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Alternative definitions of chronic bronchitis and their correlation with CT parameters

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Introduction: Phenotyping of chronic bronchitis (CB) using COPD assessment tool (CAT) scores and St George's Respiratory Questionnaire (SGRQ) has rarely been attempted. The present study defined CB using CAT 1 and 2 scores and the questions on the severity of cough and sputum from the SGRQ. Furthermore, the predictability of CT parameters was also assessed for each CB definition.

Materials and methods: Patients enrolled in the Korean Obstructive Lung Disease study from June 2005 to October 2015 were evaluated for this study. The patients were spirometrically diagnosed with COPD and had a smoking history of >10 pack-years. Volumetric CT scans were performed for each patient upon enrollment in the cohort. Two definitions of CB using CAT 1/2 scores and SGRQ questions were used to phenotype CB among the study patients. Receiver operating characteristic curve analysis was performed to estimate the predictability of CT parameters for the CB phenotypes.

Results: Using CAT 1/2 scores, 57 of 279 (20.4%) patients had CB, and 178 of 573 (31.1%) had CB when the SGRQ questions were used to phenotype it. Total CAT and SGRQ scores were significantly higher in the CB group than those in the non-CB group for both definitions of CB. Forced expiratory volume in 1 second was lower for both CAT-defined and SGRQ-defined CB than that in the non-CB group. Mean wall thickness was significantly higher for both CB groups than in the non-CB group. Expiratory lung volume was higher and mean lung density was significantly lower for the SGRQ-defined CB group than non-CB group.

Conclusion: The 2 CB definitions using CAT scores and the SGRQ questions correlated with associated CT airway parameters. SGRQ-defined CB better reflected the accompaniment of small airway obstruction when compared with CAT-defined CB.

Keywords: chronic bronchitis, chronic obstructive pulmonary disease, chest CT

Introduction

Among COPD, chronic bronchitis (CB) occurs in 14%–74% of cases, depending on the particular definition used.[1] Patients with CB are generally more symptomatic, with a higher COPD assessment tool (CAT) score, and have a lower quality of life, scoring higher on the total SGRQ.[2,3] Many studies have also shown that impaired pulmonary function is more evident for the CB type.[3] Forced expiratory volume in 1 second (FEV_1) and FEV_1/forced vital capacity (FVC) are lower for the CB type.[1] Exacerbations and mortality are higher in patients with the CB type.[1,2] In addition, total smoking pack-years and proportion of current smokers are higher for the CB group than for patients with COPD but without CB.[1,4]

CT parameters have been evaluated to identify the clinical correlation to prognostic markers in patients with COPD and distinguish specific COPD phenotypes objectively. Wall area percentage of the bronchus is positively correlated with body

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mass index in patients with COPD and the air trapping index (ATI) is inversely correlated with 6-minute walk distance (6MWD).[5] Studies have shown that CB increases bronchial wall thickness compared with non-CB,[6] and bronchial wall area is larger than in the non-CB type.[7] FEV_1 decreases with increasing mean bronchial wall thickness.[8] On the other hand, increased emphysema index (EI) and percentage of low-attenuated area are higher for emphysema-predominant COPD than for bronchitic COPD.[9,10]

Cough and sputum for at least 3 months per year and for 2 consecutive years are the most widely used definitions of CB worldwide.[4] In some studies, sputum for 3 months per year is also used as a definition for CB.[11] The answers to the questions regarding cough and phlegm in the St George's Respiratory Questionnaire (SGRQ) have also been used as alternative definitions of CB.[12,13] However, the classic definition of CB frequently has limitations in accurately phenotyping CB. For example, older males have difficulty understanding "2 consecutive years" and the resultant prevalence of CB in overall COPD seems to be lower than the reported prevalence worldwide in Korean patients with COPD.[1,3] In addition, checking whether patients have had the complaint of sputum for 3 months per year requires mental effort for older patients to recall.

Patients with COPD have responded to different questionnaires, including the CAT and total SGRQ, for initial symptoms and quality of life assessments. Among the many questions, the questions on severity of cough and sputum overlap with the widely known definition of CB, which, in turn, raises the possibility of utilizing it to phenotype CB. In fact, the SGRQ questions on cough and sputum have been used to some extent. In 1 study, if the patient answered "most days of the week" or "several days of the week" to both questions regarding cough and phlegm, the patient was phenotyped into the CB group.[12] Among CAT scores, CAT 1 is a question on the severity of cough, while CAT 2 is a question that assesses the severity of sputum. To our knowledge, these 2 questions have rarely been used to phenotype CB.

The aim of the present study was to define CB among patients with COPD using CAT 1 and 2 scores and the questions from the SGRQ on the severity of cough and sputum. The predictability of CT parameters for each CB phenotype was also assessed by receiving operating characteristic (ROC) curve analysis.

Patients and methods

Patients

Patients enrolled in the Korean Obstructive Lung Disease study cohort for which patients with COPD or asthma had been recruited from pulmonary clinics in 16 hospitals in South Korea from June 2005 to October 2015 were evaluated for this study. The study patients were spirometrically diagnosed with COPD, with postbronchodilator $FEV_1/FVC < 0.7$, and had a smoking history of >10 pack-years. In addition, patients had no or minimal abnormalities on chest radiographs. Pulmonary function test (PFT) and CT scans were performed on the same day. The institutional review board of the participating hospitals approved use of the clinical and imaging data for evaluation. Written informed consent was obtained from each patient. The names of ethics committees were as follows: Asan Medical Center, Bundang CHA Hospital, Ewha Womans University Mokdong Hospital, Korea University Anam Hospital, Hanyang University Guri Hospital, Inje University Ilsan Paik Hospital, Kangbuk Samsung Hospital, Hallym University Kangnam Sacred Heart Hospital, Kangwon National University Hospital, Seoul National University Hospital, Seoul National University Bundang Hospital, Ajou University Hospital, Konkuk University Hospital, The Catholic University of Korea Yeouido St Mary's Hospital, The Catholic University of Korea Seoul St Mary's Hospital, and National Medical Center.

CT

Volumetric CT scans were performed in all patients with COPD at full inspiration and expiration using a 16-MDCT scanner (Somatom Sensation; Siemens Medical Systems, Erlangen, Germany). Scan parameters included 0.75-mm collimation, 100 eff. mAs, and 140 kVp with pitch of 1.0. Patients were scanned craniocaudally in a supine position. The scale of attenuation coefficients in this CT scanner ranges from −1,024 to 3,072 Hounsfield unit (HU). No intravenous contrast medium was used. Using the soft kernel (B30f; Siemens Medical Systems), the images were reconstructed from the thoracic inlet to the lung base. The whole lung images were extracted automatically, and the attenuation coefficient of the pixel was measured by in-house software. The cut-off level dividing normal lung density and a low-attenuation area was –950 HU.[5,14]

The mean lung density (MLD) and the volume fraction of the lung were calculated automatically using software. Airway dimensions were measured at the site near the origin of 4 segmental bronchi (LB1+ 2, RB1, LB10, and RB10). The ATI was defined as the ratio of MLD on expiration and inspiration.

A modified sharpening filter with a 3 9 3 kernel size was used for more accurate airway measurement.

Lumen area (LA), wall area (WA), and wall area percent (WA%) were measured in each segmental bronchus.

The WA% was defined as WA/(WA + LA) × 100. The mean value of each dimension value was used for the statistical analysis. After the validation process using polyacryl tube, the software automatically discriminated the airway lumen and the inner and outer boundaries of the airway wall using the full-width-maximum method.[15,16]

CB definitions

Two definitions of CB were used. CB was defined using the answers to CAT questions 1 and 2 (questions on the severity of cough and sputum). As there is no reference, we aimed to find the CAT 1/2 cut-off value to define CB. We analyzed the prevalence of CB for each CAT 1/2 score.

Based on previous studies, responses to SGRQ questions were also used to define CB.[12] Among the patients with COPD who answered the SGRQ questions, CB was defined when patients answered "most days of the week" or "several days of the week" to the questions "How often do you complain of cough during the week?" and "How often do you complain of sputum during the week?"

Clinical parameters

The patients' clinical parameters significant to COPD were also evaluated. In addition to the previously mentioned CAT and SGRQ scores, sex and age of patients were also included in the analyses. Total numbers of COPD-related visits to the hospital, outpatient visits, visits to the emergency room, and admissions were also evaluated. Exercise capacity on the 6MWD was also evaluated. FEV_1, FVC, and FEV_1/FVC were evaluated from the results of the PFT. The diffusion capacity of the lungs for carbon monoxide (DLCO) was also evaluated.

Statistical analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences software program version 18.0 (SPSS Inc., Chicago, IL, USA). Data of continuous variables are presented as mean with range. An ROC curve was constructed to estimate the predictability of the CT parameters for the CB phenotypes. The optimum cut-off values were defined as the point closest to the upper-left angle of the chart. The chi-square test was performed to compare categorical parameters. Continuous variables were analyzed using 2-sided tests or the Mann–Whitney test depending on the normality of the data distribution. A P-value <0.05 was considered significant.

Results

A total of 279 patients had CAT scores at enrollment in the cohort. Of the 279 patients, 235 (84.2%) had CAT 1 and 2 scores ≥1, and 125 (44.8%) patients had CAT 1 and 2 scores ≥2. Fifty-seven patients had CAT scores ≥3 (20.4%). When the CAT score cut-off was <3, the percentages of alleged patients with CB were too low compared with previously reported CB percentages,[3] so only the CB group, defined as patients with COPD with a CAT score ≥3, were evaluated in depth. Table 1 shows a comparison of the clinical characteristics of the CB and non-CB groups. Mean age of the patients with CB was 66.9±8.2 years, and that for the non-CB group was 68.3±8.3 ($P > 0.05$). The percentage of males was lower in the CB group (89.5% vs 92.8%) ($P > 0.05$). The total CAT score was higher in the CB group (21.8±5.7) than the non-CB group (10.1±6.4) ($P < 0.001$). Total SGRQ score was 39.4±18.9 for the CB group, compared with 20.5±14.1 for the non-CB group ($P < 0.001$). Total COPD-related hospital visits and outpatient visits tended to be more frequent in the CB group ($P > 0.05$). Mean FEV_1 (%) was 51.4±13.8 in the CB group and 56.5±15.7 in the non-CB group ($P = 0.028$). Mean FVC (%) also tended to be lower in the CB group (80.4±14.7 vs 83.1±14.4) than the non-CB group ($P > 0.05$). Mean wall thickness was higher for the CB group (1.28±0.11 mm) than the non-CB group (1.24±0.11 mm) ($P = 0.013$). Mean WA was also higher for the CB group ($P = 0.015$).

Table 2 shows a comparison of clinical characteristics between the CB group defined by responses to the SGRQ questions and the non-CB group. Mean age of the CB group was 66.7±8.4 years, and that of the non-CB group was 66.7±7.8 ($P > 0.05$). The male percentage was lower in the CB group than the non-CB group (91.6% vs 92.2%) ($P > 0.05$). The percentage of current smokers was significantly higher in the CB group than the non-CB group (39.3% vs 27.1%) ($P = 0.001$). Total CAT score was higher in the CB group (15.8±8.4) than the non-CB group (11.1±7.0) ($P < 0.001$). Total SGRQ score was 39.4±18.6 in the CB group, compared with 26.8±17.2 in the non-CB group ($P < 0.001$). Total COPD-related hospital visits and outpatient visits tended to be higher in the CB group ($P > 0.05$). Mean FEV_1 (%) was 49.1±16.9 in the CB group and 52.9±16.2 in the non-CB group ($P = 0.012$). Mean FVC (%) was not different between the groups. FEV_1/FVC was significantly lower in the CB group (44.9%±11.6%) than the non-CB group (48.2%±11.6%). The absolute DLCO value was significantly lower in the CB group than the non-CB group ($P = 0.048$). Expiratory lung volume was higher ($P = 0.002$) and expiratory MLD was significantly lower in the CB group ($P < 0.001$) than the non-CB group. Furthermore, mean wall thickness was higher in the CB group (1.24±0.12 mm) than the non-CB group (1.22±0.11 mm) ($P = 0.047$).

Table 1 Clinical characteristics of COPD patients with CAT scores and comparison between non-chronic bronchitis and chronic bronchitis patients defined as CAT 1 and 2 scores ≥3

Characteristics	Overall patients (n=279)	CB group (n=57)	Non-CB group (n=222)	*P*-value
Mean age (years, mean, SD)	68.0±8.3	66.9±8.2	68.3±8.3	0.241
Sex (n, %)				0.407
Female	22 (7.9%)	6 (10.5%)	16 (7.2%)	
Male	257 (92.1%)	51 (89.5%)	206 (92.8%)	
Smoking				
Current smoker (n, %)	81 (29%)	15 (26.3%)	66 (29.7%)	0.870
Pack-years (mean, SD)	42.9±25.6	46.7±29.4	42.0±24.6	0.253
Body mass index (mean, SD)	24.3±2.6	24.5±2.7	24.2±2.6	0.694
CAT total score (mean, SD)	12.5±7.8	21.8±5.7	10.1±6.4	<0.001
SGRQ, total (mean, SD)	24.2±16.8	39.4±18.9	20.5±14.1	<0.001
Total visits to hospital	2.7±4.3	4.7±6.9	1.6±1.2	0.117
Outpatient visits	2.8±4.9	5.0±7.0	1.3±1.6	0.099
Emergency room visits	0.9±1.0	0.6±1.0	1.1±1.0	0.284
Admissions to hospital	1.0±0.9	0.9±0.8	1.0±0.9	0.662
FEV_1 (absolute, L)	1.6±0.6	1.5±0.5	1.7±0.6	0.025
FEV_1 (percentage predicted)	55.4±15.4	51.4±13.8	56.5±15.7	0.028
FVC (absolute value, L)	3.4±0.8	3.3±0.8	3.5±0.8	0.070
FVC (percentage predicted)	82.6±14.4	80.4±14.7	83.1±14.4	0.215
FEV_1/FVC (percentage)	47.9±11.1	46.2±10.9	48.3±11.1	0.217
DLCO, absolute	14.6±7.8	13.6±4.5	14.8±8.4	0.332
DLCO, percentage predicted	71.8±20.8	71.6±20.5	71.8±20.9	0.958
6MW (distance, meter)	403.3±84.6	398.9±89.4	404.5±83.5	0.671
CT parameters				
Inspiratory lung volume (cm^3)	5,291.3±1,054.9	5,201.6±1,188.0	5,314.7±1,019.2	0.484
Expiratory lung volume (cm^3)	3,718.4±1,050.5	3,728.4±975.6	3,715.8±1,071.3	0.937
Inspiratory MLD (HU)	–870.9±26.1	–868.2±29.2	–871.5±25.2	0.406
Expiratory MLD (HU)	–817.9±45.3	–820.7±42.6	–817.2±46.0	0.614
ATI	0.917±0.141	0.943±0.035	0.911±0.155	0.169
Inspiratory EI (%)	15.8±12.2	15.5±13.1	15.8±11.9	0.847
Expiratory EI (%)	8.5±9.8	8.5±9.7	8.6±9.8	0.957
Airway lumen diameter (mm)	3.5±1.4	3.6±0.7	3.5±1.5	0.783
Mean wall thickness (mm)	1.24±0.12	1.28±0.11	1.24±0.11	0.013
Mean wall area (mm^2)	18.7±3.8	19.8±4.5	18.4±3.6	0.015
Mean wall area (%)	66.1±4.9	66.2±5.1	66.0±4.9	0.852

Abbreviations: 6MW, 6-minute walk; ATI, air trapping index; CAT, COPD assessment test; CB, chronic bronchitis; CT, computed tomography; DLCO, diffuse capacity of the lungs for carbon monoxide; EI, emphysema index; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HU, Hounsfield unit; L, liters; MLD, mean lung density; SGRQ, St George's Respiratory Questionnaire.

Table 3 shows the results of the ROC curve analysis performed to evaluate the predictability of the CT parameters for CB phenotypes. For CAT-defined CB, mean wall thickness and mean WA were the CT parameters with statistical significance. Mean wall thickness showed an area under the curve (AUC) of 0.632 (95% CI, 0.550–0.713) with specificity of 0.797 at a cut-off value of 1.30 mm. Mean WA showed an AUC of 0.598 with sensitivity of 0.722 at a cut-off value of 17.27 mm^2. For SGRQ-defined CB, expiratory lung volume, MLD, EI, and the ATI were the significant CT parameters in the ROC curve analysis. All values had AUCs >0.5.

Discussion

The present study attempted to phenotype CB using the responses to SGRQ questions and CAT scores on cough and sputum, and compared the clinical characteristics between CB and non-CB patients with COPD. In addition to CB phenotyping, the predictability of CT parameters for CB among patients with COPD was assessed by an ROC curve analysis. The clinical characteristics of the CB group defined using CAT scores and responses to the SGRQ matched the patients with CB from previous studies.[2,3,12] We also showed that patients with CB have higher CAT scores and lower quality of life than those of the non-CB group. FEV_1 was

Table 2 Comparison of clinical characteristics between non-chronic bronchitis and chronic bronchitis patients defined by responses to SGRQ questions on cough and sputum

Characteristics	Overall patients (n=573)	CB group (n=178)	Non-CB group (n=395)	*P*-value
Mean age (years, mean, SD)	66.7±8.0	66.7±8.4	66.7±7.8	0.955
Sex (n, %)				0.813
Female	46 (8.0%)	15 (8.4%)	31 (7.8%)	
Male	527 (92.0%)	163 (91.6%)	364 (92.2%)	
Smoking				
Current smoker (n, %)	177 (30.9%)	70 (39.3%)	107 (27.1%)	0.001
Pack-years (mean, SD)	44.1±27.4	44.6±26.1	43.9±27.9	0.810
Body mass index (mean, SD)	23.7±3.1	22.5±3.1	24.1±3.0	0.003
CAT total score (mean, SD)	12.6±7.8	15.8±8.4	11.1±7.0	<0.001
SGRQ, total (mean, SD)	30.7±18.6	39.4±18.6	26.8±17.2	<0.001
Total visits to hospital	3.4±4.2	4.1±5.2	2.8±2.9	0.105
Outpatient visits	3.5±4.4	3.9±5.2	3.1±3.4	0.337
Emergency room visits	0.8±0.9	0.8±1.0	0.9±0.9	0.680
Admissions to hospital	1.2±0.7	1.3±0.7	1.1±0.7	0.239
FEV_1 (absolute, L)	1.5±0.6	1.4±0.5	1.6±5.8	0.003
FEV_1 (percentage predicted)	51.7±16.5	49.1±16.9	52.9±16.2	0.012
FVC (absolute value, L)	3.3±0.8	3.2±0.9	3.3±0.8	0.364
FVC (percentage predicted)	78.9±16.2	79.0±17.4	78.9±15.7	0.936
FEV_1/FVC (percentage)	47.1±11.7	44.9±11.6	48.2±11.6	0.002
DLCO, absolute	15.0±7.0	14.1±5.6	15.4±7.5	0.048
DLCO, percentage predicted	77.8±24.0	75.0±22.3	79.0±24.6	0.065
6MW (distance, meter)	421.5±90.3	414.5±88.6	424.6±91.0	0.233
Body fat percentage (%)	25.9±6.7	23.9±6.1	26.6±6.8	0.026
CT parameters				
Inspiratory lung volume (cm^3)	5,503.1±1,127.3	5,547.5±1,194.6	5,483.2±1,096.7	0.536
Expiratory lung volume (cm^3)	3,895.2±1,140.8	4,117.4±1,163.7	3,795.2±1,117.6	0.002
Inspiratory MLD (HU)	–877.3±27.4	–878.4±27.1	–876.8±27.6	0.532
Expiratory MLD (HU)	–825.7±47.2	–835.7±42.1	–821.2±48.7	<0.001
ATI	0.905±0.185	0.914±0.188	0.901±0.184	0.439
Inspiratory EI (%)	18.9±14.7	19.8±14.3	18.4±14.8	0.299
Expiratory EI (%)	10.8±12.4	12.1±12.0	10.2±12.5	0.081
Airway lumen diameter (mm)	3.4±1.1	3.4±0.6	3.4±1.2	0.634
Mean wall thickness (mm)	1.23±0.12	1.24±0.12	1.22±0.11	0.047
Mean wall area (mm^2)	17.9±3.7	18.2±4.0	17.8±3.6	0.262
Mean wall area (%)	66.3±5.0	66.8±5.0	66.1±4.9	0.143

Note: Data are presented as mean ± standard deviation.
Abbreviations: 6MW, 6-minute walk; ATI, air trapping index; CAT, COPD assessment test; CB, chronic bronchitis; CT, computed tomography; DLCO, diffuse capacity of the lungs for carbon monoxide; EI, emphysema index; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HU, Hounsfield unit; L, liters; MLD, mean lung density; SGRQ, St George's Respiratory Questionnaire.

Table 3 The optimum cutoff and ROC curve parameters for the prediction of chronic bronchitis type, defined by the CAT scores or SGRQ responses

Parameters	Cutoff	Sensitivity	Specificity	AUC	95% CI
CAT-defined CB					
Mean wall thickness	1.30	0.426	0.797	0.632	0.550–0.713
Mean wall area	17.27	0.722	0.449	0.598	0.512–0.683
SGRQ-defined CB					
Expiratory lung volume	3,571.2	0.678	0.468	0.583	0.531–0.634
Expiratory MLD	–807.23	0.368	0.801	0.585	0.535–0.635
Expiratory EI	2.17	0.789	0.366	0.576	0.526–0.626
ATI	0.926	0.781	0.377	0.592	0.543–0.641

Note: Only the CT parameters with *P*-value <0.05 are shown in the table.
Abbreviations: ATI, air trapping index; AUC, area under the curve; CAT, COPD assessment test; CB, chronic bronchitis; EI, emphysema index; MLD, mean lung density; ROC, receiving operating characteristic; SGRQ, St George's Respiratory Questionnaire.

lower and COPD-related hospital visits were higher in the CB group. The percentage of current smokers at enrollment in the cohort was higher in the CB group, which was consistent with a previous study on CB.[10]

The correlation between CB phenotype and CT parameters differed when the 2 definitions of CB were applied. When CAT scores were used for the CB definition, mean WA and mean wall thickness were significantly higher in the CB group than those in the non-CB group, while the AUC of mean wall thickness was >0.6. Previous studies also showed that mean wall thickness and mean WA of the bronchus increased in patients with COPD and CB.[6,7] When the SGRQ definition was used, mean wall thickness was also higher in the CB group. While inspiratory lung volume and MLD were not significantly different between the 2 groups, expiratory lung volume was significantly higher and MLD was significantly lower in the CB group. The differences between the groups in the expiratory CT findings suggested that small-airway disease coexists with CB as defined by the SGRQ questions.

The classic definition of CB and the new definition based on CAT answers suggested in our study both categorize CB according to severity of cough and sputum, which are the main complaints of CB patients. The classic definition focuses on the duration of the symptoms, on the other hand, the alternative definition focuses on how severe the symptoms are at the time of presentation.

Nevertheless, COPD patients, mostly elderly, experience difficulties in answering the question "Cough, sputum for 3 months per year for 2 consecutive years". Furthermore, the term "2 consecutive years" is difficult to translate into Korean without changing the original meaning, because there is no precise word in Korean that equates to "consecutive" in this case.[11] Considering the challenge from language difference, a more simple and easier definition will improve diagnosis of CB patients. The responses to the CAT questions depend on patients' subjective feelings and can be influenced by patient-related factors. However, we assume that the alternative definition will be more intuitive and easier for patients to answer in busy outpatients clinics.

In previous studies, the SGRQ questions were also used to define CB.[12,13] In CB, both SGRQ and CAT scores are significantly increased.[3] SGRQ has many questions and is used more in the research setting. On the other hand, the CAT has only 8 questions and is more frequently used in the outpatient clinics.[17] For this reason, the novel definition of CB based on CAT scores can be more practical in clinical settings compared with the classic definition and the SGRQ CB definition.

There are limitations, which are worthy of being mentioned. First, the CB definition based on CAT scores is novel and requires further validation process. Comparative studies would evaluate coherence with other CB definitions. In addition, cutoffs in the CAT scores should also be determined. Second, we have not used the classic definition of CB for comparison in our study due to the low percentage of patients who properly responded. Finally, the present study is a cross-sectional work, and a future study following clinical courses of CB patients is necessary to evaluate whether the new CB definition is appropriate for management of COPD patients.

Conclusion

When focusing on clinical characteristics of the patients with CB defined by the 2 different methods, both CB groups showed clinical characteristics consistent with the CB phenotypes reported from previous studies: more respiratory symptoms, lower quality of life, impaired pulmonary function, and a higher percentage of current smokers. Both the CAT- and SGRQ-defined CB groups correlated with associated CT airway parameters. The CT parameters associated with SGRQ-defined CB better reflect the accompaniment of small airway obstruction when compared with CAT-defined CB.

Disclosure

The authors report no conflicts of interest in this work.

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