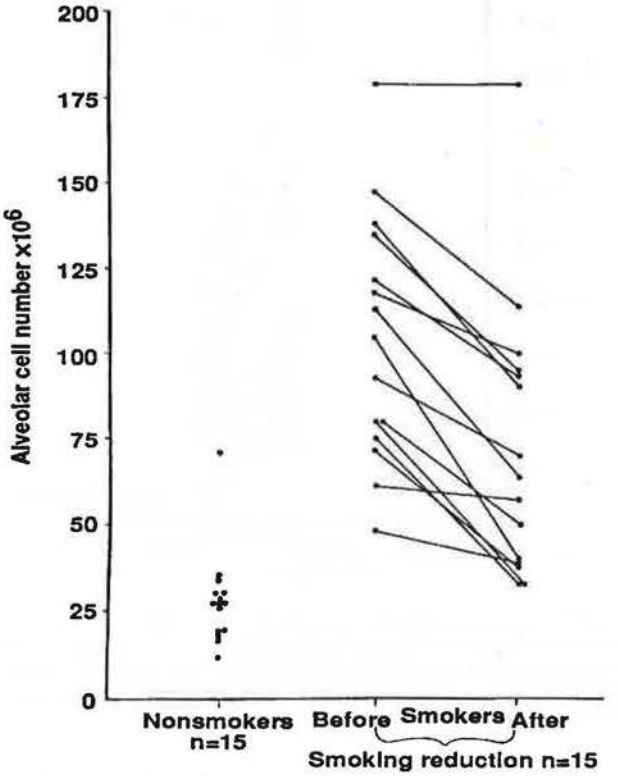

Fig. 3. – Quantitative alveolar cell recovery by bronchoalveolar lavage. Cells recovered in the alveolar sample by bronchoalveolar lavage were counted by haemocytometer (see Methods). Vertical axis: total cells recovered; horizontal axis: study group before and after reduction; normal nonsmokers are included for comparison.

of normal nonsmoking volunteers, $27.3\pm3.13 \times 10^6$ ($p<0.001$). After smoking reduction, mean alveolar cell recovery was $73.1\pm10.3 \times 10^6$, representing a significant decrease compared to values before reduction ($p<0.01$), but still increased compared to normal nonsmoking volunteers.

The increased recovery of cells in the alveolar samples of normal smokers, and the decrease following smoking reduction was not due to variable recovery of lavage fluid. When expressed per ml of lavage fluid recovered, normal smokers had increased mean concentration of cells ($0.69\pm0.07 \times 10^6$ cells·ml^{-1}) recovered in lavage fluid compared to normal nonsmokers ($0.16\pm0.02 \times 10^6$ cells·ml^{-1}), and this decreased significantly after smoking reduction ($0.52\pm0.06 \times 10^6$ cells·ml^{-1}) ($p<0.01$). The same relationship was also observed when the absolute concentrations of cells in lung epithelial lining fluid were estimated using urea as an internal marker of dilution: $52.1\pm10.4 \times 10^6$ cells·ml^{-1} before *vs* $27.4\pm2.0 \times 10^6$ cells·ml^{-1} after reduction compared to $10.4\pm1.1 \times 10^6$ cells·ml^{-1} in normal nonsmokers ($p<0.05$, all comparisons). There was no difference in the mean number of cells recovered in the bronchial samples among the three groups, ($4.1\pm0.6 \times 10^6$ normals, $3.6\pm0.6 \times 10^6$ smokers before and $5.9\pm1.3 \times 10^6$ smokers after reduction). Bronchial sample cell recoveries were also similar when compared on a concentration basis using either volume of recovered lavage or urea in the bronchial sample (data not shown).

Analysis of cell types recovered by bronchoalveolar lavage

Macrophages comprised the majority of cells recovered in both the bronchial and alveolar samples. As expected, bronchial samples were relatively enriched for ciliated epithelial cells compared to the alveolar samples for both study groups; they were also enriched for neutrophils. Smokers had a significantly greater mean percentage of neutrophils (20.7 ± 2.6) in their bronchial samples than did nonsmokers (9.6 ± 1.2, $p<0.01$) and this decreased with smoking reduction to 12.6 ± 2.0 ($p<0.05$, fig. 4A). Smokers also had a significantly greater percentage of neutrophils in their alveolar samples (5.7 ± 1.3) which also tended to decrease with smoking reduction (3.3 ± 0.8) (fig. 4B), but this did not reach statistical significance ($p=0.06$). The total number of neutrophils in the alveolar sample of smokers, however, decreased significantly with reduced cigarette intake ($5.9\pm1.5 \times 10^6$ before *vs* $2.6\pm0.7 \times 10^6$ after, $p<0.05$) (fig. 5).

Neutrophil elastase

Since one mechanism by which neutrophils can injure the lung is thought to be through the release of the potent protease, neutrophil elastase, neutrophil elastase activity was assayed in BAL fluids. No fluid contained active elastase. Using an ELISA method, however, antigenic

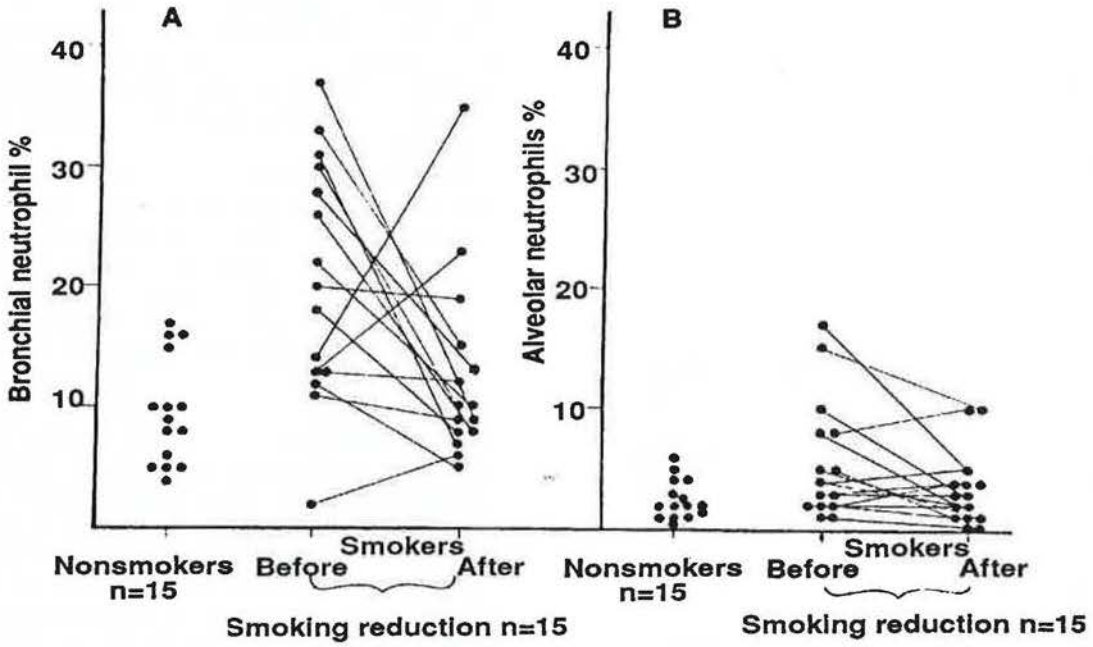

Fig. 4. – Lower respiratory tract neutrophilia. Cell differential counts were performed on 400 cells on a Diff-Quik stained cytocentrifuge preparation. Vertical axis: % neutrophils; horizontal axis: study group before and after reduction; normal nonsmokers are included for comparison. A; bronchial; B: alveolar.

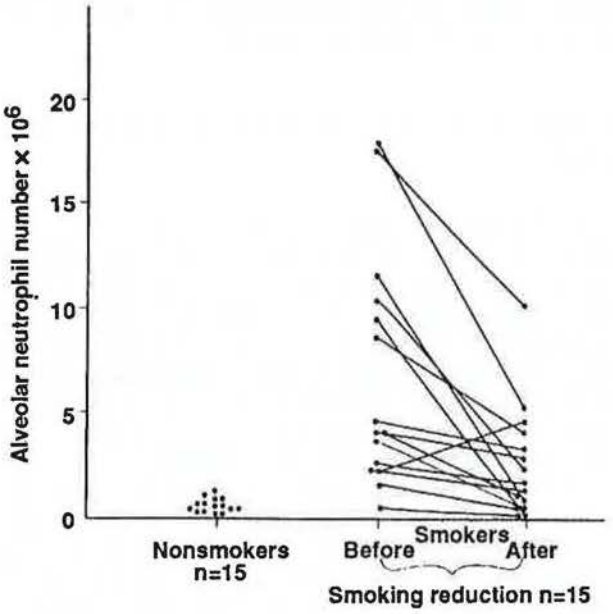

Fig. 5. – Number of alveolar neutrophils recovered. The number of alveolar neutrophils recovered for study subjects before and after reduction and normal nonsmokers for comparison is shown on the vertical axis. Vertical axis: total number of neutrophils recovered (millions).

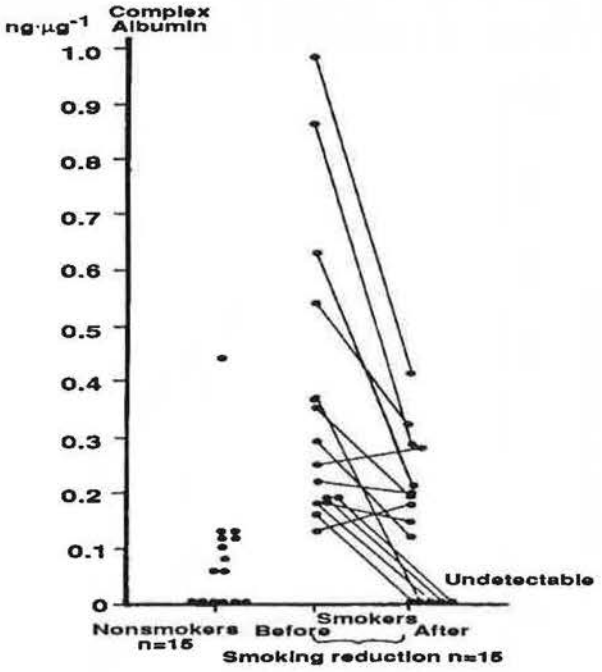

Fig. 6. – Neutrophil elastase alpha$_1$-antiprotease complex corrected for albumin. The concentration of neutrophil elastase complexed with alpha$_1$-antiprotease was determined by ELISA (see Methods). Elastase complex was corrected for bronchoalveolar lavage albumin (ng·mg^{-1}). ELISA: enzyme-linked immunosorbant assay.

neutrophil elastase: alpha$_1$-antitrypsin complex could be detected in the alveolar lavage fluids of the normal smokers. The amount of antigenic elastase complex (adjusted for albumin) was significantly elevated in smokers compared to nonsmokers and decreased significantly with smoking reduction ($p<0.01$) (fig. 6). Estimating elastase complex concentration in lung epithelial fluid using urea yielded similar findings. The lack of activity of the neutrophil elastase could be accounted for, since all of the detectable neutrophil elastase was present as complex with alpha$_1$-antiprotease.

Discussion

The present study suggests that smoking reduction may be a potential therapeutic goal for heavy smokers who cannot or who do not wish to quit. Short-term smoking reduction was clearly associated with an improvement in a number of inflammatory features present in the lower respiratory tract, specifically: a decrease in the severity of visually observed, but subclinical, bronchitis; a reduction in the number of neutrophils present in the lower airways; and a decrease in the amount of neutrophil elastase detected in the lung. The potential benefits of long-term smoking reduction remain to be determined, but may be reasonable to explore as a therapeutic option in selected smokers.

The subjects of the current study were all "normal" smokers in that clinical assessment, chest X-ray and spirometry, except for reduced expiratory flows at low volumes, were all normal. Biopsies would undoubtedly provide the best measure of lower respiratory tract inflammation. Nevertheless, while biopsies were not performed, several lines of evidence suggest improvement in lower respiratory tract inflammation: 1) reduction in inflammatory cells; 2) reduction in an inflammatory cell mediator, neutrophil elastase; and 3) improvement in directly observed airways inflammation.

In an autopsy study of normal smokers, NIEWOEHNER *et al.* [17] demonstrated a consistent accumulation of pigment-laden macrophages in the respiratory bronchioles, a lesion termed "small airways disease" [17, 18]. It has been suggested that "small airways disease" may be the precursor of fixed obstructive lung disease [19–23] . Thus, improvement in "small airways disease" might be an initial goal in the prevention of emphysema. The BAL correlate of "small airways disease" is unknown. Smokers, however, consistently have increased recoveries of pigment-laden macrophages compared to nonsmokers [24, 25]. It is likely that the macrophages which accumulate in the airways of the respiratory bronchioles, the hallmark basis of small airways disease, are being sampled by BAL. The findings in the present study, that the number of alveolar macrophages recovered decreases with smoking reduction is, therefore, consistent with an improvement in the small airways inflammation following smoking reduction.

The mechanisms which lead to fixed airways obstruction are not completely understood. Cigarette smoke, however, can lead to the release of neutrophil chemoattractants [25], and the elastase contained in the secretory granules of these cells can degrade the structural proteins of the lung connective tissue, thus contributing to lung destruction [26, 27]. In addition, elastase infusion into airways can cause the goblet cell metaplasia characteristic of chronic bronchitis [28]. The current study confirms earlier observations that smokers have increased numbers of alveolar neutrophils recovered by bronchoalveolar lavage [24–26]. It also confirms the detection of neutrophil elastase [29, 30] in the lower respiratory tract. While all of the elastase present appeared to have been inactivated by $alpha_1$-antiprotease, in contrast to the previous study of JANOFF *et al.* [29], variations in method of elastase detection and in the protocol of smoking prior to bronchoscopy probably account for the differences. Nevertheless, it is likely that prior to its inactivation, the elastase has the potential to attack lung structural proteins. The findings in the present study, that both total alveolar neutrophils and neutrophil elastase decrease following smoking reduction, suggest that the "elastase burden" of the lower respiratory tract can be reduced by smoking reduction. Clearly, not all smokers develop emphysema, and the determinants of individual susceptibility are not fully known. Thus, while the connection between elastase burden and emphysema is not fully understood, it is likely that a reduction in elastase burden may lessen the risk of developing emphysema.

Chronic bronchitis is a frequent consequence of chronic cigarette smoke exposure. While none of our subjects had the clinical criteria for a diagnosis of chronic bronchitis, all were heavy smokers and had visible abnormalities of the lower respiratory tract. Since our subjects were paid volunteers, it is possible that they had bronchitis, but denied symptoms. Evaluation of patients with the clinical diagnosis of chronic bronchitis, however, has revealed more severe abnormalities for both the visually observed airways abnormalities and for the associated bronchial neutrophilia than those seen in the current study population [31, 32]. Thus, it seems likely that the visually observed bronchitis and bronchial neutrophilia represents a subclinical abnormality. Whether it represents an early lesion which would progress to clinically manifest disease is unclear. Whether smoking reduction would have a similar effect in patients with clinically manifest bronchitis is, therefore, unknown.

Smoking reduction in the current study, however, was not easily achieved, a very high number of symptoms associated with nicotine withdrawal being reported. A different strategy for reduction may have been better tolerated. There was a similar decrement in expired CO than in the self-reported cigarette consumption in our study group. Smokers who reduce smoking compensate for decreased numbers of cigarettes by smoking each more deeply and thoroughly [5]. This suggests that the nicotine replacement used was not completely effective.

Nicotine is a biologically active drug [34, 35]. It may be directly responsible for some of the adverse effects of cigarette smoking and, thus, while nicotine replacement may reduce some of the hazards of cigarette smoking, other strategies to achieve smoking reduction may have much greater benefit than nicotine replacement. Moreover, a direct effect of the nicotine gum as an anti-inflammatory is not excluded by the data available.

Caution must be exercised in interpreting the implications of this study. The data presented are not unequivocal support for smoking reduction as a therapeutic strategy, but merely show improvement in subclinical lower respiratory tract inflammation. It is not known whether similar inflammatory changes and improvements with smoking reduction could be observed in lighter smokers. Smoking reduction will never be a

substitute for cessation. Nevertheless, in heavy smokers who cannot achieve cessation, the present study suggests reduction may be a therapeutic option, in so far as it is definitely sustained. The best strategy to achieve permanent smoking reduction remains to be determined. Based on the results of the current study, a prospective double-blind investigation of the long-term results of smoking reduction techniques seems warranted. Finally, using BAL to assess lower respiratory tract inflammation promises to provide objective criteria by which the efficacy of smoking reduction or cessation can be assessed, even in a clinically normal study population.

Acknowledgement: The authors greatly appreciate the assistance of L. Richards with the preparation of this manuscript.

References

1. Henningfield JE, Jasinski DR. – Human pharmacology of nicotine. *Psycho Pharmacol Bull*, 1983, 19, 413–415.
2. Jaffe JH, Kanzler M. – Smoking as an addictive disorder. *In*: Cigarette smoking as a dependence process. N. Kransneger ed., National Institute on Drug Abuse Research Monograph 23, Washington, D.C., pp. 4–23.
3. Russell MAH, Jarvis MJ. – Theoretical background and direct use of nicotine chewing gum. *In:* Pharmacological adjuncts in smoking cessation. J. Grebowski, S.M. Hall eds, National Institute on Drug Abuse Research Monograph 53, 1985, United States Printing Office, Washington, D.C., pp. 110–130.
4. Doll R, Peto R. – Cigarette smoking and bronchial carcinoma: dose and time relationships among regular smokers and lifelong nonsmokers. *J Epidemiol Commun Health*, 1978, 32, 303–313.
5. Ashton H, Stepney R, Thompson JW. – Self-titration by cigarette smokers. *Br Med J*, 1979, 279, 357–360.
6. Herning RI, Jones RT, Bachman J, Mines AH. – Puff volume increases when low nicotine cigarettes are smoked. *Br Med J*, 1981, 283, 187–193.
7. Jarvik ME, Glick SD, Nakamara RK. – Inhibition of cigarette smoking by orally administered nicotine. *Clin Pharmacol Ther*, 1970, 11, 574–575.
8. Lucchesi BR, Schuster CR, Emley GS. – The role of nicotine as a determinant of cigarette smoking frequency in man with observation of certain cardiovascular effects associated with the tobacco alkaloid. *Clin Pharmacol Ther*, 1967, 8, 789–796.
9. Prignot J. – Quantification and chemical markers of tobacco-exposure. *Eur J Respir Dis*, 1987, 70, 1–7.
10. Reynolds HY, Newball HH. – Analysis of proteins and respiratory cells obtained from human lungs by bronchial lavage. *J Lab Clin Med*, 1974, 84, 559–573.
11. Linder J, Rennard SI. – *In:* Bronchoalveolar lavage. ASCP Press, Chicago, 1988.
12. Ghafouri MA, Robbins RA, Rasmussen JK, Sears K, Clayton M, Ertl RF, Rennard SI. – Use of sequential bronchoalveolar lavage to enrich for "bronchial" and "alveolar" material. *Clin Res*, 1985, 33, 464A.
13. Rennard SI, Bassett G, Lecossier D, O'Donnell KM, Pinkston P, Martin PG, Crystal RG. – Estimation of volume of epithelial lining fluid recovered by lavage using urea as a marker of dilution. *J Appl Physiol*, 1986, 60, 532–538.
14. Rennard SI, Crystal RG. – Fibronectin in human bronchoalveolar lavage fluid: elevation in patients with interstitial lung disease. *J Clin Invest*, 1981, 69, 113–122.
15. Bieth J, Speiss B, Wermuth CG. – The synthesis and analytical use of a highly sensitive and convenient substrate of elastase. *Biochem Med*, 1974, 11, 350–357.
16. Brower MS, Harpel PC. – Alpha$_1$-antitrypsin human leukocyte elastase complexes in blood: quantification by an enzyme-linked differential antibody immunoassay and comparison with alpha$_2$-plasmin inhibitor-plasmin complexes. *Blood*, 1983, 62, 842–849.
17. Niewoehner DE, Kleinerman J, Rice DB. – Pathologic changes in the peripheral airways of young cigarette smokers. *N Engl J Med*, 1974, 291, 755–758.
18. Macklem PT, Thurlbeck WM, Fraser RG. – Chronic obstructive disease of small airways. *Ann Intern Med*, 1971, 74, 167–171.
19. McFadden Jr, Linden DA. – A reduction in maximum mid-expiratory flow rate. A spirographic manifestation of small airways disease. *Am J Med*, 1972, 52, 725–737.
20. Bode FR, Dosman J, Martin RR, Macklem PT. – Reversibility of pulmonary function abnormalities in smokers. A prospective study of early diagnostic tests of small airways disease. *Am J Med*, 1975, 59, 43–52.
21. Buist AS, VanFleet DL, Ross BB. – A comparison of conventional spirometric tests and the test of closing volume in an emphysema screening center. *Am Rev Respir Dis*, 1973, 107, 735–743.
22. Macklem PT. – Obstruction in small airways. A challenge to medicine. *Am J Med*, 1972, 52, 721–724.
23. Reynolds HY, Merrill WW. – Airway changes in young smokers that may antedate chronic obstructive lung disease. *Med Clin North Am*, 1981, 65, 667–689.
24. Reynolds HY. – Bronchoalveolar lavage. *Am Rev Respir Dis*, 1987, 135, 250–263.
25. Hunninghake GW, Gadek J, Crystal R. – Mechanism by which smoker attracts polymorphonuclear leukocytes to lung. *Chest*, 1980, 77, 273–276.
26. Senior RM, Tegner H, Kuhn C, Ohlsson K, Starcher BC, Pierce JA. – The induction of pulmonary emphysema with leukocyte elastase. *Am Rev Respir Dis*, 1977, 116, 469–475.
27. Janoff A. – Elastases and emphysema. Current assessment of the protease-antiprotease hypothesis. *Am Rev Respir Dis*, 1985, 132, 417–433.
28. Snider GL, Lucey EC, Christensen TG, Stone PJ, Calore JD, Cantanese A, Franzblan C. – Emphysema and bronchial secretory cell metaplasia induced in hamsters by human neutrophil products. *Am Rev Respir Dis*, 1984, 129, 155–160.
29. Janoff A, Raju L, Dearing R. – Levels of elastase activity in bronchoalveolar lavage fluids of healthy smokers and nonsmokers. *Am Rev Respir Dis*, 1983, 127, 540–544.
30. Jochum M, Pelletier A, Boudier C, Pauli G, Bieth JG. – The concentration of leukocyte elatase-α_1 proteinase inhibition complex in broncholaveolar lavage fluids of healthy human subjects. *Am Rev Respir Dis*, 1985, 132, 913–914.
31. Thompson AB, Daughton DM, Oehlerking M, Bulmash M, Stahl M, Robbins RA, Linder J, Rennard SI. – Comparison of bronchoalveolar lavage findings of chronic bronchitic patients with healthy adults. *Am Rev Respir Dis*, 1987, 135, A443.
32. Martin TR, Raghu G, Maunder RJ, Springmeyer SC. – The effects of chronic bronchitis and chronic airflow obstruction on lung cell populations recovered by bronchoalveolar lavage. *Am Rev Respir Dis*, 1985, 132, 254–260.

Une réduction brève des habitudes tabagiques est associée à une diminution des signes d'inflammation du tractus respiratoire inférieur chez les grands fumeurs. S.I. Rennard, D. Daughton, J. Fujita, M.B. Oehlerking, J.R. Dobson, M.G. Stahl, R.A. Robbins, A.B. Thompson.

RÉSUMÉ: Un effet bénéfique d'une réduction à court terme de l'habitude tabagique, dans les sens d'une diminution de l'inflammation du tractus respiratoire inférieur, a été apprécié chez 15 grands fumeurs sains. Tous ont subi une fibro-bronchoscopie et un lavage broncho-alvéolaire, et furent traités ensuite par au moins 20 mg de chewing-gum à la nicotine par jour. La consommation de cigarettes a diminué, selon leurs déclarations, de 50.7±2.3 à 18.8±1.5 cigarettes par jour ($p<0.001$). Le CO expiré a diminué de 48.5±2.5 à 27.3±2.5 ppm ($p<0.001$). Après deux mois, une nouvelle fibroscopie avec lavage broncho-alvéolaire a montré que l'inflammation bronchique estimée par l'examen endoscopique, la neutrophilie du liquide de lavage bronchique, et le nombre de macrophages alvéolaires, ainsi que le nombre de neutrophiles alvéolaires et la concentration du complexe élastase neutrophile $alpha_1$-antiprotéase dans le liquide de lavage alvéolaire, s'étaient tous améliorés de façon significative. Cette étude suggère que la réduction du tabagisme peut s'accompagner d'une amélioration de l'inflammation du tractus respiratoire inférieur chez les grands fumeurs, et pourrait être, si elle persiste, une alternative pour les fumeurs qui ne peuvent ou ne désirent pas cesser.

Eur Respir J., 1990, 3, 752–759.