

23. Hartmann JM, Booth RW: Friedreich's ataxia: a neurocardiac disease. *Am Heart J* 60:716-720, 1960
24. Eger EI II: Isoflurane: a review. *ANESTHESIOLOGY* 55:559-576, 1981
25. Bureau M, Ngassam P, Lemieux B, Trias A: Pulmonary function studies in Friedreich's ataxia. *Can J Neur Sci* 3:343-347, 1976
26. Kume M, Zin T, Oyama T: Anesthetic management of the patient with Friedreich's ataxia—a case report. *JPN J Anesth* 25:877-880, 1976
27. Peyronnard JM, Lapointe L, Bouchard JP, Lamontagne A, Lemieux B, Barbeau A: Nerve conduction studies and electromyography in Friedreich's ataxia. *Can J Neur Sci* 3:313-317, 1976
28. Shapcott D, Melancon S, Butterworth RF, et al: Glucose and insulin metabolism in Friedreich's ataxia. *Can J Neur Sci* 3:361-364, 1976
29. Lehner JT, Van Peteghem PK, Leatherman KD, Brink MA: Experience with an intraoperative autogenous blood recovery system in scoliosis and spinal surgery. *Spine* 6:131-133, 1981
30. Du Toit G, Relton JES, Gillespie R: Acute haemodilution and autotransfusion in the surgical management of scoliosis. *J Bone Joint Surg* 60B:178-180, 1978

Anesthesiology
60:380-383, 1984

Preoperative Cessation of Smoking and Pulmonary Complications in Coronary Artery Bypass Patients

MARK A. WARNER, M.D.,* MATTHEW B. DIVERTIE, M.D.,† JOHN H. TINKER, M.D.‡

Smoking-related pulmonary dysfunction is a major determinant of postoperative respiratory morbidity. Cessation of smoking often is encouraged prior to surgery, but the efficacy of short-term abstinence from cigarette smoking in reducing postoperative pulmonary complications has not been proven. Therefore, we retrospectively studied the perioperative course of a group of adult patients undergoing coronary artery bypass grafting (CABG): 1) to determine if preoperative abstinence from cigarette smoking decreases postoperative pulmonary morbidity; and 2) to quantitate any relationship between time of preoperative cessation of smoking and improvement in such morbidity.

METHODS

From January 1979 to December 1980, 1,056 patients underwent CABG at our institution. Of these, 500 patients were selected retrospectively for study by choosing alternate Mayo Clinic registration numbers in numerical sequence arranged from low-to-high. In this manner, there was no prior knowledge of vital statistics or clinical

history. The medical, anesthetic, respiratory therapy, and preoperative pulmonary function test (PFT) records were examined to ascertain specifics of smoking history, 30-day perioperative course and management, and postoperative pulmonary morbidity.

Smoking histories were elicited carefully by staff internists, cardiologists, or thoracic disease specialists. At our institution, a medical history questionnaire is answered by the patient prior to meeting a staff physician. This questionnaire specifically asks for smoking history in packs per day, number of years smoked, and duration of smoking abstinence, if any. Also, sputum production is elicited regarding quantity per day and frequency. The staff physician then reviews the questionnaire in the presence of the patient to check for completeness and reliability. Patients with symptoms or physical findings suggestive of pulmonary disease are evaluated further by thoracic disease staff physicians. Again, detailed smoking, sputum production, and asthmatic histories are reviewed thoroughly.

Sufficient symptoms of pulmonary disease were present in 94 patients, both smokers and nonsmokers, to warrant complete preoperative PFTs. Impaired respiratory function was not suspected clinically in the other 406 patients, and no preoperative PFT's were obtained. A forced expiratory volume in one second (FEV₁) of <70% predicted normal value was considered to represent abnormal function.¹ Cardiac function and pathology were detailed by left ventricular end-diastolic pressures (LVEDP), left ventricular ejection fractions (LVEF), and number of major coronary arteries with >50% luminal stenosis.

Respiratory complications were defined as problems requiring more definitive therapy than the usual postoperative care given all our CABG patients. Such prob-

* Instructor in Anesthesiology, Mayo Clinic and Mayo Medical School.

† Professor of Medicine, Mayo Clinic and Mayo Medical School.

‡ Associate Professor of Anesthesiology, Mayo Clinic and Mayo Medical School. Current address: Professor and Head, Department of Anesthesiology, University of Iowa, Iowa City, Iowa 52242

Received from the Department of Anesthesiology and Medicine, Mayo Clinic and Mayo Foundation, Rochester, Minnesota. Accepted for publication September 5, 1983.

Address reprint requests to Dr. Warner: Department of Anesthesiology, Mayo Clinic, 200 First Street SW, Rochester, Minnesota 55905.

Key words: Anesthesia; cardiovascular. Complications; pulmonary. Lung; smoking.

TABLE 1. Smoking History, Cardiac Findings, and Abnormal FEV₁ in 500 Patients Undergoing CABG

| | Smoking History (pack years) | | | Cardiac Findings | | | Abnormal FEV ₁ * | |
|----------------------|------------------------------|------------------|---------------------|------------------|-------------|------------------------------------|-----------------------------|-------------|
| | Mild (1-20) | Heavy (21-50) | Very Heavy (>50) | LVEDP (mmHg) | LVEF (%) | Number of Vessels >50% Stenosed | Number | Mean ± SD |
| Smokers (456) | | | | | | | | |
| Never stopped (124) | 23 | 85 | 16 | 18.4 ± 5.1 | 51.3 ± 16.0 | 2.2 ± 0.4 | 19 | 55.2 ± 13.8 |
| Stopped <2 wks (84) | 12 | 62 | 10 | 17.1 ± 5.0 | 48.4 ± 13.1 | 2.4 ± 0.3 | 8 | 56.2 ± 7.6 |
| Stopped 2-4 wks (44) | 12 | 26 | 6 | 18.2 ± 4.1 | 53.8 ± 12.2 | 2.0 ± 0.5 | 7 | 60.8 ± 6.3 |
| Stopped 4-8 wks (28) | 5 | 20 | 3 | 16.8 ± 4.8 | 55.7 ± 18.5 | 2.3 ± 0.4 | 4 | 54.2 ± 10.1 |
| Stopped >8 wks (176) | 28 | 122 | 26 | 18.8 ± 6.1 | 58.1 ± 15.8 | 2.2 ± 0.5 | 20 | 59.0 ± 9.0 |
| Nonsmokers (44) | | | | 17.3 ± 4.8 | 50.3 ± 18.1 | 2.1 ± 0.3 | 4 | 62.1 ± 6.9 |

* Per cent of anticipated normal.

RESULTS

lems include purulent sputum with associated oral temperatures greater than 38.3° C, secretion retention requiring inhalation and chest physical therapy not a part of the routine care, bronchospasm requiring bronchodilator therapy, pleural effusions or pneumothorax requiring drainage, and segmental pulmonary collapse. Routine care in our institution includes chest physical therapy every four hours for the first two days following surgery, frequent changes of position if possible, and early mobilization. In addition, all patients whose tracheas are intubated receive humidification of inspired gases and suctioning of the tracheobronchial passages every hour until extubation.

Comparisons of postoperative pulmonary complication rates were made between smokers and nonsmokers. The duration of cigarette abstinence prior to surgery was used to divide the patients into suitable groups for comparative purposes. In addition, the incidence of respiratory problems was compared between patients with and without abnormal PFTs. Statistical analyses were by chi-squared tests of probability.

A smoking history was obtained in 456 (91.2%) of the 500 patients. There were 385 men (77.0%) and 115 women. Average patient age was 58.2 years, and ranged from 36 to 89 years. The severity of coronary artery disease, cumulative smoking history, and presence of an abnormal FEV₁ are shown for each study group in table 1.

There was a threefold decrease in the incidence of postoperative pulmonary complications in patients who stopped smoking for more than eight weeks compared with patients who stopped smoking for less than that time (fig. 1). Pulmonary complication rates in patients who stopped smoking for periods greater than eight weeks prior to surgery appeared to plateau at 15 to 20%. Patients who stopped smoking for 8-12 weeks, 12-26 weeks, 26-52 weeks, and >52 weeks developed respiratory problems in 19.1, 18.2, 16.3, and 17.1%, respectively. Similar pulmonary problems occurred in patients who stopped smoking for less than and greater than eight weeks.

Smokers (456)

Never stopped (124)
Stopped < 2 wks (84)
Stopped 2-4 wks (44)
Stopped 4-8 wks (28)
Stopped > 8 wks (176)

Nonsmokers (44)

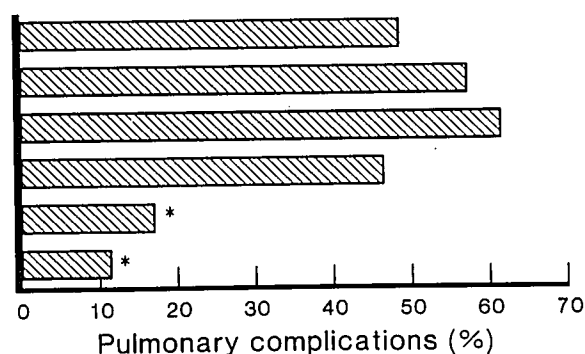


FIG. 1. Preoperative duration of smoking cessation and pulmonary complication rates in 500 CABG patients. **P* < 0.001 compared with patients who never stopped smoking preoperatively.

There was no significant improvement in the incidence of respiratory problems in patients who abstained from smoking for less than eight weeks and those who never stopped (56.4 vs. 48.4%) (fig. 1). Overall, these complications occurred in 178 of the 456 smokers (39.0%) as opposed to five of 44 nonsmokers (11.4%, $P < 0.001$). By sharp contrast, patients who ceased smoking for more than eight weeks did not have a statistically significant increase in pulmonary complications when compared with patients who had never smoked ($P > 0.1$).

Heavy smokers of >20 pack years (years \cdot packs/day) had a higher incidence of respiratory morbidity than did smokers with less pack years (fig. 2). A productive cough was present in 52.9% of current smokers. Cessation of smoking for more than four weeks decreased this incidence to 33.8%, but this improvement was not associated with a reduction in the respiratory complication rate (41.5% vs. 33.7%, $P > 0.08$). Patients with impaired pulmonary function ($FEV_1 < 70\%$ predicted normal) did not have a significantly higher incidence of lung problems compared with those with normal preoperative PFTs (41.9% vs. 36.7%, $P > 0.1$) or who did not have preoperative PFTs carried out (41.9% vs. 35.8%, $P > 0.1$).

DISCUSSION

Patients who smoke cigarettes usually are encouraged to stop doing so prior to their surgery. This advice is based on numerous studies, both prospective and retrospective, that demonstrate increased postoperative respiratory morbidity in smokers.²⁻⁷ However, it was our clinical impression that short-term abstinence prior to surgery might not be efficacious in decreasing the incidence of these pulmonary problems. This retrospective study was intended to better define any improvement in pulmonary morbidity following preoperative cessation of smoking, particularly with regard to its duration.

There is good supportive evidence that improvement in ciliary and small airway function and a decrease in sputum production occur slowly over a period of weeks after cigarette smoking is stopped. Improvement in small

airway function was documented by Buist *et al.*⁸ only after eight weeks of cessation of smoking. Improved closing volumes were recorded by Bode *et al.*⁹ at 6 and 14 weeks after smoking abstinence. Camner and Philipson¹⁰ reported that tracheobronchial clearance of radioactive Teflon® particles is slower in smokers than nonsmokers, and that improvement in clearance is effected after two to three months without cigarettes. A significant decrease in postoperative purulent sputum production was found by Mitchell *et al.*⁵ in patients who ceased to smoke two months prior to surgery, compared with those who smoked until the day of surgery. Thus, there appears to be little measurable improvement in pulmonary function or mucociliary clearance in periods of less than two months. With this background, it is understandable that the respiratory complication rate in chronic smokers was seen to improve in our patients after eight weeks without cigarettes. Of considerable clinical importance is the fact that improvement did not occur before this time.

Unfortunately, preoperative encouragement to stop smoking often entails abstinence for only a few days, and this is completely dependent on patient compliance. In one series, Bode *et al.*⁹ found that only 10 of 50 patients stopped smoking preoperatively, although all were advised to do so by their physicians. This noncompliance may be related in part to elevated anxiety in anticipation of major surgery. Abrupt cigarette withdrawal may further increase this problem in the immediate preoperative period.

Cessation of smoking for 12 hours has been demonstrated by arterial blood-gas analysis to reduce carboxyhemoglobin levels, improve blood oxygen content, and enhance hemoglobin oxygen release.¹¹ However, it is uncertain if there is any improvement in intraoperative and postoperative morbidity due to these changes. In a large prospective study, Gracey *et al.*¹² did not find preoperative arterial blood-gas analysis of carboxyhemoglobin to be of value in predicting pulmonary complications after surgery.

As with any large retrospective study, there are possible sources of error. Reliability of patients giving detailed smoking histories is suspect. Careful questioning of each

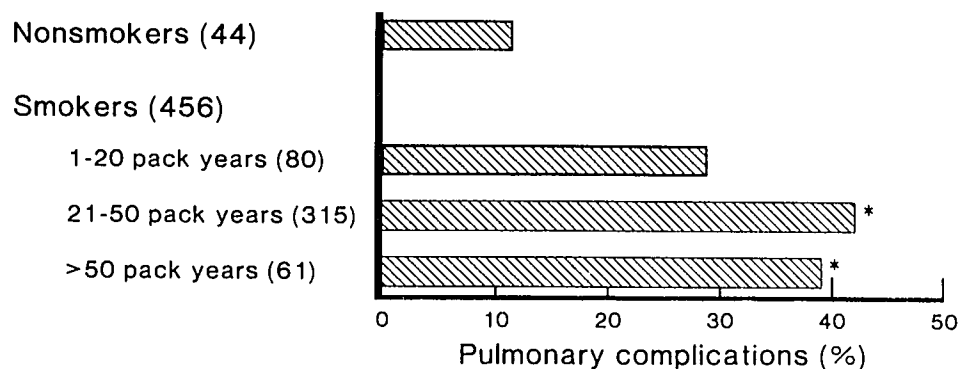


FIG. 2. Degree of smoking and pulmonary complication rates in 500 CABG patients. Degree of smoking in pack years (years \cdot packs/day). * $P < 0.04$ compared with smokers with 1-20 pack years.

patient by multiple staff physicians should have reduced inaccuracies. The existence of noncardiopulmonary disease was not included in the present investigation. While such diseases, age, sex, and other variables appear to be less important than cumulative smoking history in predicting risk of postoperative respiratory morbidity, prospective studies are necessary to further elucidate their role and that of short-term smoking abstinence in reducing pulmonary problems after surgery in this and other patient populations.

Pulmonary function tests were not obtained in most of our patients because no clinical indication existed for them. However, there is occasionally a disparity between severity of clinical symptoms and pulmonary dysfunction as measured by PFTs. The presence of significant but undetected pulmonary dysfunction in this large number could influence differences in complication rates between our groups of patients. We found a similar incidence of lung problems in patients with abnormal (41.9%) and normal (36.7%) preoperative PFTs and patients who did not have sufficient symptoms to warrant PFTs (35.8%). Previously we found that CABG patients with concomitant abnormal lung function appeared not to have an increased risk of postoperative respiratory complications on this basis alone,¹³ and a similar conclusion emerges from the present report. It is possible but unlikely that more attentive physician care is given to patients who had preoperative PFTs. Yet, at our institution, all postoperative CABG patients receive a standardized approach to respiratory care unless pulmonary complications arise.

Reduction in the pulmonary complication rate following at least two months of smoking cessation appears to be related to improvement in ciliary and airway function and decreased sputum production. Based upon our findings, we conclude that preoperative cessation of smoking in CABG patients for less than two months does not decrease postoperative respiratory morbidity. On the other hand, smoking abstinence of more than two months appears to dramatically reduce the incidence of postoperative pulmonary complications to nearly equal that of

nonsmokers. Consequently, we advise that cigarette smoking should be discontinued for more than two months prior to elective surgery if any benefit in postoperative pulmonary morbidity is to be expected.

REFERENCES

1. Miller RD, Hepper NGG, Kueppers F, Gordon H, Offord KP: Host factors in chronic obstructive pulmonary disease in an upper midwest rural community. *Mayo Clin Proc* 51:709-715, 1976
2. Morton HJV: Tobacco smoking and pulmonary complications after operation. *Lancet* 1:368-370, 1944
3. Holtz B, Bake B, Sixt R: Prediction of postoperative hypoxemia in smokers and nonsmokers. *Acta Anaesth Scand* 23:411-418, 1979
4. Garibaldi RA, Britt MR, Coleman ML, Reading JC, Pace NL: Risk factors for postoperative pneumonia. *Am J Med* 70:677-680, 1981
5. Mitchell C, Garrahy P, Peake P: Postoperative respiratory morbidity: identification and risk factors. *Aust NZ J Surg* 52:203-209, 1982
6. Wightman JAK: A prospection study of the incidence of postoperative pulmonary complications. *Br J Surg* 55:85-91, 1968
7. Latimer RG, Dickman M, Day WC, Gunn ML, Schmidt CD: Ventilatory patterns and pulmonary complications after upper abdominal surgery determined by preoperative and postoperative computerized spirometry and blood gas analysis. *Am J Surg* 122:622-632, 1971
8. Buist AS, Sexton GJ, Nagy JM, Ross BB: The effect of smoking cessation and modification on lung function. *Am Rev Respir Dis* 114:115-122, 1976
9. Bode FR, Dosman J, Martin RR, Macklem PT: Reversibility of pulmonary function abnormalities in smokers. *Am J Med* 59:43-52, 1975
10. Camner P, Philipson K: Some studies of tracheobronchial clearance in man. *Chest* 63:235-240, 1973
11. Kambam JR, Chen L, Turner ME, Hyman SA: Effect of smoking on the oxy-hemoglobin dissociation curve. *ANESTHESIOLOGY* 57:A492, 1982
12. Gracey DR, Divertie MB, Didier EP: Preoperative pulmonary preparation of patients with chronic obstructive pulmonary disease. *Chest* 76:123-129, 1979
13. Warner MA, Tinker JH, Frye RL, Westbrook PR, Divertie MB, Amonte P: Risk of cardiac operations in patients with concomitant pulmonary dysfunction. *ANESTHESIOLOGY* 57:A57, 1982