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Role of High Resolution Computed Tomography in the Evaluation and Scoring of Bronchiectasis

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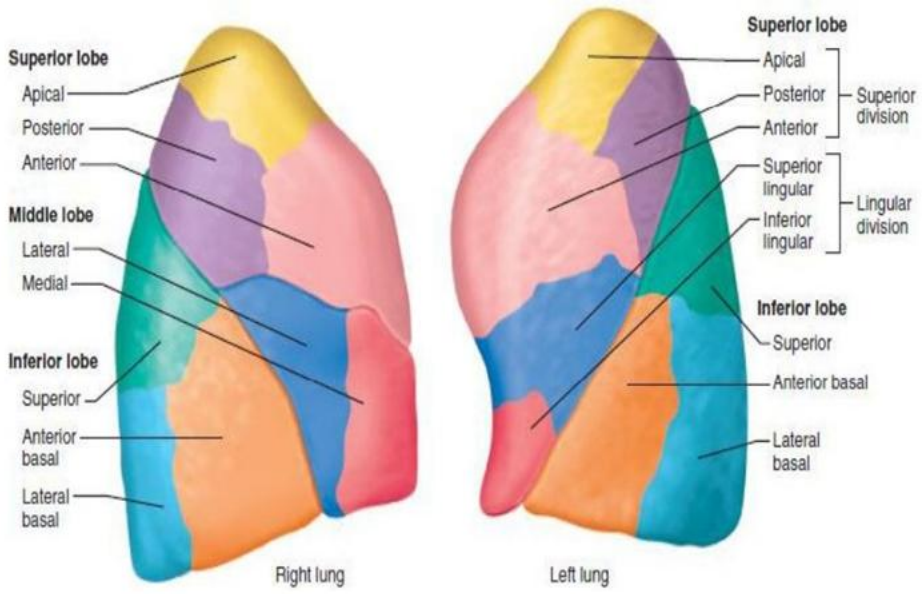
Abstract: ***Objective: To evaluate the role of HRCT in qualitative and quantitative assessment of bronchiectasis. Materials and Methods: A study of 75 patients was done in whom clinically bronchiectasis was suspected and they were subjected to HRCT examination where bronchiectasis was assessed in terms of localization, regional distribution and morphological forms and scores were assigned to extent, bronchial wall thickness, small airway abnormality, mosaic attenuation based on HRCT findings and total global scores were calculated along with associated evaluation of microbiological profile, clinical profile and pulmonary function tests to find the FACED scores. Conclusion: The study was helpful in evaluating the clinical relevance of high-resolution CT findings in patients with bronchiectasis by using a quantitative high-resolution CT protocol to assess extent of bronchiectasis, severity of bronchial wall thickening, and presence of small-airway abnormalities and mosaic pattern to calculate Global CT score and FACED scores assigned to each case helped in grading the severity which in turn aided in the further management and better follow up of cases in addition to assessment of the microbiological profile in each case of our study allow us to find the causative organism.***

Keywords: Bronchiectasis, Global HRCT score, FACED score, Microbiological profile

1. Introduction

The criteria for the radiological diagnosis of bronchiectasis on CT scanning were first established when it became possible to identify segmental bronchi and blood vessels using CT scans. Specific abnormalities related to bronchiectasis found on high-resolution CT include dilatation of an airway lumen, rendering it more than 1.5 times as wide as a nearby vessel; lack of tapering of an airway towards the periphery; varicose normalities, constrictions along airways; and ballooned cysts at the end of a bronchus. Nonspecific findings include consolidation or infiltration of a lobe with dilatation of the airways, thickening of the bronchial walls, mucous plugs, enlarged lymph nodes and reduction in vascular markings similar to that seen in emphysema, probably as a result of the inflammatory destruction of smaller airways and vessels.[1] It is traditionally classified into three anatomical phenotypes 1. Cylindrical 2. Varicoid 3. Saccular or cystic. Radiological classification for bronchiectasis is localised versus more diffuse disease, localised cause of bronchiectasis include post infectious aetiology with inflammatory changes and scarring as in tuberculosis, pertussis, chronic airway obstruction due to tumour or foreign body and chronic aspiration whereas most other causes have a more diffuse pattern of involvement. Currently, high resolution CT (HRCT) employing the thin collimation of 1-1.25 mm is diagnostic test of choice for bronchiectasis. Classic HRCT findings of bronchiectasis include dilated bronchi that fail to taper, bronchi visible in peripheral 1 cm of the lungs and, increased bronchial: arterial ratio, producing signet ring sign on cross sectional view. Once bronchiectasis is identified on HRCT, a detailed family and past medical history, particularly of underlying conditions should be taken to identify genetic risk factors or any prior inciting event like tuberculosis.[2]



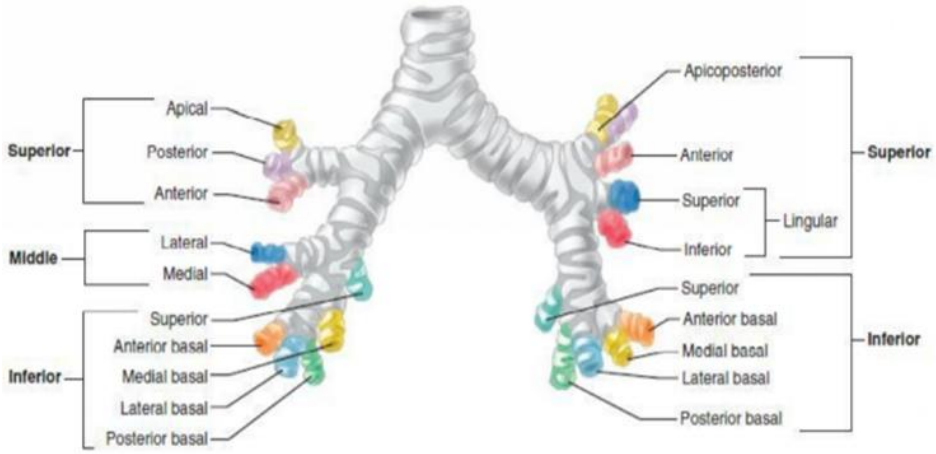


Figure 1: Distribution of bronchopulmonary segments on lateral surface of lungs

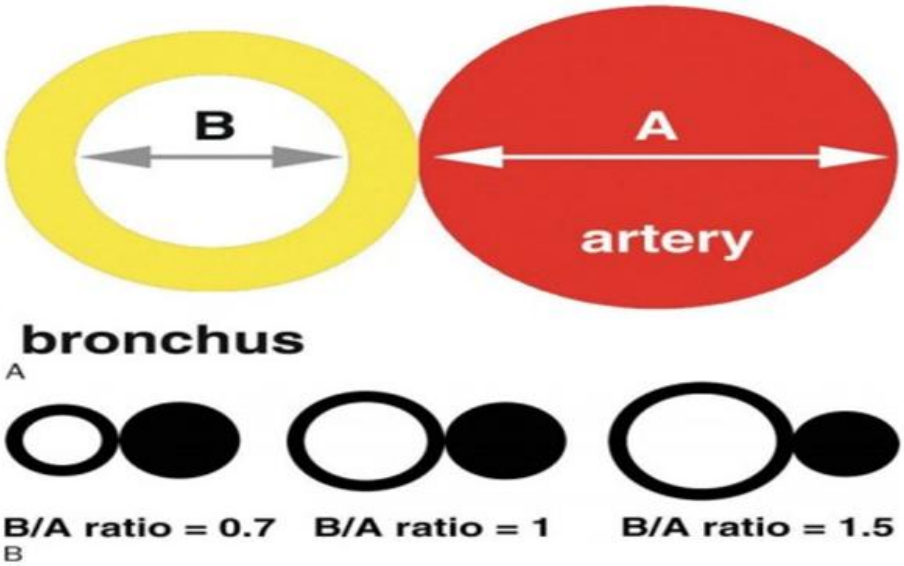


Figure 2 A: Bronchoarterial (B/A) ratio equals the internal diameter of a bronchus, divided by the diameter of the adjacent pulmonary artery branch. As shown in this diagram, it measures 0.65 to 0.7 in normals.17

Figure 2 B: Appearance of a normal B/A ratio (0.70) and B/A ratios of 1.0 and 1.5.
-A B/A ratio greater than 1 may be seen in some normal patients. A B/A ratio of 1-5 is almost always due to true bronchiectasis.17

Aim of the Study:

To assess the role of high resolution computed tomography in diagnosis and scoring of bronchiectasis for qualitative and quantitative assessment and its clinical outcome.

Objectives of the Study: (a) Primary Objective:

1. To evaluate the role of HRCT in qualitative and quantitative assessment of bronchiectasis.

(b) Secondary Objectives:

1. To identify the regional distribution of bronchiectasis in HRCT.
2. To characterize bronchiectasis morphologically.
3. To assess the severity of bronchiectasis based on the scores and clinical profile.
4. To assess the type of bronchiectasis and its microbiological profile.
5. To identify the etiology of bronchiectasis in each patient by assessing the HRCT findings, clinical profile and sputum/swab results.

2. Materials and Methods

Source of data: The study was done in the Department of Radiodiagnosis, Assam Medical College & Hospital,

Dibrugarh with a duration of 1 year (June, 2021-May, 2022, the type of the study being Hospital based cross-sectional study. The study population included all clinically suspected cases of bronchiectasis who were referred for HRCT thorax to Department of Radiodiagnosis, Assam Medical College and Hospital with the sample size being 75. Patients of adult age groups and both sexes with chronic cough and ± expectoration with clinical suspicion of bronchiectasis were

included and pregnant and patients not giving consent were excluded from the study. Ethical clearance was taken before commencement of the study from the Institutional Ethics Committee (Human), Assam Medical College, Dibrugarh.

3. Methodology

A thorough case history preceded the clinical examination viz symptoms, duration of symptoms, etc. Complete general and physical examination was performed. All was advised to do PFT. These patients were subjected to HRCT evaluationin the following steps.

1. Bronchiectasis was assessed in terms of localization, regional distribution and morphological forms. Scores were assigned to extent, bronchial wall thickness, small airway abnormality, mosaic attenuation based on HRCT findings and global scores were calculated.[3]
2. The median scores for extent, bronchial wall thickness, small airway abnormality, mosaic attenuation, age distribution and total score for incidence in male and female patients were calculated. The most common morphological form of bronchiectasis, most common lobar distribution and most commonly encountered pattern of bronchiectasis in my study population were calculated.[3]
3. The microbiological profile, clinical findings in patients, duration of symptoms, past history, family history and associated systemic findings were assessed to guide the most probable cause of bronchiectasis in the examined patients.
4. Moreover we also calculated the FACED severity score based on the parameters including FEV1, age, chronic colonization by P. aeroginosa, radiological extension and dyspnea (mMRC scale) and calculated the severity in the patients[4].

Radiology Protocol: All High Resolution Computed Tomography scans were performed at our hospital using the -PHILIPS BRILLIANCE iCT 256 CT SCAN, (model no-4598 016 10641). The patients were placed supine, and no gantry tilt was given. Scout films were taken routinely in all patients before starting the scan. Scanning commenced from lung apices to lung bases. Scans were performed in suspended inspiration. Lung window setting used with window width of 1000 to 1600 HU and window level of-600 to-700 HU. HRCT was performed obtaining 1mm section at 10 mm intervals and kVp of 120 and mA of 120. Coronal and sagittal reformatting was done to a slice thickness of 0.23 mm. Each HRCT was analysed for specific features relevant to the evaluation of bronchiectasis.

Techniques:

HRCT evaluation parameters that were used in this study:

1. Extent of bronchiectasis was assessed by first assigning a score to each of the lobes according to the percentage (i. e., grade) of lobar involvement, according to the following scale: grade 0-none; grade1-mild (<25 % involvement of each lobe), grade 2-moderate (25-50 % percent involvement of each lobe), grade 3-severe (>50% involvement of each lobe). All individual lobar scores will be summed to calculate the overall score for the extent of bronchiectasis.[3]
2. Thickness of the bronchial wall relative to the external diameter of dilated bronchi (EDB) perpendicular to the transverse plane was assessed in each lobe. This score was determined with the following scale: grade 0, normal thickness; grade1, thickness greater than 20 % and less than 50 % EDB; grade 2, thickness greater than 50 % EDB; and grade 3, complete obliteration of the bronchial lumen. If there was a range of bronchial wall thickening noted in each lobe assessed, a mean score was calculated per lobe whereby the score calculated. The sum of individual lobar bronchial wall thickening scores was the overall score for each patient.[3]
3. Small-airway abnormalities include centrilobular opacities tree-in-bud opacities and bronchiectasis. In each lobe, the presence of small-airway abnormalities was assessed as grade 1 when these findings were considered present and grade 0 when they were considered absent. Individual lobar scores were summed to calculate the total score of small-airway abnormalities for each patient.[3]
4. Mosaic attenuation was defined as the presence of alternating areas of hypoattenuation and hyper attenuation of the lung parenchyma. In each lobe, the presence of mosaic pattern was assessed as grade I when these findings were considered present and grade 0 when they were considered absent. Individual lobar scores was summed to calculate the total score for mosaic attenuation for each patient.[3]
5. A global bronchiectasis score was also calculated including all four high-resolution CT scores.3Total aggregate global score including all 4 parameters will be divided into mild (score 1-16), moderate (score 17-25) and severe (score >26) for analysis.
6. Moreover we also calculated the FACED severity score in each patient based on the parameters including F-FEV1 (FEV1≥50%=0 points, <50% =2 points), A-age (<70 yrs =0 points, ≥70 yrs= 2 points), C-chronic colonization by P. aeroginosa (yes=1 point, no= 0 point), E-Extension (1-2 lobes affected =0 points, >2 lobes affected= 1 point) and D-dyspnea (modified Medical Research Council (mMRC scale) - (0-2 = 0 points, 3-4 = 1 point.4Then we calculated the total aggregate score and determined severity in the patients as mild bronchiectasis (0-2 score), moderate bronchiectasis (3-4 score) and severe bronchiectasis (5-7 score).

Microbiological Assessment-1: Bacterial isolation-The sputum samples were sent to the department of microbiology for gram staining, fungal staining, Z-N staining and culture and sensitivity to isolate the causal bacteria.2**.** Covid-19 detection-Molecular detection of SARS-Cov-2 virus was done by reverse transcriptase polymerase chain reaction /Rapid antigen testing from sputum/swab of patients in the microbiology lab.

Statistics: The data was tabulated in Microsoft Excel Worksheet and categorical variables were summarized using Rates, ratios and percentages. The study is a hospital based observational study, so no statistical analysis between parameters was evaluated.

4. Observation and Results

Table 1: Distribution of Cases in Various Age Groups

Age group in yrs	No. of cases	Percentage (%)
15-25	6	8.00
26-35	12	16.00
36-45	14	18.67
46-55	21	28.00
56-65	11	14.67
66-75	6	8.00
76-85 or above	5	6.67

Table 2: Distribution of Cases According to Sex

SEX	No. of cases	Percentage (%)
Male	59	**78.67**
Female	16	**21.33**

Table 3: Localisation of Bronchiectasis

Lisation of Bronchiectasi	No of Patients	Percentage%
Unilateral	13	**17.33**
Bilateral	62	**82.67**

Table 4: Regional Lobar Distribution of Bronchiectasis

Location	Right	%	Left	%	Total
Upper lobe	45	60.00	45	60.00	**90**
Middle lobe/lingular lobe	46	61.33	52	69.33	**98**
Lower	55	73.33	62	82.67	**117**

Table 5: Morphological Types of Bronchiectasis

Type of Bronchiectasis	N	%
Tractional	35	46.67
Varicose	3	4.00
Cylindrical	16	21.33
Mixed	9	12.00
Cystic	12	16.00
Total	**75**	**100.00**

Table 6: Severity of Bronchiectasis Based on Global HRCT Scores Only

Severity	N	%
Mild	37	49.3
Moderate	3	30.6
Severe	**15**	**20**

Mild (Global CT score-<16); Moderate (Global CT score-17-25); Severe (Global CT score->26) 18

In the severe group of cases most common type of bronchiectasis was cystic (60%), in moderate cases, cylindrical (39.1%) was the common type and tractional (83.8%) type was most commonly found in mild cases.

Table 7: HRCT Scores Based on 4 Parameters by OO ET AL18

HRCT Scores	Mean	SD	Range	Median
Lobar	6.24	3.50	1-14	6.00
Bronchial thickening	4.89	3.20	0-10	4.00
Peripheral airways	4.24	1.83	0-6	4.00
Mosaic attenuation	0.81	1.30	0-4	0.00
Global score	16.04	8.23	2-30	17.00

Table 8: Severity of Bronchiectasis Based on Faced Score 83

Severity	N=75	%
Mild	42	56%
Moderate	3	30.6%
Severe	10	13.3%
Total	75	100%

Table 9: Broncho-Arterial Ratio

B/A ratio	N	%
<1.5	35	46.67
>1.5	40	53.33
Total	**75**	**100.00**

Table 10: Bacterial Isolates from Sputum / Swab

Bacterial isolates from sputum/swab	N	%
Acinetobacter baumanii	7	14.8
E Coli	1	21.2
Klebsiella pneumonia	17	36.17
Pseudomonas aeroginosa	2	4.2
Streptococcus pneumonia	3	6.3
Negative	17	36.1
Total	**47**	**100.00**

Table 11: COVID-19 Confirmed Cases by RT-PCR/RAT Detection Methods

COVID-19 INFECTED CASES	N	%
RT-PCR +ve	4	.2
RAT +ve	24	.7
	Total-28	**100**

Table 12: Etiology

ETIOLOGY	N	%
Adenocarcinoma	1	**1.33**
Bacterial	28	**37.33**
COPD	2	**2.67**
COPD with infection	2	**2.67**
Covid 19 (SARS-Cov-2)	28	**37.33**
Aspergilloma	2	**2.67**
ILD	2	**2.67**
P/H/O TB	3	**4.00**
Systemic sclerosis	1	**1.33**
UIP with COPD	1	**1.33**
No identifiable cause (N/A)	5	**6.67**
Total	**75**	**100.00**

Representative Cases:

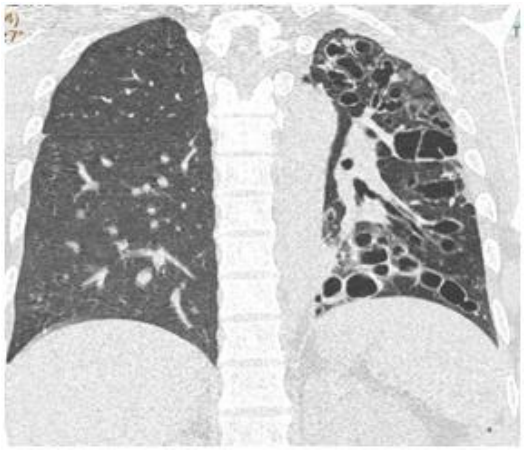


Figure (1) is coronal image of a 32 yr old female patient showing cystic bronchiectasis in left lung whose sputum results isolate was found to be Pseudomonas aeroginosa.

Figure 2

Figure (2) is axial images of a case of a 65 y male with interstitial lung disease (UIP) showing honeycombing, tractional bronchiectasis and reticular opacities in predominantly peripheral regions of bilateral middle and lower lung lobes with negative sputum results.

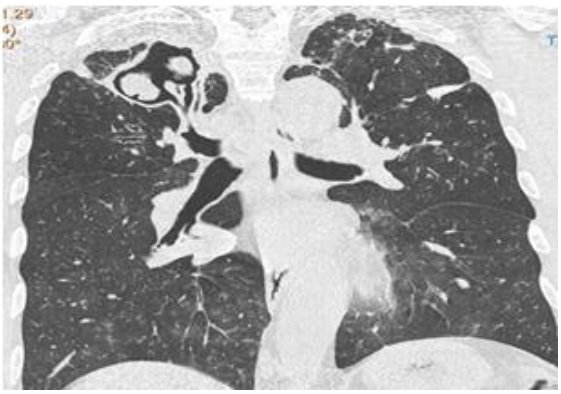


Figure 3

Figure (3) are coronal and axial images of a 48 yr old man with cylindrical bronchiectasis with a bronchiectatic cavity showing a central soft tissue attenuating round mass surrounded by 'air crescent sign' in right upper lung lobe, diagnosed to be case of aspergilloma.

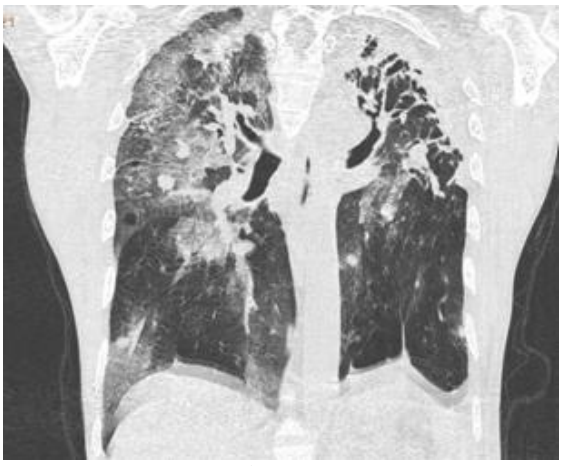


Figure 4

Figure (4) Axial and coronal images of a 65 yr old male patient who was COVID-19 positive case showed tractional bronchiectasis involving apico-posterior segment of left upper lung medial segment of right middle lung lobe along with patchy predominantly peripheral ground glass opacities and fibrotic opacities.

Figure 5

Figure (5) Axial image of a 21 yr female patient systemic sclerosis with tractional bronchiectasis in posterior basal segment of right lower lung lobe along with reticular opacities and groundglass opacities predominantly in basal segments of bilateral lower lung lobes with negative sputum results.

Figure 6

Figure (6) Axial image of a 78 yr old male patient showed cylindrical bronchiectasis involving anterior segment of right upper lung lobe with a spiculated marginated soft tissue attenuated lesion with infiltration of parietal pleura, which was diagnosed as a case of adenocarcinoma.

5. Discussion

A total of 305 lobes were found to be bronchiectatic in our study. Out of these, majority were lower lobes 117 (38.3%) of which left lower lung lobe was the most commonly affected lobe 62 (82.67%) with posterior basal segment of left lower lung lobe being the most common affected segment. Studies conducted by COLEMAN et al. in which the left lower lobe was the most commonly affected segment.5Total of 35 (46.67%) patients in our study had tractional bronchiectasis followed by 16 patients (21.33 %) in our study who had cylindrical bronchiectasis, while 3 patients (4 %) had varicose variety, 12 patients (16%) had cystic bronchiectasis and 9 patients (12%) had mixed variety. In our study most common type was tractional bronchiectasis followed by cylindrical variety. In a study by REIFF et al. cylindrical bronchiectasis were found to be most common followed by mixed variety.[6] In our study lack of bronchial tapering was noted in 64 patients (85.3%), **Kang et al** found lack of tapering of bronchial lumina in 79%.[7] In my study, total number of severe, moderate and mild cases were found to be 15 (20 %), 23 (30.6%) and 37 (49%) respectively determined by global CT scoring method used by **OO et al.**[3] **Lee J et al** in their study of radiological scores according to physiologic outcomes found that number of severe, moderate and mild cases were 13 (26%), 10 (20.4%) and 10 (20.4%) respectively.[8] We also calculated the severity by using the **FACED scoring method**[4] using additional clinical parameters, PFT and bacterial profile and found that mild, moderate and severe cases in my study accounted for 42 (56%), 23 (30.6%) and 10 (13.3%) respectively which were consistent with the findings of global CT score. Bacterial examination was able to isolate bacteria in 28 out of total 75 (37.3%) cases in my study. **Bopaka RG et al** in their study found that bacteriological examination was able to isolate the bacteria in as 35% of the cases in their study.[9]

6. Conclusion

HRCT serves as the best modality in confirming the diagnosis of bronchiectasis. Regional distribution of bronchiectasis can be well visualized by HRCT. Left lower lobe, especially posterior basal segment is most commonly involved. In this study incidence is most common in the age group of 46-65 years and is more common in males than females. Grade of lobar involvement had the highest score in our study followed by bronchial wall thickening score.

Tractional bronchiectasis was the most common morphological form of bronchiectasis followed by cylindrical bronchiectasis. Varicose form of bronchiectasis was the least common morphological form in our study. Cystic bronchiectasis presented with significantly higher CT score than in cases of cylindrical bronchiectasis. Most of the cases of bronchiectasis were mild in severity followed by moderate severity as calculated by global CT scores. The FACED score can be used as a tool which is easy to use and interpret and assists with the assessment of morbidity andmortality of the people with bronchiectasis by embracing the various clinical, functional, radiological and microbiological aspects characteristic of the disease. FACED severity scores were consistent with the global CT scoring in our study. Variousetiologies of bronchiectasis were found in our study with infective etiology being the most common etiology which included both bacterial and viral (SARS-Cov-2) etiology. The purpose of this study, therefore, was to evaluate the clinical relevance of high-resolution CT findings in patients with bronchiectasis by using a quantitative high-resolution CT protocol to assess extent of bronchiectasis, severity of bronchial wall thickening, and presence of small-airway abnormalities and mosaic pattern and a global score assigned to each case helped in grading the severity which in turn can aid in the further management and better follow up of cases. Isolation of bacteria in all the infective cases of bronchiectasis was not possible due to non-productive cough, scanty sputum production and post antibiotic therapy sputum culture.

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