Anesthesiology
1999; 90:372–9

Airway Obstruction and Perioperative Complications in Smokers Undergoing Abdominal Surgery

David O. Warner, M.D., Mark A. Warner, M.D.,† Kenneth P. Offord, M.S.,‡ Darrell R. Schroeder, M.S.,§ Pamela Maxson, R.N.,‖ Paul D. Scanlon, M.D.#*

Background: **The goal of this study was to determine whether airway obstruction determined by preoperative spirometry predicts perioperative complications in smokers undergoing abdominal surgery whose treatment is managed according to current clinical practice.**

Methods: **A pulmonary function database identified patients undergoing abdominal surgery who met the following criteria for airway obstruction (n = 135): a forced expiratory volume less than 40% of predicted normal value, a forced expiratory volume:forced vital capacity ratio less than the lower limit of predicted normal, a smoking history of more than 20 pack-years, and an age older than 35 yr. A group of patients without airway obstruction (n = 135) was matched for gender, surgical site (upper *vs.* lower abdominal), smoking history, and age. Medical records were reviewed by an abstractor to identify perioperative complications that occurred within 30 days after surgery.**

Results: **The forced expiratory volume values were 0.9 ± 0.2 l (mean ± SD) and 2.9 ± 0.6 l in patients with and without airway obstruction, respectively. When analyzed by conditional logistic regression using the 1:1 matched-pairs feature, including age, pack-year smoking history, site of incision, and current smoking status as covariates, in patients with airway obstruction bronchospasm was more likely to develop (odds ratio, 6.9 [95% confidence interval, 1.2 to 38.4]) but the patients were not more likely to need prolonged endotracheal intubation (odds ratio, 1.1 [95% confidence interval, 0.4 to 3.2]). They were also no more likely to need prolonged intensive care admission or readmission. The frequency of other complications was less than 5%.**

Conclusion: **When other factors were considered, preoperative airway obstruction predicted the occurrence of bronchospasm, but not prolonged endotracheal intubation, in smokers undergoing abdominal surgery who are treated according to current clinical practices. (Key words: Chronic obstructive pulmonary disease; emphysema; postoperative pulmonary complications; case-control study; morbidity.)**

This article is accompanied by an Editorial View. Please see: Kimball W: The role of spirometry in predicting pulmonary complications after abdominal surgery: Progressing toward an answer. ANESTHESIOLOGY 1999; 90:356–7.

* Associate Professor of Anesthesiology.

† Professor of Anesthesiology.

‡ Associate Professor of Biostatistics.

§ Statistician.

‖ Advanced Practice Nurse Study Coordinator.

Associate Professor of Medicine.

Received from the Perioperative Outcomes Group, Departments of Anesthesiology and Health Sciences Research, and the Department of Internal Medicine, Mayo Foundation, Rochester, Minnesota. Submitted for publication January 14, 1998. Accepted for publication September 21, 1998. Supported in part by grant HL-45532 from the National Institutes of Health, Bethesda, Maryland, and by the Mayo Foundation, Rochester, Minnesota. Presented in part at the annual meeting of the American Society of Anesthesiologists, San Diego, California, October 17–21, 1997.

Address reprint requests to Dr. David Warner: Department of Anesthesiology, Mayo Foundation, Rochester, Minnesota 55905. Address electronic mail to: warner.david@mayo.edu

PREVIOUS studies suggest that patients with chronic obstructive pulmonary disease (COPD) experience postoperative complications, especially those related to the lungs, more often than do patients with normal lungs.[1–13] The possibility of prolonged postoperative mechanical ventilatory support may be of particular concern to patients and physicians. Clinical strategies in response to this finding have included preoperative optimization of lung function, avoidance of general anesthesia, and outright denial of surgery to patients with severe COPD. However, previous studies that investigated perioperative outcomes in these patients had several limitations. Many studies have not adequately controlled for factors other than airway obstruction, such as site of surgery, comorbid disease, and smoking history, that may contribute to risk. The definition of postoperative pulmonary complications and the definition of chronic lung disease vary considerably among studies. Many complications attributed to the lungs, such as postoperative fever, may not be of pulmonary origin. Some complications, such as evidence of atelectasis on chest roentgenograms, are of uncertain clinical significance. The severity of preoperative lung disease in many studies is either not reported or is relatively mild. Finally, recent advances in surgical, anesthetic, and postopera-

tive nursing care make the applicability of findings from earlier studies to current practice uncertain.

Case series of patients with severe COPD suggest that most of these patients actually tolerate surgery relatively well, with rates of postoperative ventilatory failure of approximately 5%.[1,14–16] Relating the frequency and severity of complications to the severity of airway obstruction, the hallmark of COPD, as measured by preoperative pulmonary function testing, has proved difficult in these and other studies.[17] This questions the significance of airway obstruction as a risk factor for perioperative pulmonary complications in these patients. Other factors present in patients with COPD, especially a history of smoking or comorbid disease, may be more important determinants of risk than the severity of airway obstruction. In addition, the presence of severe airway obstruction may affect the perioperative management of these patients, such that they receive more intensive perioperative respiratory therapy in an attempt to prevent pulmonary complications.

Our aim in this study was to determine whether the presence of moderate to severe airway obstruction predicts the development of perioperative complications in patients with a significant history of smoking who are undergoing abdominal surgery. In particular, we hypothesized that perioperative changes in respiratory function would lead to a greater frequency of prolonged postoperative intubation (> 24 h) in patients with severe airway obstruction, despite clinical attempts to prevent such complications. We retrospectively evaluated the medical records of two cohorts of patients: those with severe airway obstruction, and a gender- and age-matched cohort consisting of patients with a similar smoking history but without airway obstruction as measured by spirometry. Therefore, the cohorts were matched at least for smoking history and site of surgery, two important factors known to influence the risk of perioperative complications.

Materials and Methods

The Mayo Institutional Review Board approved this investigation. The pulmonary function database at Mayo Rochester contains the results of all pulmonary function tests performed since 1990. Each result includes extensive data obtained from a questionnaire eliciting a pulmonary history, such as information regarding smoking status. This information is verified during an interview by a certified pulmonary function technologist. From this database, patients with severe airway obstruction who were tested between January 1991 and December 1995 were identified according to the following criteria: forced expiratory volume in 1 s (FEV_1) less than 40% of predicted normal, the ratio of FEV_1 to forced vital capacity less than the lower limit of predicted normal, a smoking history more than 20 pack-years, and age older than 35 yr.[18] These criteria were chosen to include patients with COPD without distinguishing the specific causes of airway obstruction, such as asthma, bronchitis, or emphysema. Patients with a similar smoking history but without airway obstruction, as measured by spirometry, were also identified using the following criteria: FEV_1 equal to or greater than the lower limit of predicted normal, a FEV_1:forced vital capacity ratio equal to or greater than the lower limit of predicted normal, a smoking history more than 20 pack-years, and age older than 35 yr.

The identification numbers of these two groups of patients were cross-matched with the Mayo Rochester surgical database to identify those who had undergone abdominal surgery (according to ICD-9 codes indicating abdominal procedures) within 6 months after the pulmonary function test. All patients with airway obstruction undergoing an abdominal procedure subsequent to the date of the first pulmonary function test were selected for review (n = 135). Laparoscopic procedures were not included. Each patient with airway obstruction was matched with a patient without airway obstruction based on gender, site of incision (upper *vs.* lower abdominal), pack-year smoking history, and age. Exact matching was used for the matching factors of gender and site of surgery (as determined by ICD-9 codes). For the continuous factors of age and pack-year smoking history, the optimal set of matched pairs was identified using the approach described by Rosenbaum.[19]

The perioperative medical, surgical, nursing, and anesthesia records for each surgical episode were reviewed by a nurse abstractor. In addition to pulmonary function data, preoperative information that was recorded included smoking history, American Society of Anesthesiology physical status (a preoperative assessment scale from 1 to 5, with 1 representing healthy patients and 5 representing patients with severe disease), and comorbid medical conditions diagnosed according to published criteria.[20] Intraoperative information included the type and duration of anesthesia and the type of postoperative analgesia. The site of surgical incision was also noted from the operative record, with an upper abdominal incision defined as cephalad to the umbilicus. Inci-

sions extending cephalad and caudad to the umbilicus were considered upper abdominal incisions. Records were evaluated from the hospital course and for as many as 30 days after surgery.

Outcomes were defined as follows. A pulmonary embolus was considered present if there were diagnostic defects during pulmonary angiography, or if a ventilation–perfusion scan finding indicated a high probability of pulmonary embolus. Definite pneumonia was defined as a new infiltrate seen on a chest radiograph combined with fever, leukocytosis, and a positive sputum Gram stain or culture. Probable pneumonia was diagnosed according to the same criteria, except that a positive Gram stain or culture was not needed. Prolonged tracheal intubation was defined as failure to extubate within 24 h after the operation or the need to reintubate and mechanically ventilate a patient who was extubated previously for more than 15 min. Bronchospasm was present if a notation of bronchospasm, wheezing, increased airway pressure, or prolonged expiration was recorded and required treatment with bronchodilators (not including the resumption of the patient's routine preoperative medication regimen). Other outcomes that were sought included prolonged admission to the intensive care unit (> 96 h), readmission to the intensive care unit after previous discharge, death of any cause, myocardial infarction, central nervous system morbidity, renal dysfunction, biliary dysfunction, and sepsis, defined according to previously published diagnostic criteria.[20]

Statistics

All analyses were performed using the 1:1 matched-set feature of 135 patients with airway obstruction and 135 patients without airway obstruction. The demographic and procedural characteristics of the two groups were compared using the signed rank test for continuous variables and the McNemar test for categoric variables. Conditional logistic regression was used to determine whether airway obstruction was an independent risk factor for perioperative complications. Because there was no exact matching for age, smoking history, and actual site of surgical incision (upper *vs.* lower abdominal), these variables were included as covariates in the logistic regression analysis. In all cases, two-sided tests were used with P values ≤ 0.05 used to denote significance.

Table 1. Surgical Procedures

	No Airway Obstruction (N = 135)	Airway Obstruction (N = 135)
Abdominal wall herniorraphy	5	6
Large bowel resection	20	21
Small bowel resection	3	1
Splenectomy	3	3
Cholecystectomy	4	4
Liver resection	5	4
Nephrectomy	8	9
Exploratory laparotomy	8	11
Gastrectomy/pancreatectomy	8	4
Esophagogastrectomy	4	5
Total abdominal hysterectomy	4	5
Repair abdominal aortic aneurysm	16	19
Aortobifemoral grafting	15	15
Radical retropubic prostatectomy	32	30

Values are the number of patients undergoing each type of procedure.

Results

The median time from the pulmonary function test to the date of surgery was 10 and 8 days in patients with and without airway obstruction, respectively. The types of surgical procedures were similar for the two groups (table 1). The FEV_1 was 0.9 ± 0.2 l (mean ± SD) and 2.9 ± 0.6 l in patients with and without airway obstruction, respectively (30 ± 6% and 92 ± 10% of their predicted normal values, respectively). The two groups were matched with respect to gender. Patients with airway obstruction were slightly but significantly older than patients without airway obstruction (table 2). Age was matched within ± 5 yr for 95% of the matched pairs, with a median difference (patients with airway obstruction minus patients without airway obstruction) of +1 yr (range, −4 to +13 yr). Pack-year smoking history was matched within ± 10 pack-years for 85% of the matched pairs, with a median difference (patients with airway obstruction minus patients without airway obstruction) of 10 pack-years (range, −38 to +52 pack-years). Although initially the patients were also matched according to the site of surgical incision (upper *vs.* lower abdominal), as estimated by the surgical procedure code, this site was reclassified in six patients based on reviews of the operative notes. However, even after this reclassification, the proportion of patients who underwent upper abdominal incisions still did not differ between the groups (table 2). Although the total smoking experience of the groups was not significantly different, a greater proportion of patients without airway obstruction were current smokers compared with patients with

Table 2. Patient/Procedural Characteristics

Characteristic	No Airway Obstruction (N = 135)	Airway Obstruction (N = 135)	*P* Value*
Age (yr) (mean ± SD)	67.2 ± 6.6	68.9 ± 7.0	<0.001
Gender (%)			NS
Female	22	22	
Male	78	78	
Smoking history			
Pack-years (mean ± SD)	50.5 ± 19.5	51.5 ± 18.6	NS
Current smoker (%)	47	27	<0.001
FEV_1 (L)			
Mean ± SD	2.9 ± 0.6	0.9 ± 0.2	<0.001
Range	1.3 to 4.2	0.4 to 1.7	
% predicted (mean ± SD)	91.7 ± 9.9	30.2 ± 6.1	<0.001
Range	71 to 134	14 to 40	
Upper abdominal incision (%)	60	64	NS
Anesthetic technique (%)			NS
General	96	95	
Spinal/epidural	4	2	
Combined	0	3	
Duration of anesthesia (h)	4.4 ± 1.6	4.5 ± 2.2	NS
Postoperative epidural analgesia (%)	39	48	NS
Comorbid conditions (%)			
Diabetes	3	1	NS
Hypertension	38	30	NS
Dysrhythmias	4	7	NS
Coronary artery disease	29	19	NS
Prior myocardial infarction	7	10	NS
Other cardiovascular diseases	6	3	NS
Renal disease	2	3	NS
Hepatic disease	4	1	NS
CNS disease	9	15	NS
Asthma	6	20	<0.001
ASA classification (%)			<0.001
1–2	30	7	
3–4	70	93	

FEV_1 = forced expiratory volume in 1 second; CNS = central nervous system; ASA = American Society of Anesthesiologists.

Patients with and without airway obstruction were matched 1:1 for gender, age, site of surgery (upper *versus* lower abdominal), and pack-year smoking history. Paired comparisons were performed using the 1:1 matched pairs feature of 135 with airway obstruction and 135 patients without airway obstruction.

* *P* values given are those associated with signed rank test and McNemar's test for continuous and categorical variables, respectively (NS = not significant, $P > 0.05$).

airway obstruction (table 2). The frequency of comorbid conditions was similar in the two groups, with the exception that more patients with airway obstruction also were diagnosed clinically as having asthma (table 2). The American Society of Anesthesiologists physical status classification was higher in patients with airway obstruction (table 2). The two groups did not differ in the proportion of patients who received regional anesthesia, the duration of anesthesia, and the use of postoperative epidural analgesia (table 2).

Twenty-two (16%) patients without airway obstruction and 34 (25%) patients with airway obstruction had at least one perioperative complication (table 3). Because the two groups were not exactly matched for age, smoking history, and site of surgical incision, conditional logistic regression analysis was performed to determine whether the presence of airway obstruction predicted outcomes, using the 1:1 matched-set feature and including additional covariates of current smoking status and incision site and the continuous variables of age and pack-years of smoking. This analysis was applied to outcomes that occurred in 5% or more of either group. Of these outcomes (bronchospasm, prolonged intubation, total intensive care unit stay > 96 h, and intensive care unit readmission), the presence of airway obstruction was a significant risk factor only for bronchospasm. The frequency of other outcomes was low (≤ 5%), precluding meaningful statistical analysis. However, the frequencies of these outcomes were similar between groups, with the exception of definite pneumonia, which occurred in five patients with airway obstruction and in one patient without airway obstruction.

Patients with airway obstruction were admitted to the intensive care unit immediately after surgery significantly more often (in 79 [59%] and 55 [41%] patients with and without airway obstruction, respectively; $P = 0.004$). For those admitted, the duration of postoperative intensive care unit admission did not differ significantly between the groups (50 ± 103 h and 38 ± 92 h in patients with and without airway obstruction, respectively; $P = 0.068$), and neither did the duration of hospital stay (median of 8 and 7 days in patients with and without airway obstruction, respectively, $P = 0.37$).

Two patients with airway obstruction and one patient without airway obstruction died. One patient with airway obstruction, who had undergone a transhiatal distal esophagectomy and partial gastrectomy *via* an abdominal and cervical approach, was extubated in the postanesthesia recovery unit and initially did well. However, 1 week after operation a chyle leak developed that necessitated thoracotomy, and ultimately the patient died of empyema and pneumonia. The other patient with airway obstruction required reoperation for wound dehiscence after radical retropubic prostatectomy but otherwise re-

Table 3. Perioperative Complications

	No Airway Obstruction (N = 135)		Airway Obstruction (N = 135)		Conditional Logistic Regression Results		
	N	%	N	%	*P* Value	Odds Ratio	95% CI
Any complication	22	16.3	34	25.2	NS	1.3	0.6–2.4
Bronchospasm	3	2.2	17	12.6	0.027	6.9	1.2–38.4
Prolonged intubation	10	7.4	13	9.6	NS	1.1	0.4–3.2
Definite pneumonia	1	0.7	5	3.7			
Probable pneumonia	2	1.5	2	1.5			
Pulmonary embolus	0	0.0	0	0.0			
Total ICU stay >96 h	11	8.1	16	11.9	NS	1.6	0.5–5.5
Readmitted to ICU	10	7.4	10	7.4	NS	0.7	0.2–2.6
Central nervous system morbidity	0	0.0	2	1.5			
Definite myocardial infarction	3	2.2	2	1.5			
Probable myocardial infarction	1	0.7	1	0.7			
Renal dysfunction	1	0.7	1	0.7			
Biliary dysfunction	2	1.5	0	0.0			
Sepsis	0	0.0	0	0.0			
Death within 30 days of surgery	1	0.7	2	1.5			

Analysis was performed using conditional logistic regression and the 1:1 matched pairs feature of 135 patients with airway obstruction and 135 patients with no airway obstruction. Since there was not exact matching for age and pack-year smoking history, these variables, along with indicator variables defining upper abdominal incision (yes *vs.* no) and current smoking status (current *vs.* former), were included as covariates in the analysis.

* *P* values and odds ratios are given for complications that were experienced by ≥5% of either group. These values cannot be directly computed from the information provided.

covered without complications and was discharged 2 weeks after the initial surgery. Written correspondence indicated that he died 2 weeks after discharge of unspecified causes; no further follow-up was obtained. The patient without airway obstruction, who had undergone radical pancreaduodenectomy, had an initially uncomplicated postoperative course but died of myocardial infarction 2 weeks after surgery.

Discussion

A substantial number of these predominantly elderly patients experienced complications after abdominal surgery. For those complications that occurred with sufficient frequency to permit statistical evaluation, airway obstruction predicted only bronchospasm. The presence of airway obstruction did not increase the frequency of prolonged endotracheal intubation in these patients who were managed at the discretion of the responsible clinician.

Factors that predicted postoperative pulmonary complications in previous studies include age, site of operation, smoking history, overall physical status, anesthesia duration, and need for emergency surgery. In addition, multiple previous studies concluded that patients with COPD are at significantly greater risk for postoperative pulmonary complications to develop compared with patients with healthy lungs.[1–10] Three relatively large prospective studies comparing pulmonary outcomes in patients with and without lung disease are available. Wightman[4] found in a series of 785 patients undergoing nonthoracic surgery that postoperative pulmonary complications developed in 8% of patients without chronic respiratory disease, compared with 26% of patients with chronic respiratory disease. Pedersen *et al.*[2,21] studied approximately 7,000 patients undergoing nonthoracic surgery. Postoperative complications developed in approximately 4% of patients without lung disease, compared with 12% of patients with COPD. With multiple logistic regression analysis to account for other risk factors, COPD was a significant risk factor for postoperative pulmonary complications, with an odds ratio of approximately 3. In a multicenter study of approximately 17,000 patients receiving general anesthesia for all types of surgery (including cardiac and thoracic), Forrest *et al.*[12] found that COPD predicted severe respiratory outcomes, with an adjusted odds ratio of approximately 3. Therefore, these three studies found that patients with clinical COPD were approximately three times more likely to have pulmonary complications compared with

patients without COPD. Neither diagnostic criteria for COPD nor pulmonary function data were provided in any of these three studies.

Based on these studies, it was assumed that the severity of airway obstruction, the hallmark of COPD, should predict the occurrence of perioperative complications. However, this has been a difficult assertion to prove. Lawrence *et al.*[17] reviewed 22 available studies of preoperative spirometry before abdominal operations (as of 1989) and found that all contained significant flaws that precluded valid conclusions about the relation between airway obstruction as assessed by spirometry and pulmonary complications. Problems included selection bias, lack of inclusion of patients with healthy lungs, lack of stratification for other risk factors such as site of surgery and comorbid disease, lack of blinding, inappropriate or inconsistent definitions of outcomes, and others.

Other factors present in patients with airway obstruction, especially a history of smoking, may be more important determinants of perioperative risk than the severity of airway obstruction. By matching patients with and without airway obstruction for factors known to influence risk, such as surgical site and smoking history, we wanted to evaluate the influence of airway obstruction itself in these high-risk patients. Spirometric criteria were designed to exclude other diagnoses associated with decreases in FEV_1, such as restrictive lung disease, and to match the clinical profile of the typical patient with COPD (older age and a history of smoking). Diagnostic classifications of patients with chronic airway obstruction include asthma, asthmatic bronchitis, chronic bronchitis, and emphysema. Criteria distinguishing these classifications are controversial,[18] and no attempt was made to distinguish between these diagnoses. Outcome events were chosen to be well defined, clinically relevant, and readily determined from a review of medical records. We specifically evaluated a category of surgical procedures known to have increased the risk for pulmonary complications to maximize our ability to detect differences between patients with and without airway obstruction, also controlling for the site of incision, because upper abdominal surgery is associated with a higher frequency of complications. Other putative risk factors, such as the duration of anesthesia and the use of postoperative epidural analgesia,[22] were similar between the two groups.

Previous case series showed that patients with severe COPD tolerate anesthesia and surgery relatively well,[1,14–16] a result that is consistent with the experience of our patients with airway obstruction. As was true in these previous reports, most patients undergoing these often extensive procedures did not require prolonged ventilatory support. We could not confirm the hypothesis that the presence of airway obstruction predicted prolonged intubation. Consistent with this finding, airway obstruction also did not predict prolonged intensive care unit stays or readmission to the intensive care unit. Postoperative pneumonia developed in more patients with airway obstruction, although the frequency of this outcome was not sufficient to perform a statistical comparison. It is encouraging that definite or probable pneumonia developed in only 5% of these patients with significant airway obstruction. The only significant difference in the frequency of perioperative complications was in the occurrence of bronchospasm. This is perhaps not surprising, because the patients had preexisting airway obstructions. However, in all patients bronchospasm was treated successfully and did not appear to cause additional complications. Only one episode of bronchospasm occurred in the intraoperative period; the median postoperative time to the development of bronchospasm was 2 days. Other complications such as myocardial infarction occurred infrequently.

Our study should be interpreted with caution for several reasons beyond the usual caveats applied to retrospective studies. First, we must emphasize that the patients without airway obstruction were not necessarily free of respiratory disease; in fact, all had a significant history of smoking, and sufficient clinical concern existed to prompt preoperative pulmonary function testing. Therefore, our study did not compare patients with COPD and patients with healthy lungs. As reviewed before, studies consistently show that patients with a clinical diagnosis of chronic respiratory disease or COPD experience a higher frequency of perioperative complications. Rather, our results show that airway obstruction itself predicted only bronchospasm, suggesting that other factors such as smoking or other comorbid conditions may account for the higher frequency of other complications reported in previous studies.

Second, the presence of airway obstruction may have influenced perioperative care, which could have affected the frequency of complications. For example, patients with airway obstruction were more likely to be admitted to an intensive care unit after operation, where they may have received more intensive respiratory therapy. However, this consideration should not have affected the proportions of patients who needed prolonged intubation, and readmission rates to the intensive care unit were identical between the two groups. Pa-

tients with airway obstruction may have received more intensive preoperative pulmonary preparation, which could have influenced outcomes. According to the practice followed at our institution, all patients received a preoperative medical evaluation by an internist before surgery. At that time, preoperative pulmonary therapy was optimized as indicated in both groups according to the judgment of the internist and the needs of the individual patient (*i.e.*, no standard regimens were applied to either group). Indeed, a smaller proportion of patients with airway obstruction were admitted the morning of surgery compared with patients without airway obstruction (20% and 36%, respectively; $P = 0.009$), a finding that may indicate earlier admission of some patients with airway obstruction for preoperative pulmonary preparation. Our results therefore should be interpreted as representing outcomes achieved when preoperative pulmonary function is optimized and when current standards of postoperative care are applied at the discretion of the clinician. Our study cannot determine whether the presence of airway obstruction itself would affect perioperative risks if perioperative respiratory therapy had been standardized for the two groups.

Finally, although this study represents the largest published series of patients with severe airway obstruction undergoing surgery, the relatively low frequency of some complications limits its power to detect the effect of airway obstruction on the risk of these complications. We cannot exclude the possibility that a true difference exists in the frequency of these infrequent complications. For example, the frequency of perioperative death was low in both groups. For complications related specifically to the lungs, this is especially true for the occurrence of pneumonia and pulmonary embolus. In particular, to detect with 80% power a difference in the frequency of definite or probable pneumonia consistent with that observed in the current study for patients with *versus* without airway obstruction (5.2% *vs.* 2.2%), we would need to study more than 500 patients in each group, which would not be practical using our design. However, the fact that these complications occurred relatively infrequently, even in these patients with significant lung disease, is itself an interesting observation. Clinically, it appears from these data that these patients can be reassured that their risk for significant perioperative complications after these procedures is relatively low with current medical practice.

In conclusion, in patients with a significant history of smoking undergoing abdominal surgery who are treated according to current clinical practice, perioperative bronchospasm is more likely to develop in those with severe airway obstruction, as measured by preoperative spirometry. However, the presence of preoperative airway obstruction did not predict prolonged intubation when other factors such as age, smoking history, and site of surgical incision were considered. More prospective studies are needed to determine whether this finding can be attributed to more intensive perioperative respiratory therapy applied to patients with airway obstruction or whether airway obstruction truly does not influence the incidence of prolonged intubation and other complications. Other factors present in patients with airway obstruction, such as a history of smoking, may be more important determinants of perioperative risk for some complications than the severity of airway obstruction.

The authors thank Janet Beckman for secretarial support and Kenneth O. Parker for assistance with the pulmonary function database.

References

1. Wong DH, Weber EC, Schell MJ, Wong AB, Anderson, CT, Barker SJ: Factors associated with postoperative pulmonary complications in patients with severe chronic obstructive pulmonary disease. Anesth Analg 1995; 80:276–84

2. Pedersen T, Eliasen K, Henriksen E: A prospective study of risk factors and cardiopulmonary complications associated with anaesthesia and surgery: Risk indicators of cardiopulmonary morbidity. Acta Anaesthesiol Scand 1990; 34:144–55

3. Vodinh J, Bonnet F, Touboul C, Lefloch JP, Becquemin JP, Harf A: Risk factors of postoperative pulmonary complications after vascular surgery. Surgery 1989; 105:360–5

4. Wightman JAK: A prospective survey of the incidence of postoperative pulmonary complications. Br J Surg 1968; 55:85–91

5. Tarhan S, Moffitt EA, Sessler AD, Douglas WW, Taylor WF: Risk of anesthesia and surgery in patients with chronic bronchitis and chronic obstructive pulmonary disease. Surgery 1973; 74:720–6

6. Gass GD, Olsen GN: Preoperative pulmonary function testing to predict postoperative morbidity and mortality. Chest 1986; 89:127–35

7. Stein M, Cassara EL: Preoperative pulmonary evaluation and therapy for surgery patients. JAMA 1970; 211:787–90

8. Stein M, Koota GM, Simon M, Frank HA: Pulmonary evaluation of surgical patients. JAMA 1962; 181:765–70

9. Gracey DR, Divertie MB, Didier EP: Preoperative pulmonary preparation of patients with chronic obstructive pulmonary disease. A prospective study. Chest 1979; 76:123–9

10. Tisi GM: Preoperative identification and evaluation of the patient with lung disease. Med Clin North Am 1987; 71:399–413

11. Hall JC, Tarala RA, Hall JL, Mander J: A multivariate analysis of the risk of pulmonary complications after laparotomy. Chest 1991; 99:923–7

12. Forrest JB, Rehder K, Cahalan MK, Goldsmith CH: Multicenter study of general anesthesia. III. Predictors of severe perioperative adverse outcomes. ANESTHESIOLOGY 1992; 76:3–15

13. Wirén JE, Janzon L: Respiratory complications following sur-

gery. Improved prediction with preoperative spirometry. Acta Anaesthesiol Scand 1983; 27:476–9

14. Kroenke K, Lawrence VA, Theroux JF, Tuley MR: Operative risk in patients with severe obstructive pulmonary disease. Arch Intern Med 1992; 152:967–71

15. Milledge JS, Nunn JF: Criteria of fitness for anaesthesia in patients with chronic obstructive lung disease. BMJ 1975; 3:670–3

16. Boutros AR, Weisel M: Comparison of effects of three anaesthetic techniques on patients with severe pulmonary obstructive disease. Can Anaesth Soc J 1971; 18:286–92

17. Lawrence VA, Page CP, Harris GD: Preoperative spirometry before abdominal operations. A critical appraisal of its predictive value. Arch Intern Med 1989; 149:280–5

18. American Thoracic Society: Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med 1995; 152: S77–120

19. Rosenbaum PR: Optimal matching for observational studies. J Am Stat Assoc 1989; 84:1024–32

20. Warner MA, Shields SE, Chute CG: Major morbidity and mortality within 1 month of ambulatory surgery and anesthesia. JAMA 1993; 270:1437–41

21. Pedersen T, Viby-Mogensen J, Ringsted C: Anaesthetic practice and postoperative pulmonary complications. Acta Anaesthesiol Scand 1992; 36:812–8

22. Jayr C, Thomas H, Rey A, Farhat F, Lasser P, Bourgain J-L: Postoperative pulmonary complications. Epidural analgesia using bupivacaine and opioids versus parenteral opioids. ANESTHESIOLOGY 1993; 78:666–76