Preoperative Spirometry and Perioperative Drug Therapy in Patients with Obstructive Pulmonary Dysfunction

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Objective: The presence and severity of obstructive pulmonary diseases is important determinants of non-fatal and fatal postoperative complications. This study examined the characteristics of patients in need of perioperative drug therapy for obstructive pulmonary dysfunction.
Methods: Among 2,358 surgical patients who, between September 2009 and February 2010, underwent spirometry at the Tokai University Hospital, the 333 whose forced expiratory volume in 1 second (FEV_1) / forced vital capacity ratio was <0.7 were studied retrospectively. Single and multiple variable logistic regression analyses were performed in search of predictors of need for drug therapy.
Results: Among the 230 men and 103 women (mean age = 68 ± 11 years) with obstructive pulmonary dysfunction, 108 (32%) received perioperative drug therapy with bronchodilators, inhaled corticosteroids or both. By multiple variable analysis, perioperative drug therapy was significantly correlated with a history of asthma and ever smoking, cough or sputum production, FEV_1 <50% predicted, and emphysema, independently of consultations with pulmonologists. In a decision tree analysis, FEV_1 and smoking history were the independent predictors of perioperative drug therapy.
Conclusions: Composite assessment of clinical history, respiratory symptoms, and pulmonary function is necessary for the efficient screening of the subjects who require perioperative drug therapy for obstructive pulmonary dysfunction.

Key words: Spirometry; chronic obstructive pulmonary disease; asthma; bronchodilator; inhaled corticosteroids

INTRODUCTION

Clear guidelines have been issued that describe the perioperative cardiovascular evaluation and management recommended for non-cardiac surgery, with a view to prevent postoperative cardiac complications [1]. In contrast, limited resources are available for the evaluation and management of pulmonary complications of non-thoracic surgery, often coincided with cardiovascular complications and a well-known source of postoperative morbidity, mortality, and prolonged hospitalizations [2]. For example, chronic obstructive pulmonary disease (COPD) is a notorious cause of postoperative complications [3], although, in the majority of cases of COPD, the disease is undiagnosed or its severity underestimated by the patient or the physician. In the Nippon COPD Epidemiology (NICE) study, COPD was diagnosed in only 9% of patients presenting with obstructive pulmonary dysfunction [4]. Therefore, a thorough preoperative screening and management of COPD is essential to prevent postoperative complications.

Spirometry is a simple and practical test for the diagnosis of obstructive pulmonary diseases such as COPD, since the latter is defined as a forced expiratory volume in 1 second (FEV_1) / forced vital capacity (FVC) ratio below 0.7 after inhalation of a bronchodilator [5]. However, whether preoperative spirometry reliably estimates the risk of postoperative pulmonary complications remains controversial. A single study found that a preoperative FEV_1/FVC ratio <0.7 was associated with a significant increase in postoperative respiratory complications [6], while other studies concluded that pulmonary function tests made no contribution in the identification of patients at increased risk [7–9].

Since long-acting, potent bronchodilators and anti-inflammatory drugs have become the mainstay in the treatment of asthma and COPD, the control and prognosis of these disorders have markedly improved [10, 11]. However, because of underdiagnosis of the disease, only a small proportion of patients suffering from COPD is treated according to the recommendations made in the practice guidelines issued by international and Japanese professional societies [4]. Therefore, a systematic preoperative screening of COPD with spirometry and the implementation of a targeted drug regimen might be justified, although the evidence remains weak.

We retrospectively reviewed the spirometry database of Tokai University Hospital, where preoperative spirometry is performed routinely in nearly all patients who undergo major surgery. We then studied the pa-

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tients who received perioperative pharmaceuticals for obstructive pulmonary dysfunction.

PATIENTS AND METHODS

This study was approved by the institutional review board of Tokai University Hospital (#12R-093, approved on July 26, 2012).

Patient sample and data collection

We retrospectively reviewed the records of 2,358 patients who underwent spirometry between September 2009 and February 2010 for the evaluation of pulmonary function before undergoing general, orthopedic, gynecologic, otorhinolaryngologic, and other surgery at the Tokai University Hospital, in Kanagawa, Japan. The cases whose chest radiograph was not obtained preoperatively were excluded. The patients' ages, genders, heights and spirometric measurements, made with a Superspiro DISCOM-21FX III spirometer (CHEST Corporation, Tokyo, Japan), were recorded. The predicted values of FEV_1 were calculated, using the equation published by the Japanese Respiratory Society [12]. We retrospectively reviewed the medical records and answers to a questionnaire from the pulmonary function laboratory, completed by patients whose pre-bronchodilator FEV_1/FVC ratio was <0.7, with a view to gather clinical information, including manifestation of respiratory disease (cough and sputum production, dyspnea on exertion), history of cigarette smoking, asthma and other respiratory diseases, consultation with pulmonary disease specialists, and pharmaceuticals prescribed for the management of obstructive pulmonary diseases. The images of chest radiographs and thoracic CT scans were analyzed by 2 experienced pulmonologists for the presence of pulmonary emphysema, fibrosis or both.

Statistical analysis

Data are presented as means and standard deviations (SD). Groups were compared, using two-sided Fisher's exact and unpaired t-tests. Multiple variable, logistic regression analyses adjusted for age, sex and consultation with a pulmonologist were performed in search of predictors of perioperative drug therapy in the patients whose FEV_1/FVC was <0.7. Variables included in the analysis were smoking status (ever or never smoker, current or past smoker, pack-years), respiratory disease manifestations (cough, sputum production, dyspnea on exertion), a history of asthma or other respiratory diseases, vital capacity and FEV_1 (% predicted), FEV_1 <50% of predicted value, abnormal chest radiograph, and emphysema or fibrosis on chest CT scan. Odds ratios (OR) and 95% confidence intervals (CI) were calculated. A decision tree was developed using the chi-squared automatic interaction detection (CHAID) method. A p value <0.05 was considered statistically significant. The statistical analyses were performed, using the SPSS software package Ver. 21 (SPSS Inc., Chicago, IL).

RESULTS

Study sample

Among the 2,358 patients who underwent preoperative spirometry, 335 (14%) had a FEV_1/FVC <0.7. Two patients were excluded from the analysis due to the lack of chest radiograph data, and 333 subjects, including 230 men and 103 women, were evaluated, Their mean age was 68 ± 11 years, versus 55 ± 16 years in the group without airflow obstruction (p <0.001). The proportion of men with obstructive pulmonary dysfunction was higher than women and increased with age (Fig. 1).

The characteristics of the entire study sample with obstructive pulmonary dysfunction are shown in Table 1. Among 237 patients (71%) whose chest CT scans were available, 106 (45%) presented with emphysema and 26 (11%) with fibrotic changes. Chest CT scans tended to be performed in the patients with abnormal chest radiograph as well as elderly subjects and heavy smokers (supplemental Table 1). A preoperative consultation with a pulmonologist was obtained for 191 patients (57%). Patients with histories of asthma or smoking, and those with respiratory manifestations, such as cough, sputum production or dyspnea were more likely to be seen in consultation (supplemental Table 2).

Drug therapy

One or more pharmaceutical was administered perioperatively for the treatment of obstructive pulmonary diseases in 108 patients (32%), 83 of whom received a combination of inhaled corticosteroid and long-acting -adrenergic agonist, 20 received long-acting anticholinergics, and 23 patients received theophylline. Histories of smoking and asthma, presence of respiratory disease manifestations such as chronic cough, sputum or dyspnea, a low FEV_1, an abnormal chest radiograph, findings of emphysema on chest CT scan, and consultation with pulmonologist were significantly associated with the prescription of perioperative drug therapy (Table 1).

In 55 patients (51%), the treatment was new and prompted by the preoperative evaluation. A history of smoking, pulmonary emphysema on chest CT scan, and consultation with pulmonologist were associated with the introduction of treatment for obstructive disorders, while patients with histories of asthma or severe pulmonary dysfunction were more likely to have been treated with medications before undergoing a preoperative evaluation (Table 2).

Multiple variable logistic regression analysis

We performed a multiple variable logistic regression analysis adjusted for age, sex and consultation with a pulmonary disease specialist to assess the factors associated with perioperative drug therapy for obstructive pulmonary diseases. The independent correlates of perioperative drug therapy in the entire study sample are shown in Table 3A, and in the subgroup of 237 patients who underwent preoperative chest CT scan, are shown in Table 3B.

CHAID analysis

The decision tree of the CHAID analysis is shown in Fig. 2. In this analysis, FEV_1, % predicted, and smoking history were the only significant predictors of perioperative drug therapy. In the patients with FEV_1 ≤85.2% of predicted, treatment for respiratory disorders was

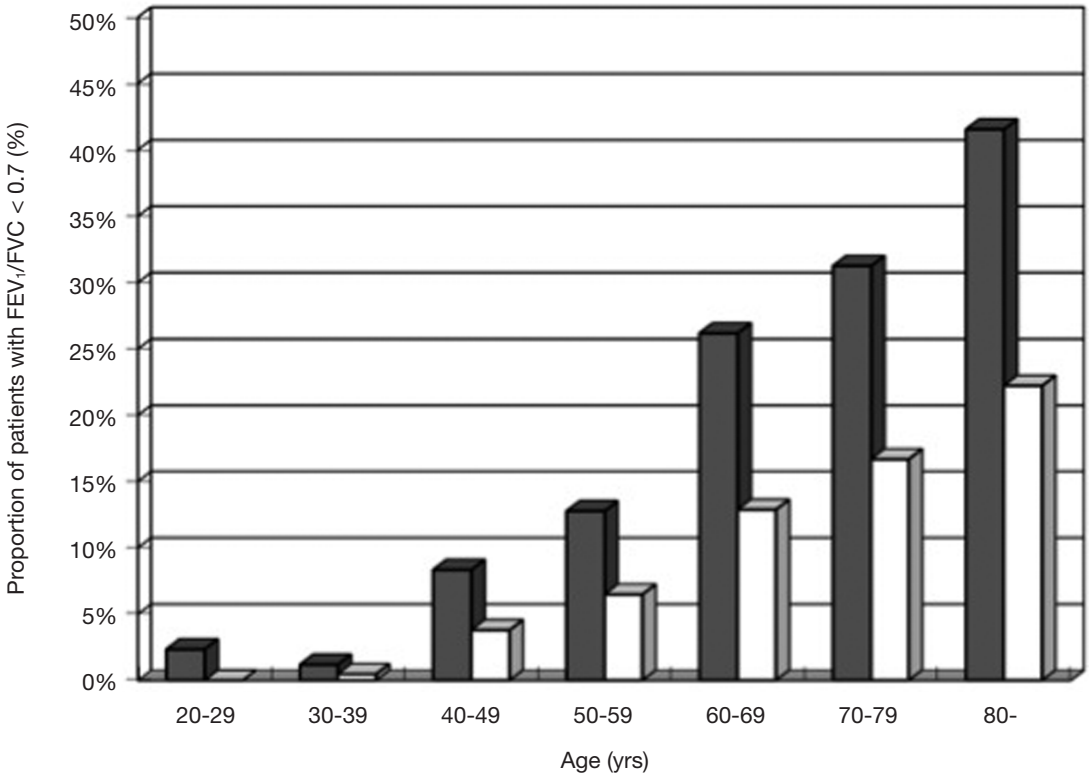

Fig. 1 Prevalence of airflow obstruction, defined as a pre-bronchodilator FEV_1/FVC <0.7, and its relationship with age and sex. Closed bars represent men and open bars indicate women.

required in 77 of 166 (46.4%) patients. When FEV_1 was >85.2% of predicted, 31 of 167 patients (18.6 %) were treated, and only 10.1% of patients who had never smoked received perioperative drug therapy.

DISCUSSION

In this study, approximately one seventh of patients undergoing a surgical intervention had preoperative spirometric measurements consistent with obstructive pulmonary dysfunction, a third of whom required perioperative medical therapy. We found that the presence of respiratory symptoms such as dyspnea, cough or sputum, histories of asthma and cigarette smoking, and pulmonary emphysema on chest CT scan were significantly related with the need to introduce a perioperative drug regimen independently of severe pulmonary dysfunction.

In the NICE study, the prevalence of airflow obstruction was 11% in a general Japanese population >40 and 19% among subjects >60 years of age [4]. In our study, the prevalence was 17% and 23% in patients >40 and >60 years of age, respectively. The higher prevalence of obstructive pulmonary dysfunction observed in our population may be explained by the confounding effects of cigarette smoking with both COPD and other disorders, including malignancies. In addition, selection biases may have played a role, although, at our institution, preoperative spirometry is performed in nearly all patients who undergo major surgery.

Among the 333 patients who had findings of airflow obstruction, only 53 (16%) were on an ongoing pharmaceutical treatment. This low treatment rate is consistent with the observations made in the NICE study, in which <10% of subjects presenting with obstructive pulmonary dysfunction had been previously diagnosed with COPD [4]. A FEV_1/FVC <0.7 as a criterion of airflow obstruction may overdiagnose COPD in elderly subjects, though even among those with FEV_1 <50% predicted, a third of patients were untreated before the evaluation, suggesting that a large proportion of patients are undiagnosed and do not receive optimal medical treatment for COPD.

Pulmonary complications are associated with prolonged hospitalizations and are accompanied by cardiac complications [2]. Spirometry, available clinically since the mid-1950s, is an inexpensive and readily available preoperative screening test, easy to implement in large numbers of patients [13]. In one study, a FEV_1/FVC <0.7 was associated with significantly higher rate of postoperative respiratory complications [6] and FEV_1/FVC <0.7 is a reasonable cut off value for screening the patients with COPD, however, it may overestimate airflow obstruction in elderly subjects as previously discussed. The lower limit of normal value of FEV_1/FVC, on the other hand, may lead to misclassification of patients in early disease [14]. We found that, in our decision tree analysis, 46.4% of patients with a FEV_1 ≤85.2% predicted were treated with bronchodilators or inhaled corticosteroids, or both, while only 18.6% of patients whose FEV_1 was >85.2% predicted were treated respiratory drug therapy was initiated or continued perioperatively. Therefore, preoperative spirometry may be a simple and cost-effective approach to estimate the necessity of perioperative pharmacotherapy with the combined cut-off value of

Table 1 Characteristics of all studied patients, and of the subgroups treated versus untreated perioperatively

	All patients (n = 333)	Treated (n = 108)	Untreated (n = 225)	p^1
Age	68.0 ± 10.8	67.6 ± 10.5	68.2 ± 10.9	0.6
Men	230 (69)	78 (72)	152 (68)	0.39
Smoking status				
Ever smokers	220 (66)	85 (79)	135 (60)	0.001
Current smokers	74 (22)	32 (30)	42 (19)	0.024
Pack-year	25 ± 29	32 ± 33	22 ± 26	0.002
History of asthma	43 (13)	36 (33)	7 (3)	<0.001
Respiratory disease manifestations				
Cough/sputum	38 (11)	23 (21)	15 (7)	<0.001
Dyspnea	35 (11)	22 (20)	13 (6)	<0.001
Pulmonary function tests				
Vital capacity, % predicted	91 ± 17	88 ± 18	92 ± 16	0.033
Vital capacity, <80% predicted	83 (25)	34 (31)	49 (22)	0.055
FEV_1, % predicted	84 ± 20	75 ± 21	88 ± 18	<0.001
FEV_1, <50% predicted	24 (7)	16 (15)	8 (4)	<0.001
Abnormal chest radiograph	103 (31)	46 (43)	57 (25)	0.001
Thoracic CT scan	237 (71)	81 (75)	156 (69)	0.30
Emphysema	106 (45)	51 (63)	55 (35)	<0.001
Fibrosis	26 (11)	9 (11)	17 (11)	0.96
Consultation with pulmonologist	191 (81)	97 (90)	94 (42)	<0.001

Values are means ± SD, or numbers (%) of observations.
CT, computed tomography. FEV_1, forced expiratory volume in 1 sec.
[1]Comparison of treated versus untreated groups; between-groups comparisons were made, using Fisher's exact test or unpaired *t*-test, as appropriate.

Table 2 Characteristics of patients with newly-treated versus pretreated obstructive lung disease

	Untreated (n = 225)	Newly treated (n = 55)	Pretreated (n = 53)	p^1
Age	68 ± 11	67 ± 9	68 ± 12	0.86
Men	152 (68)	43 (78)	35 (66)	0.16
Smoking status				
Ever smokers	135 (60)	47 (85)	38 (72)	0.081
Current smokers	42 (19)	21 (38)	11 (21)	0.047
Pack-year	22 ± 26	39 ± 36	25 ± 28	0.025
History of asthma	7 (3)	11 (20)	25 (47)	0.003
Respiratory disease manifestations				
Cough/sputum	15 (7)	10 (18)	13 (25)	0.42
Dyspnea	13 (6)	10 (18)	12 (23)	0.6
Pulmonary function tests				
Vital capacity, % predicted	92 ± 16	91 ± 17	84 ± 18	0.034
Vital capacity, <80% predicted	49 (22)	15 (27)	19 (36)	0.34
FEV_1, % predicted	88 ± 18	81 ± 18	69 ± 22	0.003
FEV_1, <50% predicted	8 (4)	3 (5)	13 (25)	0.005
Abnormal chest radiograph	57 (25)	25 (45)	21 (40)	0.54
Thoracic CT scan	156 (69)	39 (71)	42 (79)	0.38
Emphysema	55 (35)	29 (74)	22 (52)	0.041
Fibrosis	17 (11)	3 (8)	6 (14)	0.28
Consultation with pulmonologist	94 (42)	53 (96)	44 (83)	0.022

Values are means ± SD, or numbers (%) of observations.
CT, computed tomography. FEV_1, forced expiratory volume in 1 sec.
[1]Comparison of newly treated versus pretreated groups; between-groups comparisons were made, using Fisher's exact test or unpaired t-test, as appropriate.

Table 3 Independent predictors of perioperative drug therapy for obstructive pulmonary disease

A) all patients (n = 333)						
	Unadjusted			Adjusted*		
	Odds ratio	95% confidence interval	*p*	Odds ratio	95% confidence interval	*p*
Asthma	24.8	9.3–66.2	<0.001	26.1	8.4–81.4	<0.001
FEV_1, <50% predicted	5.4	1.9–15.6	0.002	12.0	3.2–45.4	<0.001
Ever smoking	4.5	2.2–9.3	<0.001	2.9	1.2–7.0	0.021
Cough/sputum	4.1	1.9–9.1	<0.001	2.2	0.95–4.9	0.066

B) patients who underwent thoracic CT scans (n = 237)						
	Unadjusted			Adjusted*		
	Odds ratio	95% confidence interval	*p*	Odds ratio	95% confidence interval	*p*
Asthma	33.4	9.1–123	<0.001	31.8	7.7–131	<0.001
Emphysema	4.2	1.9–9.2	<0.001	4.6	2.0–10.8	<0.001
Ever smoking	2.7	1.1–7.0	0.036	1.8	0.6–5.4	0.31
Cough/sputum	8.4	3.0–23.0	<0.001	5.4	1.9–15.5	0.002
Dyspnea	4.3	1.5–12.3	0.006	3.7	1.2–11.5	0.023

*Adjusted for age, sex, and consultation with a pulmonologist.
CT, computed tomography. FEV_1, forced expiratory volume in 1 sec.

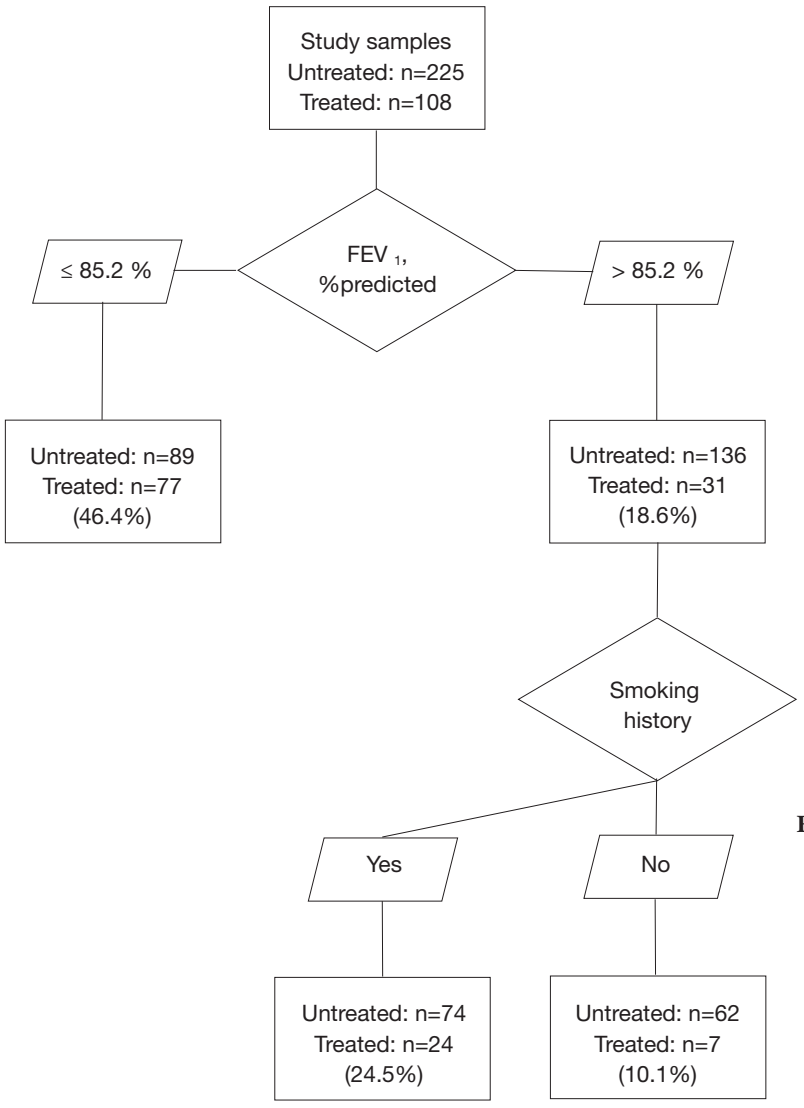

Fig. 2 Decision tree analysis of perioperative drug therapy in 333 patients with obstructive lung dysfunction, developed using the chi-squared automatic interaction detection (CHAID) method. The number is the proportion (%) of patients who received drug therapy in each group. FEV_1, % predicted, and smoking history were the significant predictors of perioperative drug therapy.

FEV_1/FVC <0.7 and FEV_1 <85% predicted value.

Another study, however, found that FEV_1 correlated weakly with respiratory symptoms and exercise capacity and, by itself, did not reliably predict the prognosis of individual patients [7]. Some studies reported that pulmonary function testing does not identify patients at increased risk of postoperative pulmonary complications, emphasizing that spirometric abnormalities should be interpreted in light of other information, such as age, smoking habits and abnormal physical examination [8, 9]. Concomitant illnesses, such as chronic bronchitis and asthma, are strongly associated with an increased risk of postoperative pulmonary complications [8, 15]. These observations were confirmed in our study.

We found no association between chest radiographic abnormalities and prescription of perioperative drug therapy. This finding is consistent with the results of a meta-analysis showing that, while 10% of preoperative chest radiographs showed abnormalities, only 1.3 % were unexpected and only 0.1% modified the patient management [16]. In contrast, the chest CT scans, obtained in >70% of patients to look for pulmonary metastases had a significant influence on the perioperative drug regimens.

Study limitations

First, this study was retrospective. Second, some patients, especially those with dementia or severe respiratory failure, might have been excluded from the evaluation with spirometry. Third, its endpoint was the prescription of perioperative drug therapy for obstructive pulmonary diseases. In contrast to incidence of pulmonary complications, length of hospitalization and mortality, this endpoint depends largely on the subjective judgment of surgeons or pulmonary physicians. Thus, the need for medical treatment may have been underestimated, especially when the patients were not seen by a lung disease specialist. Finally, the patients' symptoms and physical activity should have been ascertained with a validated questionnaire such as COPD assessment test, or with an objective measurement such as the six-minute walk test.

CONCLUSIONS

Considerable proportion of patients scheduled to undergo surgery may exhibit undiagnosed or untreated obstructive pulmonary disease. A thorough evaluation of clinical history, respiratory symptoms, together with spirometry, is essential to identify the patients in need of perioperative medical therapy.

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Conflict of interest statement: The authors have no potential conflict of interest to disclose.

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Supplemental table 1 Characteristics of patients in whom preoperative thoracic CT scan was performed versus not performed.

	Thoracic CT scan performed (n = 237)	Thoracic CT scan not performed (n = 96)	*p*
Age	69 ± 10	65 ± 12	<0.001
Men	170 (72)	60 (63)	0.099
Smoking status			
Ever smokers	160 (68)	60 (63)	0.38
Current smokers	52 (22)	22 (23)	0.85
Pack-year	28 ± 31	17 ± 21	<0.001
History of asthma	27 (11)	16 (17)	0.19
Respiratory disease manifestations			
Cough/sputum production	32 (14)	6 (6)	0.059
Dyspnea	28 (12)	7 (7)	0.22
Pulmonary function tests			
Vital capacity, % predicted	90 ± 17	93 ± 16	0.15
Vital capacity, <80% predicted	65 (27)	18 (19)	0.097
FEV_1, % predicted	83 ± 21	86 ± 18	0.20
FEV_1, <50% predicted	19 (8)	5 (5)	0.37
Abnormal chest radiograph	81 (34)	22 (23)	0.044

Values are means ± SD, or numbers (%) of observations.
CT, computed tomography. FEV_1, forced expiratory volume in 1 sec.

Supplemental table 2 Characteristics of patients with preoperative diagnosis of obstructive pulmonary disease seen versus not seen in consultation preoperatively by a pulmonologist

	Consultation (n = 191)	No consultation (n = 142)	*p*
Age	68 ± 10	69 ± 12	0.36
Men	131 (69)	99 (70)	0.83
Smoking status			
Ever smokers	143 (75)	77 (54)	<0.001
Current smokers	50 (26)	24 (17)	0.044
Pack-year	29 ± 30	19 ± 26	0.002
History of asthma	36 (19)	7 (5)	<0.001
Respiratory disease manifestations			
Cough/sputum production	35 (18)	3 (2)	<0.001
Dyspnea	29 (15)	6 (4)	0.001
Pulmonary function tests			
Vital capacity, % predicted	92 ± 17	89 ± 17	0.14
Vital capacity, <80% predicted	48 (25)	35 (25)	0.92
FEV_1, % predicted	83 ± 19	85 ± 21	0.5
FEV_1, <50% predicted	12 (6)	12 (8)	0.45
Abnormal chest radiograph	63 (33)	40 (28)	0.35
Thoracic CT scan	142 (74)	95 (67)	0.14
Emphysema	67 (47)	39 (41)	0.35
Fibrosis	14 (10)	12 (13)	0.5

Values are means ± SD, or numbers (%) of observations.
CT, computed tomography. FEV_1, forced expiratory volume in 1 sec.