Original Research Paper

Volume - 13 | Issue - 06 | June - 2023 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Radiology

THE 'FEEDING BRONCHUS SIGN' IN CAVITARY LUNG LESIONS, ITS EVALUATION WITH COMPUTED TOMOGRAPHY AND A GUARDED OPINION REGARDING PHYSIOTHERAPY

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ABSTRACT **BACKGROUND** Bronchiectasis and cavitation are key features of acute and chronic pulmonary infections. Cavitary lesions may carry unfavourable prognosis with regard to complete restoration of pulmonary function in few patients. **OBJECTIVES** To evaluate type and site of bronchiectasis, its relation with cavity formation on computed tomography and providing an insight to sorting out subjects suited for physiotherapy. A radiological sign-"Feeding bronchus sign" has been discussed with reference to bronchiectasis, its origin, natural course and a suggestion of guarded future management and rehabilitation. **METHODS** Total 150 chest CT scans with presence of cavity and bronchiectasis were retrospectively reviewed and followed up for type, site of bronchiectasis, signs of active infection, site of cavity and presence of "feeding bronchus sign". Final diagnosis was confirmed by sputum sample, acid-fast bacillus test or culture or polymerase chain reaction. **RESULTS** Out of 150 cases, 70 (46%) had chronic and 80 (53%) had active infection. 33 (22%) had solitary and 117 (78%) had multiple cavities. 37 (34.6 %) patients had cylindrical, 11 (7.3 %) had varicose, 27 (18%) had cystic bronchiectasis, 23 (15.3%) had cylindrical and varicose, 19 (12.6%) had cylindrical and cystic and 33 (22%) had all three types. "Feeding bronchus sign" was observed in 102 (68%) patients. Radiological evidence of disease progression was seen in 21 patients, improvement in 19 and no change in 17 on follow-up CT. **CONCLUSION** Patients with positive "Feeding bronchus sign" are at risk for increased disease transmission and secondary opportunistic infections. Improvement and maintenance of quality of life is ultimate goal of management. Apart from antibiotics, pulmonary rehabilitation also plays an important role in cavitary lung disease.

KEYWORDS : feeding bronchus sign, cavity, bronchiectasis, rehabilitation, tuberculosis.

INTRODUCTION

Cavitation and bronchiectasis are key pathological events in many pulmonary infections. Bronchiectasis is irreversible localized or diffuse bronchial dilatation, usually resulting from chronic infection, proximal airway obstruction, or congenital abnormality.[1] Most often it is understood as bronchial dilatation as a result of chronic parenchymal scarring, commonly called as traction bronchiectasis frequently seen in chronic or healed pulmonary infections like tuberculosis. However, in active pulmonary infections, bronchial wall inflammation can manifest as dilatation in different forms usually, cylindrical or varicose bronchiectasis.[2,3,4] Whether this inflammatory bronchial dilatation is reversible, partially reversible or totally irreversible cannot be predicted on a single computed tomography (CT) scan. Follow up by serial radiological imaging can help predict the disease course, response to treatment and final outcome.

Often active or healed pulmonary cavities can be seen draining into or communicating with adjacent bronchus/bronchiole or a patent bronchus can be seen leading directly into a cavity described as the "Feeding bronchus sign".[5] The purpose of this study is to determine whether this radiological appearance is a cavity associated with a patent dilated bronchus or actually an inflamed ectatic bronchus and to opine if resolution is possible with medical or rehabilitative measures. We will also discuss the possible clinical implications of "Feeding bronchus sign".

MATERIAL AND METHOD

This was a retrospective study comprising of patients with fever, cough and/or shortness of breath evaluated with non contrast or contrast enhanced chest CT scan between January 2022 to October 2022. The study was approved by institutional ethics committee and need to obtain written and informed consent was waived.

High resolution images of chest were acquired on 128 slice CT scanner with or without intravenous contrast administration. All scans with presence of cavity with bronchiectasis were included in the study. Final diagnosis was based on microbiological tests by sputum sample obtained spontaneously or by broncho alveolar lavage (BAL), acid-fast bacillus (AFB) smear test or culture, or polymerase chain reaction (PCR) test. Uninterpretable scans due to lack of adequate breath hold and cavities other than infections were excluded from the study.

CT images were independently reviewed by two radiologists with 4 and 18 years of experience. Radiologists were blinded to the reports of other imaging tests but were aware that all patients had pulmonary symptoms. Images were reviewed and evaluated for signs of active infection viz. parenchymal consolidation and nodules, features of chronicity viz. parenchymal destruction and fibrosis, type of bronchiectasis, site of cavity and relationship between cavity and bronchus. Images were also reviewed for presence of "Feeding bronchus sign".

Criteria for Analysis

1. For purpose of image analysis, broncho-arterial ratio of more than 1 was considered as bronchial dilatation.[6]
2. Types of bronchiectasis were divided into three groups: cylindrical (type I), varicose (type II), and cystic (type III) (Figure 1 a-c).
3. Radiographically cavity was considered as lucency within a zone of pulmonary consolidation, or nodule that may or may not contain fluid level and is surrounded by a wall.[7]
4. Location of cavity was assessed according to lobar distribution as located in upper, middle or lower lobe and also classified with proximity to the hilum as hilar, parahilar/mid lung or peripheral/subpleural.
5. Relationship between cavity and bronchiectasis was described by "Feeding bronchus sign". Feeding bronchus sign has been described as an imaging appearance where a cavity is seen draining into or communicating with the adjacent bronchus/bronchiole or where a patent dilated bronchus can be seen leading directly into a cavity.[5]
6. Inter observer agreement was calculated.

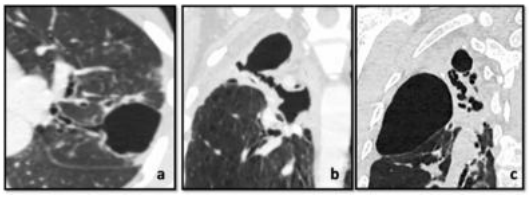

Figure 1: CT sections (lung window) showing lung cavities associated with different types of bronchiectasis (a) Cylindrical (b) Varicose and © Cystic.

Statistical analysis

Continuous data was reported as mean with range and categorical data was reported in percentage and proportion. Proportion of patients with feeding bronchus sign was reported. Inter observer agreement was calculated using Cohen's kappa statistics. The interpretation is non-agreement, slight, fair, moderate, substantial, near perfect, and perfect agreement of k-values of 0, 0.10-0.20, 0.21-0.40, 0.41-0.60, 0.61-0.80, 0.81-0.99, and 1. Statistical analysis was done using SPSS 25.0 version.

RESULT

Over the study period, 150 patients of cavitary pulmonary infections showing presence of bronchiectasis were included. Mean age of the study group was 57 years (range = 15-77 years). There were 30 (20%) females and 120 (80%) males.

Feeding bronchus sign

The "feeding bronchus sign" was present in 102 (68%) patients. Out of these, 10 (10%) patients had presence of fungal ball within the cavitary lesion signifying superimposed infection. 61 (60%) patients with positive feeding bronchus sign had extensive lung fibrosis and parenchymal destruction which was beyond repair and 41 (40%) patients had signs of active infection in the form of multiple nodules and consolidations.

Observations

Out of 150 cases, 70 (46%) had parenchymal fibrosis (chronic infection) and 80 (53%) had active infection. 33 (22%) had solitary cavitary lesion and 117 (78%) had multiple cavitary lesions. Based on location, 49 (32.6%) had peripheral cavity, 23 (15.3%) had mid lung cavity and 16 (10.6%) had hilar cavity, 25 (16.6 %) patients had cavity involving periphery and mid lung region, 15 (10%) involving mid lung and hilar region and 22 (14.6%) reaching from hilum upto periphery. These 22 (14.6%) patients had extensive parenchymal destruction and fibrosis leading to large cavities extending from hilum to periphery. Upper lobe cavity was present in 61 (40.6%), middle lobe in 9 (6%) and lower lobe in 26 (17.3%), upper and middle lobes in 10 (6.6%), upper and lower lobes in 25 (16.6%) and all lobes involved in 19 (12.6%). Cases with multiple cavities involving all lobes had greater parenchymal destruction with more severe disease. Based on type of bronchiectasis, 37 (34.6 %) patients had cylindrical bronchiectasis (type I), 11 (7.3 %) had varicose bronchiectasis (type II), 27 (18%) had cystic bronchiectasis (type III), 23 (15.3%) had combined type I and II, 19 (12.6%) had type I and III and 33 (22%) had all types of bronchiectasis. Patients with cylindrical bronchiectasis had mild infection while those with varicose and cystic bronchiectasis had more severe infection.

TABLE I

	CT features of cavitary pulmonary infections
FEEDING BRONCHUS SIGN	102 (68%)
CHRONIC INFECTION	70 (46%)
ACTIVE INFECTION	80 (53%)
SOLITARY CAVITY	33 (22%)
MULTIPLE CAVITIES	117 (78%)
LOCATION OF CAVITY	
Peripheral	49 (32.6%)
Mid lung	23 (15.3%)
Hilar	16 (10.6%)
Periphery + mid lung	25 (16.6 %)
Mid + hilar region	15 (10%)
Periphery+mid +hilar	22 (14.6%)
LOBE OF LUNG	
Upper	61 (40.6%)
Middle	9 (6%)
Lower	26 (17.3%)
Upper+middle	10 (6.6%)
Upper+lower	25 (16.6%)
Upper+middle+lower	19 (12.6%)
TYPE OF BRONCHIECTASIS	
Type I	37 (34.6 %)
Type II	11 (7.3 %)
Type III	27 (18%)
Type I + II	23 (15.3%)
Type I + III	19 (12.6%)
Type I + II + III	33 (22%)

Interobserver agreement

There was substantial agreement between both the observers (Kappa – 0.70) for depiction of "feeding bronchus sign" on CT.

Investigations

Sputum samples were tested for all patients in our study. 112 (74.6%) were diagnosed with pulmonary tuberculosis and 38 (25.3%) were diagnosed with other bacterial infections viz. Klebsiella and Staphylococcus. 10 (0.06%) patients had presence of fungal ball within the cavitary lesion signifying superimposed infection with Aspergillus. All these 10 patients had positive "feeding bronchus sign".

Follow up

Follow-up CT was performed on 57 patients. Radiological evidence of disease progression was seen in 21 patients, improvement was seen in 19, and no change in 17. In 38 patients who did not show improvement or in which disease progression was observed, were directed to the department of physiotherapy for rehabilitative measures. Of them, 32 patients were not suggested vigorous exercises as their cavitary lesions were subpleural or carried at least two types of bronchiectatic changes in either lung.

DISCUSSION

Pulmonary cavity is a walled off gas-filled space formed by complex host-pathogen interaction. It acts as immune sheltered zone with high oxygen levels, conducive for accelerated pathogen replication with poor treatment outcome, delayed sputum culture conversion, treatment relapse, and development of drug resistance, posing as a public health threat greatly increasing risk of disease transmission.[8,9] Cavitary pulmonary disease may result in significant morbidity and mortality and may be associated with life-threatening sequelae like Rasmussen aneurysm.[10]

As a three layered pathological structure, walls of a cavity comprise of innermost layer of necrotic debris and extracellular microorganisms, middle layer is infiltrated by inflammatory cells and fibroblasts and encircling layer has lymphocytes and macrophages continuous with intact alveoli and vasculature. Being devoid of normal alveolar structure and basement membrane, parenchyma thereby loses its elastic recoil.[11]

Cavity formation occurs when inflammatory nodules or consolidations in close proximity to airways erode into adjacent bronchus or bronchioles, expelling their necrotic contents into airway with a cavity directly communicating with adjacent patent inflamed airway depicting the "feeding bronchus sign" (Figure 2 a-f). This sign was first described in literature in non tuberculous mycobacterial infections as a cavity seen draining into or communicating with adjacent bronchus/bronchiole or where a patent dilated bronchus can be seen leading directly into a cavity.[5]

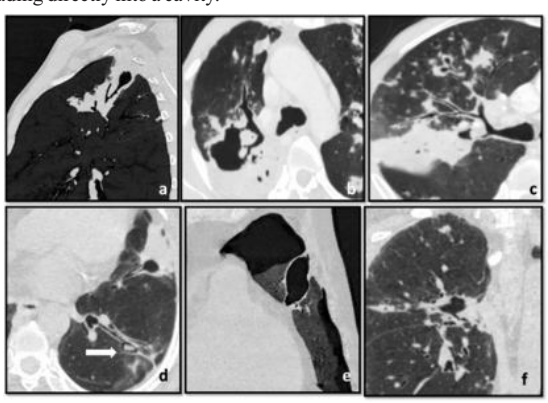

Figure 2: Feeding bronchus sign and its variants (a) peripheral cavity directly communicating with ectatic bronchus suggestive of feeding bronchus sign, (b) multiple feeding bronchi communicating with a large cavity, (c) branching feeding bronchi communicating with cavity, (d) positive feeding bronchus sign with fungal ball within one of the cavities (white arrow), (e) peripheral cavity with positive

feeding bronchus sign leading to large pneumothorax, (f) hilar cavity with feeding bronchus.

Open cavities with positive "feeding bronchus sign" continue to generate and expel micro organisms. Healed aseptic cavities are still vulnerable for secondary and recurrent opportunistic infections by fungi. Functional pulmonary deficit and recurrent opportunistic infections is a lifelong burden for patients.12 In our study, out of 150 cases, we identified "Feeding bronchus sign" in 102 (68%) and among these, 10 (10%) patients showed fungal ball within cavity (Figure 2d).
Type of bronchial communication also determines tension within the cavity. Cavities with positive "feeding bronchus sign" may have positive or negative atmospheric pressure within them. However, if the feeding bronchus undergoes partial obstruction due to inflammatory infiltrates, secretions or local bronchial spasm, cavity becomes tense with positive internal pressure where partially obstructed draining bronchus acts as a ball valve. Activities like coughing or vigorous chest exercises associated with forceful inspiratory effort can result in sudden increase in intra bronchial pressure and air may be forced into cavity that consequently enlarges in size with greater parenchymal destruction. This fastidious cavity may explode leading to pneumothorax or pneumomediastinum and haemorrhage with grave consequences.13 Risk of pneumothorax is specially exaggerated in peripheral cavities as encountered in 2 cases in our study (Figure 2e). Strenuous physical activity where wide fluctuation of tidal volume is expected, leading to tachypnoea or dyspnoea, coughing, blowing balloons or playing mouth instruments must be totally avoided by such patients.

Cavities with multiple dilated feeding or intercommunicating bronchi were seen in our study suggesting transbronchial spread of infection leading to larger cavities with more parenchymal destruction in due course of time (Figure 2b-c). Apart from three types of bronchiectasis discussed in literature, we noticed two other variants. A cylindrical ectatic bronchus leading into a pot like closed cavity interpreted as an inflamed cystic bronchus or a bronchiectatic cavity, radiologically consistent with "feeding bronchus sign" (Figure 3a). Another was a cylindrical ectatic bronchus leading into a pot like open cystic cavity distally continuous with an ectatic bronchus resembling a snake charmer's flute. These type of ectatic bronchi provide greater surface area for spread of infection upto lung periphery (Figure 3b).

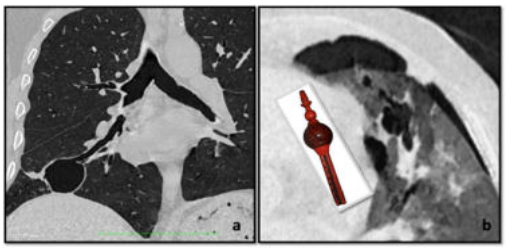

Figure 3 : Variants of bronchiectasis in association with feeding bronchus sign (a) cylindrical ectatic bronchus leading into a pot like closed cystic cavity interpreted as an inflamed cystic bronchus or a bronchiectatic cavity (b) cylindrical ectatic bronchus leading into a pot like open cystic cavity distally continuous with an ectatic bronchus resembling a snake charmer's flute (inset)

OPINION ON MANAGEMENT PERSPECTIVE

Antibiotic therapy, intensive and/or long term, coupled with mucolytics and expectorants is standard therapy in cavitary infections to maintain bronchial hygiene and prevent pathogen load, superadded infections, drug resistance and relapse of disease process. This monitoring is essentially revised and tailored as per microbiological reports. [14,15]

Literature review suggests that 20-50% patients of tuberculosis have persistent cavities after completion of therapy. [16] Healing may result in fibrotic scarring which can lead to open (cavity airspace remains) or closed healing (cavity resolved to scar tissue or calcified foci).[17,18] Improvement and maintenance of quality of life by achieving an optimum lung function is the ultimate goal of management by a team of clinic-radiological exerts and physiotherapists. Apart from antibiotics, pulmonary rehabilitation also plays an important role in cavitary lung disease. Cough, progressive dyspnoea and loss of exercise tolerance are frequently occurring symptoms in such conditions. Optimisation of oxygen therapy, delivery of appropriate non-invasive ventilatory support, management of breathlessness, exercise advice and maximisation of functional activity are aspects of care that physiotherapists provide.[19,29]

Although early rehabilitation to improve quality of life is advisable but our study suggests that all patients with cavitary lung disease cannot be subjected to chest physiotherapy or pulmonary yoga exercises without understanding the baseline lung condition for which imaging is an essential requisite apart from clinical assessment. Patients with extensive lung damage and large cystic bronchiectatic cavities at sites vulnerable to pneumothorax should avoid strenous respiratory exercises because the damaged lung parenchyma cannot be subjected to the same tidal volumes as a healthy lung. Active rehabilitation of large pulmonary cavities should not be attempted irrespective of their site. A large cavity with a feeding bronchus should not be expanded. In these cases, oxygen supplementation with monitoring of oxygen saturation is recommended. Patients with active lung infections and open bronchiectatic cavities should be treated with airway clearance techniques, slow and deep breathing exercises and postural drainage along with expectorants and mucolytic agents.[20,21] CT scan can help identify affected bronchopulmonary segments and aid selection of the appropriate postural drainage positions.

Literature review documents a study conducted in China by An et al. on treatment of tuberculous cavities in patients of multidrug resistant tuberculosis (MDR-TB).[22] They successfully implemented the concept of "feeding bronchus sign" in 35 patients by using one-way endobronchial valve (EBV) to seal the draining feeding bronchus so that air can exit but not enter into cavity.[23] Size of lung cavity was reduced in all patients with 100%sputum culture conversion rate and 68.8 % cavity closure rate. EBV were initially designed to treat persistent air leaks, pneumothorax, emphysema and bronchopleural fistula .[24,25,26,27]

To our knowledge, Italy, Russia and China have conducted trials on the use of EBV for MDR-TB treatment.[22] This new treatment option seems promising for treatment and closure of open lung cavities thus reducing morbidity and mortality.[28] Presence of "feeding bronchus sign" is a critical determinant in deciding appropriateness and patient eligibility for opting this treatment modality.

CONCLUSION

Bronchiectasis and cavitation are common in active and chronic pulmonary infections. Focal erosions in bronchial wall can lead to intercommunicating cavities or genesis of inflamed ectatic bronchus as described by the "feeding bronchus sign". Role of pulmonary rehabilitation is decided not only by the size and location of cavity but also by extent of bronchiectasis. Hence, a multidisciplinary approach is required wherein active physiotherapy is prescribed only if there is a possibility of partial or total reversibility of bronchiectasis whereas it is contraindicated in larger feeding bronchial cavities and significant volumes of pulmonary destruction.

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