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How are radiological, spirometric and quality of life measures related to each other in cases of bronchiectasis

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Abstract:

BACKGROUND: Radiological, spirometric, and quality-of-life (QoL) measures are essential parameters influencing the prognosis of patients with bronchiectasis (BE). However, to date, few studies have evaluated these measures together.

OBJECTIVE: The study objective is to assess the relationships between high resolution computed tomography, spirometric and QoL scores considered in the steady and exacerbation states of BE.

METHODS: We reviewed retrospectively patients who had been diagnosed with BE. Ninety-two cases were deemed eligible and completed the Short Form-36 (SF-36) and St George's Respiratory Questionnaire (SGRQ). A statistical assessment looking for correlations between HCRT, spirometry and QoL questionnaires was performed. Besides, factors for the modified Bhalla score (MBS) and clinical exacerbations were evaluated.

RESULTS: İn the exacerbation state, patients' spirometric parameters and the domains of the SF-36 were even more strongly correlated with MBS, in particular, symptom duration, exacerbation and hospitalization rates in the previous year. Linear regression models for the steady and exacerbation state revealed SF-36 domains, forced expiratory volume in 1 s predicted and symptom duration were more related to MBS. In addition, the exacerbation rate was related to the domains of the SF-36, MBS and hospitalization within the previous year in both the steady and exacerbation state of BE.

CONCLUSIONS: As a result of this study, SF-36, which is rarely used in clinical practice, has been demonstrated to be more correlated with radiological and pulmonary function test (PFT) scores than SGRQ. Assessing the patient's disease status can be performed more efficiently if MBS and SF-36 are combined with PFT.

Keywords:

Bronchiectasis, quality of life, spirometry, surveys and questionnaires, tomography computed

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Introduction

Bronchiectasis (BE) has been described as abnormal, irreversibly dilated, and thick-walled bronchi.[1] It is an important cause of suppurative lung disease, with significant impacts on both the quality of life (QoL) of individuals and on the health system as a whole, since affected patients call on many health-care resources, such as frequent clinic visits, hospitalization, diagnostic imaging (e.g., high-resolution computed tomography scanning [HRCT] of the chest) and parenteral antibiotics.[2] The evaluation of patients with BE generally includes HRCT in addition to making clinical findings,

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pulmonary function testing, and chest radiography. Clinicians need to interpret the extent of BE in detail to guide clinical management. The relationship between the modified Bhalla scoring system (MBS) with (QoL) and pulmonary function tests (PFTs) may predict disease progression. Ensuring the balance of importance given to these three clinical parameters will help the clinician to manage effectively any exacerbations of BE.

There is a discrepancy between pulmonary function and the extent of BE as seen radiologically. The severity of airflow obstruction was found to be related to the extent of bronchiectatic segments as demonstrated by HRCT[3] but in asthma and chronic obstructive pulmonary disease (COPD) patients, morphological changes associated with BE do not influence lung function.[4] Moreover, the radiological extent of BE is negatively correlated with obstructive parameters in some studies,[5] and with both obstructive and restrictive parameters in other studies.[6]

Within the literature, there is insufficient data to evaluate the relationship between QoL and radiological findings in BE. The minor correlation has been found between more severe and extensive disease as expressed in HRCT measures and the QoL.[5] There is considerable data indicating that BE in COPD patients increases exacerbations, but there are a lack of data concerning the correlation between the extent of BE seen radiologically and exacerbations of BE.

This research investigates the correlations between the radiological extent of bronchiectasis (on the basis of HRCT), PFT and QoL, by developing and testing a series of hypothesis indicating how these three entities may interact as well as analyzing the relationship between these measures and exacerbations of BE.

Methods

Study design and participants

This was a cross-sectional study design involving 92 patients with previously diagnosed BE, confirmed by HRCT, who were enrolled in the study from the outpatient clinic at the Yedikule Chest Disease and Chest Surgery Research and Training Hospital between January and December 2014. The study protocol was approved by the local hospital Ethics Committee (February 10, 2015/81). Signed informed consent was obtained from each patient who was willing to participate in the study.

- Inclusion criteria were: (1) patients diagnosed as BE over 18 years old, (2) patients who had HRCT before study enrollment
- Exclusion criteria were: (1) patients who refused to participate in the study, (2) patients who had missing data (3) patients who had missing PFT during the previous 6 months (4) patients who were unable to complete SGRQ, 5) patients with other associated lung diseases.

Demographic data including age, sex, smoking status, body mass index (BMI), comorbidities, symptom duration, sputum cultures, PFT (during the previous 6 months, not in the exacerbation state), HRCT (during the previous 12 months, not in the exacerbation state) and biochemical values were recorded from the hospital's database and exacerbation rates were recorded as patients' statements.[7] We did not performed bronchodilator reversibility test since our aim was not to diagnose asthma. HRCTs were evaluated and scored by the modified Bhalla scoring system by a radiologist and a chest physician simultaneously. Any differences in score interpretation were resolved by achieving consensus between raters.

Short Form-36 and St George's Respiratory Questionnaire

The Short Form-36 (SF-36) is a questionnaire with 36 items that measure functional health and well-being. It consists eight domains and two psychometric components, each derived from four domain scores. Domain and summary component scores range from 0 to 100; higher scores reveal better health status or well-being.[8]

The St George's Respiratory Questionnaire (SGRQ) is a questionnaire with 50 items comprising three domains: symptoms, activity and psychosocial impact. Each score from 0 to 100, with higher scores corresponding to, worsened QoL.[9] Validated Turkish version of SGRQ was used to evaluate health-related QoL. SF-36 and SGRQ were conducted by a blinded pollster.

Modified Bhalla scoring system

The extent of BE, severity of bronchial dilatation, bronchial wall thickness (BWT), the presence of mucous plugging in large and small airways, and the decrease in parenchymal Decreased Attenuation (DA) were scored for each lung lobe (the lingula being considered a lobe in its own right, making a total of 6 lobes) separately, according to MBS. The scoring system was as follows: (1) extent of BE (0 = none, 1 = one or partial broncho-pulmonary segment involvement, 2 = two or more bronchopulmonary segments involved, 3 = generalized cystic BE); (2) severity of bronchial dilatation (0 = normal, 1 = less than twice the diameter of the adjacent pulmonary artery, 2 = more than twice the diameter of the adjacent pulmonary artery); (3) severity of bronchial wall thickening (0 = normal, 1 = 0.5 × the diameter of the adjacent pulmonary artery, 2 = 0.5–1.0 × the diameter of the adjacent pulmonary artery, 3= ≥1.0 × the diameter of the adjacent pulmonary

artery); 4) presence of mucous plugging in large airways (0 = none, 1 = present); (5) presence of mucous plugging in small airways (0 = none, 1 = present); and (6) extent of decreased attenuation (0 = normal, 1 = ≤50% of lobar volume, 2 = >50% of lobar volume).[10]

Exacerbation and steady state

Acute deterioration in three or more of the following symptoms for at least 48 h: cough, sputum (color, viscosity, and volume), breathlessness and/or exercise intolerance, fatigue and/or malaise, hemoptysis, were defined as exacerbation state.[7]

Patients with no major deterioration in symptoms within 4 weeks were defined as steady state.[7]

Study outcomes

The primary outcome was to investigate if there is any correlation between MBS, PFT and QoL in patients diagnosed with BE, whether in the steady or exacerbation state. Secondary outcomes were correlations between exacerbation rates and MBS of patients diagnosed with BE and prediction of exacerbations using radiology, clinical findings or PFT.

Statistical analysis

Continuous data are presented as the mean and standard deviation (SD) and categorical data as frequencies and percentages. Comparisons between-groups were made using two-sided pairwise *t*-tests or Chi-square tests, as appropriate. The internal consistency of SGRQ and SF-36 was assessed by calculating Crohnbach's α. Univariate correlations between variables were evaluated using Pearson's correlation coefficient. Multiple linear regression models by enter and stepwise methods were performed to identify which variables were significantly related to MBS and exacerbation rates in the steady and exacerbation states. A value for $P < 0.05$ was considered statistically significant.

Results

Patient characteristics

A retrospective search of the chest disease department database was performed for patients for whom HRCT had been performed and who had been diagnosed with BE. Ninety-two patients over 18 years of age were included in the study.

A total of 92 patients were enrolled and grouped into steady or exacerbation state cases. The steady-state BE group consisted of 55 patients (of which, 28 were female). Thirty-seven patients (24 of which were female) were in the exacerbation state. The mean age was 51.76 ± 17.73 for the steady-state and 54.59 ± 16.15 for the exacerbation state. Twenty-two out of 55 patients were active smokers in the steady-state group, whereas 12 out of 37 patients were smokers in the exacerbation group [Table 1]. In total, 50 (54.3%) patients had no comorbidity, whereas 5 (5.4%) patients had three comorbidities. Cardiovascular comorbidities were the most prevalent (27.34%), followed by COPD (8.68%), diabetes (6.85%) and asthma (5.08%), as shown in Table 2 and Figure 1. 21/55 of steady-state and 10/37 of the exacerbation state cases were unable to produce a sputum sample. Commensals were isolated in 53.3% of clinically stable cases, and 70% of exacerbation cases. Most of the cases (32/55) in the steady-state group had had an exacerbation in the previous year, whereas 21/37 of exacerbation group had had 2 or more exacerbations in the previous year. Hospitalizations in the previous year were seen more in the exacerbation group (74%). Pulmonary function test variables, health-related questionnaires, modified Bhalla scores (MBSs), and further patient characteristics are shown in Table 1 and grouped by actual steady or exacerbation state.

After dividing patients into a steady state and exacerbation group, we evaluated differences between the groups. There were no differences in terms of sex, age, smoking status, and smoking package years or BMI. There were 31 patients in the steady-state group and 19 patients in the exacerbation group who had no comorbidities. Cardiovascular diseases were the most commonly observed comorbidity in both groups (18/55, 14/37; respectively). COPD was seen in 3/55 patients in the steady state and 7/37 patients in the exacerbation group. There was no statistically significant difference between steady and exacerbation states in terms of comorbidities ($P = 0.253$). Sputum cultures revealed no significant difference between the two groups. In the steady-state group, most of the patients (21/55) were unable to supply sputum samples. In contrast, most of the patients (21/37) in the exacerbation group had positive sputum cultures.

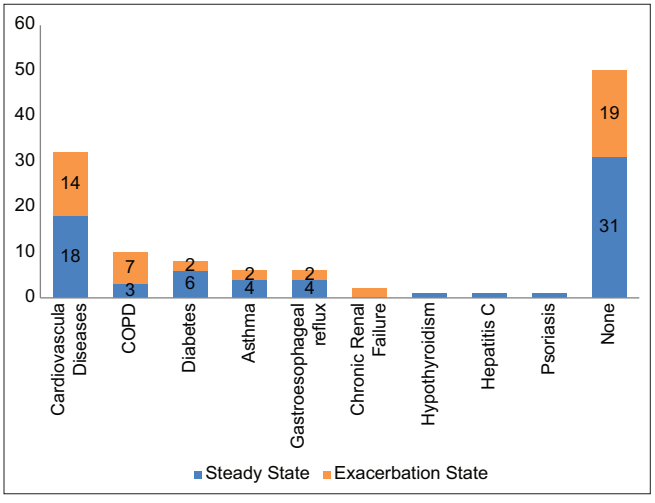

Figure 1: Comorbidities of patients

Table 1: Demographic and clinical data of steady state and exacerbation of bronchiectasis

Variables	Steady-state BE (*n*=55)	Exacerbation of BE (*n*=37)	*P*
Sex, *n* (%)			
Men	27 (67.5)	13 (32.5)	0.20
Women	28 (53.8)	24 (46.2)	
Age, mean±SD	51.76±17.73	54.59±16.15	0.44
Smoking, *n* (%)			
Smoker	22 (64.7)	12 (35.3)	0.50
Nonsmoker	29 (56.9)	22 (43.1)	
Smoking pack-year	11.0±16.54	9.71±±16.09	0.72
BMI, mean±SD	24.37±3.59	25.13±5.55	0.43
Comorbidities, *n* (%)			
None	31 (62.0)	19 (38.0)	0.45
1 comorbidity	14 (60.9)	9 (39.1)	
2 comorbidities	6 (42.9)	8 (57.1)	
3 comorbidities	4 (80.0)	1 (20.0)	
Sputum cultures, *n* (%)			
No sputum	21 (67.7)	10 (32.3)	0.50
Culture (−)	18 (58.1)	13 (41.9)	
Culture (+)	16 (42.1)	21 (57.9)	
Exacerbation previous year, *n* (%)			
None	14 (82.4)	3 (17.6)	0.036*
1 exacerbation	32 (71.1)	13 (28.9)	0.03*
≥2 exacerbation	9 (30.0)	21 (70.0)	<0.001*
Exacerbation previous year, mean±SD	1.25±1.48	2.49±2.07	<0.001*
Hospitalization previous year, *n* (%)			
None	49 (71.0)	20 (29.0)	<0.001*
≥1 hospitalization	6 (26.0)	17 (74.0)	<0.001*
Hospitalization previous year, mean±SD	0.11±0.32	0.95±1.79	<0.001*
Symptom duration, year, mean±SD	6.37±6.09	9.86±9.26	0.032*
PFT, mean±SD			
FVC	2.36±1.03	1.69±0.69	0.001*
FVC %	68.99±17.51	54.86±22.47	0.001*
FEV_1	1.94±1.0	1.16±0.54	<0.001*
FEV_1 %	67.65±22.30	46.37±22.80	<0.001*
FEV_1/FVC	75.45±12.67	65.96±13.46	0.001*
SF-36, mean±SD			
PF	65.65±19.05	49.73±21.54	<0.001*
RP	65.28±40.17	35.81±39.78	0.001*
BP	55.60±28.03	46.27±26.53	0.11
GH	41.28±21.75	28.16±18.12	0.003*
VT	52.69±21.07	40.67±17.92	0.006*
SF	65.48±27.46	48.30±22.08	0.002*
RE	62.95±38.68	52.24±40.48	0.20
MH	65.70±18.63	57.40±19.95	0.046*
PCS	40.74±10.50	33.87±9.59	0.002*
MCS	46.40±10.21	42.01±9.67	0.042*
SGRQ, mean ± SD			
Symptom score	63.80±18.21	69.81±23.17	0.16
Activity score	50.63±24.53	52.86±19.80	0.64
Impact score	43.72±19.37	51.33±20.43	0.07
Total score	48.57±18.70	55.36±18.18	0.08
MBS, mean±SD			
Severity of BE	1.93±0.84	2.00±0.78	0.67
Peribronchial thickening	1.33±0.82	1.38±0.98	0.78
Extent of BE	1.91±0.70	2.05±0.78	0.35
Extent of mucous plugging	0.69±0.77	1.05±0.91	0.042*

Contd...

Table 1: Contd...

Variables	Steady-state BE (*n*=55)	Exacerbation of BE (*n*=37)	*P*
Sacculation/abscesses	0.49±0.69	0.78±0.89	0.07
Generation of bronchial divisions	0.89±0.85	1.38±0.95	0.012*
Bullae	0.27±0.59	0.27±0.65	0.98
Emphysema	0.29±0.66	0.38±0.76	0.55
Collapse/consolidation	0.38±0.56	0.35±0.67	0.81
Mosaic perfusion	0.24±0.51	0.46±0.84	0.11
MBS total score	8.18±3.69	10.11±4.20	0.022*
Biochemical values, mean±SD			
CRP, mg/L	7.96±7.35	75.90±84.30	<0.001*
WBC, $10^3/mm^3$	8.24±1.88	14.41±5.46	<0.001*
HB, g/dL	13.50±1.59	12.60±1.60	0.010*
PLT, $10^3/mm^3$	255±77.86	310.19±106.06	0.005*

Two-sided pairwise t tests or chi-square tests were used as appropriate. SD: Standard deviation, BMI: Body mass index, PFT: Pulmonary function test, FVC: Forced vital capacity, FVC %: Forced vital capacity % predicted, FEV_1: Forced expiratory volume in the 1 s, FEV_1 %: Forced expiratory volume in the 1 s % predicted, SF-36: Short form-36, SGRQ: Saint George Respiratory questionnaire, MBS: Modified Bhalla Score, CRP: C-reactive protein, WBC: White blood cell count, HB: Haemoglobin, PLT: Platelet count, BE: Bronchiectasis, PF PF: Physical functioning, RP: Role physical, BP: Bodily pain, GH: General health, VT: Vitality, SF: Social functioning, RE: Role emotional, MH: Mental health, PCS: Physical component summary, MCS: Metal component summary. *P<0.05 was determined significant

Table 2: Internal consistency of Short form-36 and Saint George Respiratory questionnaire

	Steady - State BE (*n*=55)	Exacerbation BE (*n*=37)
SF-36 PCS, mean±SD	40.74±10.50	33.87±9.59
SF-36 MCS, mean±SD	46.40±10.21	42.01±9.67
Crohnbach's α coefficient (95% CI)	0.845 (0.774- 0.900)	0.850 (0.765- 0.913)
SGRQ, mean±SD		
Symptom score	63.80±18.21	69.81±23.17
Activity score	50.63±24.53	52.86±19.80
Impact score	43.72±19.37	51.33±20.43
Total score	48.57±18.70	55.36±18.18
Crohnbach's α coefficient (95% CI)	0.871 (0.804- 0.919)	0.891 (0.820- 0.939)

SGRQ: Saint George Respiratory Questionnaire, SF-36: Short form-36, SD: Standard deviation, CI: Confidence interval, BE: Bronchiectasis, PCS: Physical component summary, MCS: Metal component summary

According to the patients' histories, exacerbation rate in the previous year was significantly higher in the exacerbation group than in the steady group (2.49 ± 2.07, 1.25 ± 1.48 respectively, $P < 0.001$). 21/37 patients of the exacerbation group had had 2 or more exacerbations in the previous year, in contrast to the steady-state group, in which 14/55 patients had no exacerbations in the previous year. The steady state group had 6.37 ± 6.09 years' symptom duration, while in the exacerbation group, it was stated as 9.86 ± 9.26 years. The exacerbation group had significantly lower pulmonary function test results compared to the steady-state group ($P < 0.001$).

As shown in Table 1, the exacerbation group cases had lower SF-36 scores but higher SGRQ scores. Steady-state and exacerbation groups' MBS were calculated according to the ten categories indicated in Table 1. Significant differences were confirmed between groups in the extent of mucous plugging, generation of bronchial divisions and MBS (0.69 ± 0.77 for steady state, 1.05 ± 0.91 for exacerbation, $P = 0.042$; 0.89 ± 0.85 for steady state, 1.38 ± 0.95 for exacerbation, $P = 0.012$; 8.18 ± 3.69 for steady state, 10.11 ± 4.20 for exacerbation, $P = 0.022$; respectively).

Internal consistency of St George's Respiratory Questionnaire and Short Form-36

The internal consistency of the three components and total scores for SGRQ in the steady-state and exacerbation groups were (Crohnbach's α coefficient, 95% confidence interval [CI]) 0.871, (0.804–0.919) and 0.891, (0.820–0.939), respectively. Internal consistency for the SF-36 physical component summary (PCS) and mental component summary (MCS) in the steady-state and exacerbation groups (Crohnbach's α coefficient, 95% CI) were 0.845, (0.774–0.900) and 0.850, (0.765–0.913), respectively [Table 2].

Correlations between modified Bhalla score, pulmonary function test, and quality of life

We used the SGRQ and SF-36 for evaluating patients' QoL. SF-36 yielded more correlations than the SGRQ. In steady-state patients, the SF-36 physical functioning (PF) was inversely correlated with the extent of BE (EBE), sacculation/abcesses (S/A) and MBS, ($r = -0.421$, $P = 0.009$; $r = -0.396$, $P = 0.015$, $r = -0.392$, $P = 0.017$, respectively) [Table 3a and b]. Notably, SF-36 PCS was correlated with the extent of mucous plugging (EMP) and S/A ($r = -0.326$, $P = 0.049$; $r = -0.343$, $P = 0.037$,

Table 3a: Correlations between Modified Bhalla Score, pulmonary function test and quality of life in exacerbation state

Variables	MBS		Components		
	EBE	EMP	S/A	C/C	MBS
FVC %	−0.343	-	−0.376	-	−0.439
FEV_1	−0.377	-	−0.402	-	−0.436
FEV_1 %	−0.473	−0.365	−0.471	-	−0.536
SF-36 components					
PF	-	-	-	-	0.332
RP	-	-	-	0.331	-
BP	-	-	-	0.335	-
PCS	-	-	-	0.364	0.322
SGRQ components					
Symptom	0.332	0.366	0.379	-	0.379
Activity	-	0.411	0.346	−0.323	-
Impact	-	0.495	0.464	-	-
Total	-	-	-	0.364	0.322
Clinical components					
Symptom duration	0.332	0.366	0.379	-	0.379
Exacerbation	-	0.411	0.346	−0.323	-
Hospitalization	-	0.495	0.464	-	-

Data are correlation coefficient (*r*). Variables with statistical significance ($P<0.05$) under Pearson's correlation are demonstrated in table. Exacerbation: Exacerbation rate in the previous year, Hospitalization: Hospitalization in the previous year. BE: Bronchiectasis, EBE: Extent of BE, EMP: Extent of mucous plugging, S/A: Sacculation/Abcesses, C/C: Consolidation/collapse, MBS: Modified Bhalla Score, FEV1: Forced expiratuar volüme in 1 s, FEV_1 %: Forced expiratuar volume in 1 s % predicted, FVC %: Forced vital capacity % predicted, SF-36: Short form-36, SGRQ: Saint George Respiratory questionnaire, PF: Physical functioning, RP: Role physical, BP: Bodily pain, PCS: Physical component summary

Table 3b: Correlations between Modified Bhalla Score, pulmonary function test and quality of life in steady state

Variables	MBS		Components		
	SBE	PBT	EBE	C/C	MBS
FVC%	−0.321	−0.276	-	−0.329	−0.350
FEV_1	-	−0.321	-	-	-
FEV_1%	−0.286	−0.291	−0.268	−0.283	−0.403
SF-36 components					
PF	−0.295	−0.326	−0.323	−0.305	−0.416
BP	−0.346	-	−0.317	−0.317	-
GH	−0.438	-	−0.328	-	-
PCS	−0.272	-	−0.272	-	−0.347
SGRQ components					
Symptom	0.287	-	-	-	-
Activity	0.282	0.279	0.297	-	-
Impact	0.235	0.310	-	-	-
Total	0.326	0.314	0.292	-	-
Clinical components					
Symptom duration	-	-	-	-	-
Exacerbation	-	-	-	-	-
Hospitalization	-	-	-	-	-

Data are correlation coefficient (*r*). Variables with statistical significance ($P<0.05$) under Pearson's correlation are demonstrated in table. Exacerbation: Exacerbation rate in the previous year, Hospitalization: Hospitalization in the previous year. BE: Bronchiectasis, EBE: Extent of BE, C/C: Consolidation/Collapse, MBS: Modified Bhalla Score, SBE: Severity of BE, PBT: Peribronchial thickening, FEV_1: Forced expiratuar volüme in 1 s, FEV_1 %: Forced expiratuar volume in 1 s % predicted, FVC %: Forced vital capacity % predicted, SF-36: Short form-36, SGRQ: Saint George Respiratory questionnaire, PF: Physical functioning, BP: Bodily pain, GH: General health, PCS: Physical component summary

respectively). In the exacerbation cases, inverse correlations were found between SF-36 PF and the severity of BE (SBE), peribronchial thickening (PBT), EBE, consolidation/collapse (C/C) and MBS ($r = -0.295$, $P = 0.031$; $r = -0.326$, $P = 0.033$; $r = -0.323$, $P = 0.017$; $r = -0.305$, $P = 0.025$; $r = -0.416$, $P = 0.002$). The SGRQ had fewer correlations with the MBS. The most noteworthy correlations were between the total score, C/C and MBS in steady-state patients, and in addition, in exacerbation patients, there were no significant correlations with the MBS and the SGRQ. The Activity scores within the SGRQ were correlated with SBE, PBT and EBE ($r = 0.282$, $P = 0.039$; $r = 0.279$, $P = 0.041$; $r = 0.297$, $P = 0.029$ respectively). PFT parameters were inversely correlated with the MBS and its components in both the steady-state and exacerbation cases, as shown in Table 3a and b.

Correlations between modified Bhalla score and symptom duration, exacerbation and hospitalization rate in the previous year

There was no significant correlation between symptom duration, exacerbation and hospitalization rate in the previous year and MBS in the steady-state group. In the exacerbation group, symptom duration was found to be correlated with EBE, EMP, S/A, and MBS ($r = 0.332$, $P = 0.045$; $r = 0.366$, $P = 0.026$; $r = 0.379$, $P = 0.021$; $r = 0.379$, $P = 0.021$, respectively) [Figure 2]. The exacerbation rate in the previous year was significantly correlated with EMP, S/A and C/C ($r = 0.41$, $P = 0.011$; $r = 0.346$, $P = 0.036$; $r = -0.323$, $P = 0.051$). The hospitalization rate in the previous year was correlated with EMP and S/A ($r = 0.495$, $P = 0.002$; $r = 0.464$, $P = 0.004$).

Linear regression models for predicting modified Bhalla score and exacerbations in the previous year

Finally, we produced linear regression models by the stepwise method to predict MBS and the number of exacerbations in the previous year in the steady-state and exacerbation groups. Exacerbation rate was related to forced expiratory volume in 1 s (FEV1%) and SF-36 vitality (VT) (coefficient: −0.217, $P = 0.026$ and coefficient: −0.380, $P < 0.001$ respectively). Similarly, SF-36 VT and SF-36 PCS were independently related to exacerbation rate in the previous year (coefficient: −0.238, $P = 0.036$ and coefficient: −0.321, $P = 0.005$, respectively). As for MBS FEV1% and SF-36 PF (coefficient: −0.388, $P < 0.001$ and coefficient: −0.312, $P = 0.001$, respectively); as well as FEV1% and SF-36 PCS (coefficient: −0.434, $P < 0.001$ and coefficient: −0.206, $P = 0.033$, respectively) were found to be significant independent predictors [Table 4].

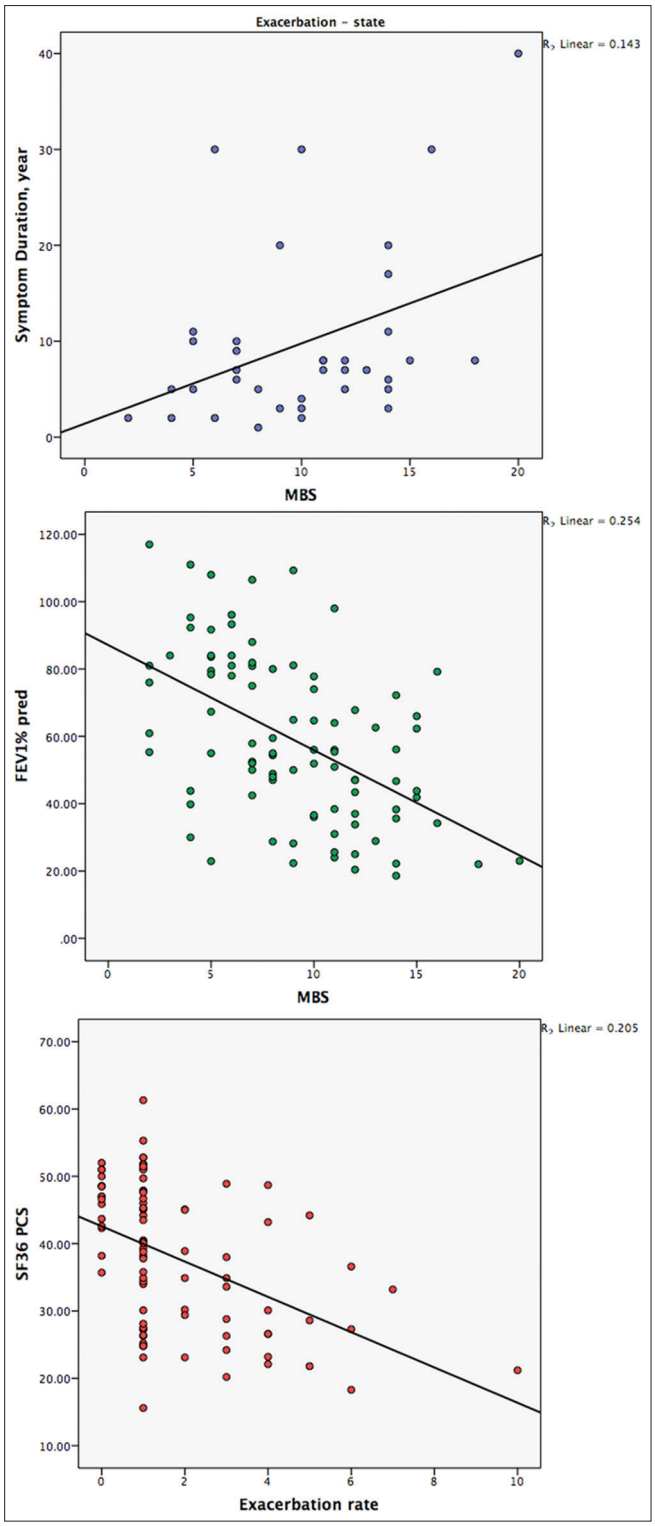

Figure 2: Correlations

Discussion

The present study is the first study to systematically describe the associations of radiological features and pulmonary function tests on the QoL in patients with steady BE or those experiencing an exacerbation. We found significant correlations for the MBS with SF-36 and PFT. By contrast, we found only weak or no correlation for the SGRQ with MBS and PFT. Moreover, experiencing an exacerbation was correlated with symptom duration and the previous year's exacerbation and hospitalisation rates. Thus, our findings suggest that the combination of these variables may have additive value in predicting the radiological features of this chronic airway disease and the risks for possible future exacerbation; however, this area still needs to be investigated further with regard to forthcoming clinical practice.

Table 4: Lineer regression models by stepwise method to predict Modified Bhalla Score and number of exacerbations in stable and exacerbation of bronchiectasis

Predictive models	Variables	St coeff	*P*	r^2
	Exacerbation rate			
Model 1	FEV1%	−0.217	0.026	0.218
	SF-36 VT	−0.380	<0.001	
Model 2	SF-36 VT	−0.238	0.036	0.244
	SF-36 PCS	−0.321	0.005	
	MBS			
Model 1	FEV1%	−0.388	<0.001	0.332
	SF-36 PF	−0.312	0.001	
Model 2	FEV1%	−0.434	<0.001	0.286
	SF-36 PCS	−0.206	0.033	

P value under 0.005 is considered to be significant, r^2: Summary of the model, MBS: Modified Bhalla Score, FEV_1%: Forced expiratory volüme in 1 s % predicted, St coeff: Standardized coefficients of the model, SF-36: Short form-36, PF: Physical functioning, VT: Vitality, PCS: Physical component summary

Strong correlations have been defined between the Bhalla scoring system in adults with non-CF BE and the degree of impairment of pulmonary functions.[10,11] Another study demonstrated that the severity of BWT was the primary determinant of functional decline, suggesting that HRCT scans can be used for follow-up disease progression.[12] It is generally agreed today that The Bhalla scoring system, used particularly in paediatric or adult cystic fibrosis patients, is a method proven to correlate with clinical and physiological characteristics.[13,14] Despite the widespread use of the Bhalla score, it is unclear how to use this scoring system for quantifying disease status. Moreover, the relationship between pulmonary function and HRCT is conflicting.

Patients' general well-being and mental state, as well as the impact of the disease on their activities of daily living are important, as it will affect compliance with medical therapy, and eventually morbidity and mortality rates.[15,16] SGRQ has been validated for better psychometric validity and has association with dyspnea. However, it is too long to complete and may not detect variances, for that needs additional studies.[17]

In this study, strong correlations were found with the MBS and QoL [Table 3a and b]. In steady-state

patients, SF-36 scores were significantly correlated with almost all the HRCT scores, most markedly in the case of severity of BE, peribronchial thickening, extent of BE, collapse/consolidation and the total MBS score. In the exacerbation-state these correlations were less prominent, with the extent of BE, sacculation/abcesses and total MBS scores being the strongest correlations detected. In comparison with SGRQ, SF-36 was more related to HRCT. SGRQ had fewer correlations with radiological scores such as the severity of BE was correlated to all of SGRQ four domains, including total score. Unfortunately, there was no significant correlation between the total MBS score and SGRQ in the steady-state cases. On the other hand, in the exacerbation group, SGRQ was correlated with collapse/consolidation and symptom and total scores were significantly correlated with the total MBS score. In 2006, Eshed *et al.*[5] evaluated the relationship between HRCT and SGRQ, but in contrast to the present study, there were no correlations found between overall lung scores and SGRQ scores. However, there was a significant correlation between CT scores for the middle and distal lung zones and SGRQ. The authors concluded that these findings could be attributed to radiological classification. Lynch *et al*., found weak correlations between the severity of BE on CT and the severity of patients' symptoms.[18] Similarly, Martínez García *et al.*, detected a correlation between the extent of BE and SGRQ, despite using only a limited HRCT scoring system, not the MBS.[19] In this study, pulmonary function test parameters of patients with BE in the steady state were inversely correlated with the Severity of BE, Peribronchial thickening, Extent of BE, collapse/consolidation and total MBS, while the exacerbation period was mostly inversely correlated with the extent of BE, Extent of mucous plugging, Sacculation/Abcesses and total MBS. Similarly to the present study, Habesoglu *et al.*[4] found a strong inverse correlation between the extent of BE, the degree of bronchial dilatation, bronchial thickening, decreased attenuation, and PFT parameters. However, unlike in the present study, mucous plugging was only correlated with the decrease in FEV1/forced vital capacity (FVC) ratio. That study found no correlations between FEV1/FVC ratio and HRCT scores. Lee *et al.*[6] investigated the relationship between HRCT, lung function and bacteriology in 49 Korean patients with steady-state BE. No significant correlations were found between cylindrical BE and obstructive disease or between cystic BE and mixed disease. However, FVC, FEV1 and the FEV1/FVC ratio were significantly associated with a CT scoring system which was different from the MBS. A study from Turkey by Gokdemir *et al.*[20] demonstrated a positive correlation between SF-36 PCS and predicted FEF_{25-75}%. Although the authors reported no correlations between SGRQ and the HRCT scores, SGRQ symptom scores were correlated with the duration of regular follow-up and moreover, symptom scores were inversely correlated with PFT values and frequent antibiotic requirements.

In the study of Habesoglu *et al.*,[4] patients were divided into three groups: pure BE, asthma, and COPD. The authors' opinion was that the aggravating effect of BE on asthma was independent of the effect on pulmonary function. As in COPD, there was no significant correlation between the morphological changes caused by BE and pulmonary function in the COPD group. BE patients were not divided into COPD and asthma groups in the present study, owing to the small sample size of COPD and asthma patients. Instead of grouping by comorbidities, we grouped patients by the number of comorbidities. Similarly, no difference was found between groups (P = 0.452). The study by Eshed *et al.*[5] showed a significant inverse correlation between all SGRQ scores and FEV1, FVC, MMEF, similarly to the present study. They have reported that this finding reflects the reliability of the questionnaire as a disease-specific questionnaire.

The impact of smoking was reported to be associated with a 15% reduction in pulmonary function in the study by Ellis *et al.*;[21] Lee *et al.*[6] reported there were too few current smokers in the sample to show pulmonary effects. In the present study, there was no difference between the steady-state and exacerbation state patients with regard to smoking status. Likewise, there was no significant difference in pulmonary function tests between smokers and nonsmokers.

The present study showed correlations between symptom duration, previous exacerbations and hospitalizations in exacerbation state patients. 70% of the actual exacerbation state patients had had two more exacerbations in the previous year than the steady-state patients (P < 0.001). The exacerbation state cases had higher symptom duration time, exacerbation and hospitalization rates than the steady-state cases [Table 1]. These findings were similar to those found in the ERS guidelines for the management of adult BE. It has been reported that European registry data show 50% of BE patients have two or more exacerbations per year and one third require at least one hospitalization per year.[22]

Finally, according to our stepwise linear regression analysis, exacerbation rate in the previous year was found to be related with FEV1% and SF-36 VT (r^2: 0.218), in addition SF-36 VT and SF-36 PCS were found to be related with exacerbation rate in the previous year (r^2: 0.244). Furthermore, MBS was related with FEV1% and SF-36 PF (r^2: 0.332) also FEV1% and SF-36 PCS (r^2: 0.286) [Table 4].

The limitations of our study are the study being retrospective and single-centred study, besides which

SGRQ and SF-36 are not the gold standard in evaluating BE patients' QoL.

In conclusion, whilst SGRQ is widely used in BE patients, it has not been well validated for this disease. SF-36 is strongly correlated with SGRQ, and the form is shorter and requires less effort to fill in. This study demonstrates that SF-36 is more strongly correlated with pulmonary function tests and MBS.

Conclusion

This study has highlighted factors related to exacerbation rates in both the steady and exacerbation groups. To our knowledge, this is the first study evaluating exacerbation rates with consideration of the BE status. Radiographical and spirometric assessment of the patient, using a combination of QoL scales, we believe, will provide better disease control and improve prognosis.

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Conflicts of interest
There are no conflicts of interest.

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