The Egyptian Journal of Radiology and Nuclear Medicine (2014) **45**, 69–73

Egyptian Society of Radiology and Nuclear Medicine

The Egyptian Journal of Radiology and Nuclear Medicine

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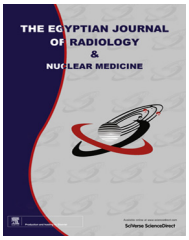

ORIGINAL ARTICLE

Bronchiolitis Obliterans (BO): HRCT findings in 20 patients

Youssriah Yahia Sabri [a], **Iman M. Hamdy Ibrahim** [a,*], **Adriana Fouad Radman** [b]

[a] *Department of Radiodiagnosis, Cairo University, Egypt*
[b] *Aden University, Yemen*

Received 25 July 2013; accepted 30 September 2013
Available online 7 November 2013

KEYWORDS

Bronchiolitis obliterans (BO);
HRCT;
Air-way diseases

Abstract *Introduction:* Bronchiolitis obliterans (BO), also known as constrictive bronchiolitis is a fibrosing form of obstructive lung disease that follows a severe insult to the lower respiratory tract. It occurs in a heterogenous group of lesions varying in their etiology, clinical settings and pathologic features but are centered in small conducting airways.
Patients and methods: The study included 20 patients 14 females and 6 males, mean age range 7–64 years (average of 39.25 years) with a variety of chest symptoms on whom HRCT was performed.
Results: Mosaic attenuation pattern was seen in all patients. Other HRCT findings included bronchiectasis, bronchial wall thickening and centrilobular nodules.
Conclusion: High-resolution CT is currently superior as an imaging modality in diagnosis of bronchiolitis obliterans, however, diagnosis of BO requires exclusion of other causes of chronic airway obstruction.

1. Introduction

Bronchiolitis obliterans (BO), also known as constrictive bronchiolitis is a fibrosing form of obstructive lung disease that follows a severe insult to the lower respiratory tract (1). It is characterized by irreversible concentric narrowing of the bronchial lumen by submucosal and peribronchial fibrosis (2).

Bronchiolitis occurs in a heterogenous group of lesions varying in their etiology, clinical settings and pathologic features but are centered in small conducting airways (Table 1) (3,4).

Bronchiolitis obliterans has been described in all age groups, the frequency of underlying causes and potential prognoses are different for children and adults. It is mostly seen in children following a severe lower-respiratory-tract infection, usually of adenovirus (5) whereas in adults, it is more commonly associated with occupational inhalation injuries, hypersensitivity pneumonitis, and autoimmune disorders (6).

A presumptive diagnosis of BO can often be made with a high degree of confidence based on a clinical history of persistent symptoms of obstructive pulmonary disease, evidence of airflow obstruction on pulmonary function tests and

* Corresponding author. Tel.: +20 1009705377.
E-mail address: iman92@yahoo.com (I.M. Hamdy Ibrahim).
Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

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Table 1 Most common conditions associated with BO (4).

Most common conditions associated with BO
Childhood respiratory infection
Post inhalational
Bronchiectasis
Ingested toxins
Connective tissue disorders
Drugs
Inflammatory bowel diseases
Cryptogenic (Idiopathic)

characteristic findings on high-resolution CT (HRCT). However, the clinical diagnosis of BO requires exclusion of other causes of chronic airway obstruction, including emphysema, chronic bronchitis and asthma (7).

There is no individual method or specific imaging for BO. However, imaging assists in reaching the diagnosis when considered in conjunction with clinical and laboratory information and provides information regarding the extent of pulmonary involvement. The three commonly used imaging methods nowadays are: conventional chest radiograph (CXR), lung ventilation/perfusion scans (V/Q scan) and HRCT (8).

HRCT is more sensitive than both CXR and V/Q scans for detecting airway and parenchymal abnormalities occurring in BO. Its greatest limitation is the elevated radiation dose, compared to CXR and V/Q scans, so lower dose protocols are now available without much loss of image quality and should always be sought when performing HRCT studies in children. The advantage of HRCT is the possibility of identifying small airway anomalies as well as other lung lesions (9).

The bronchiolar wall is too thin to be visualized on HRCT, even in patients with BO. So the analysis of the CT images is limited to assessment of secondary signs related to the small airway obstruction. The main CT finding of BO on CT scans performed at end inspiration is geographic in homogeneity of lung attenuation (mosaic attenuation pattern), seen in 40–80% of patients (Table 2) (4,10).

Several studies have suggested that post-processing of HRCT images particularly with the use of minimum intensity projection (minIP) reconstructions improves the detection of subtle areas of low attenuation encountered in patients with emphysema and small airway disease. This may be particularly helpful in patients with high clinical suspicion for BO and otherwise apparently normal CT (11).

In the appropriate clinical settings, the presence of mosaic attenuation perfusion, air trapping, and ancillary CT findings can be diagnostic of BO, however it should be emphasized that mosaic perfusion is a nonspecific finding seen in a number of conditions and that mild air trapping is commonly seen in normal subjects (12).

Table 2 HRCT findings of BO (4).

The common HRCT findings in BO	The ancillary findings
Decreased attenuation and vascularity	Bronchiectasis and bronchiolectasis
Mosaic perfusion pattern	Bronchial wall thickening
Air trapping at expiratory images	Centrilobular nodules
	Tree-in-bud opacities

The aim of this study is to show/discuss the role of HRCT in the diagnosis of bronchiolitis obliterans.

2. Patients and methods

2.1. Patients

The study included 20 patients, 14 females and 6 males, mean age range 7–64 years (average of 39.25 years) with a variety of chest symptoms including dyspnea, chronic productive cough, dry cough and fever. One patient was a known case of rheumatoid arthritis and one of scleroderma. Also one patient gave a history of subglottic stenosis after an incident of chlorine inhalation.

3. Methods

All patients were subjected to:

(1) Thorough clinical examination with history taking, general and chest examination.
(2) Pulmonary function test (PFT).
(3) Laboratory tests mostly complete blood picture (CBC). Other tests were considered according to each case e.g., sputum analysis, sputum culture, tuberculin test, etc.
(4) HRCT of the chest:Examinations were performed using a 4-detectors multidetector scanner (Light Speed Plus; GE medical systems, Milwawkee, Wisconsin, USA) in the radiology department, Cairo University.No preparation or IV contrast was needed.The examination was done in supine position.A scout was taken with kV 120 and mA 120, then helical scanning in full inspiration in caudo-cranial direction to minimize the respiratory artifacts.The used parameters are shown in Table 3.
(5) Virtual bronchoscopy was only done in the case giving history of accidental inhaling chlorine to assess the extent of subglottic stenosis.The acquired images were sent to the workstation for adequate multiplanar reconstruction to be viewed in the axial, sagittal and coronal planes as well as for the displaying volume rendering. Mediastinal windows are also taken. Several reconstruction techniques are done including 3D internal surface

Table 3 The scanning parameters of HRCT of the chest.

Parameters	
Scan type	Helical 0.5 s
Detector row	4
Helical thickness	1.25
Pitch	1.5:1
Speed (mm/rot)	7.5
Detector configuration	4×1.25
Beam collimation	5
Interval (mm)	1
Gantry tilt	0
FOV	Depends on patient's size
kV	120–140
mA	120–160
Total exposure time	16–20 s

rendering, 3D volume rendering, 2D minimum intensity processing (minIP) and 2D multiplanar image reconstruction (MPR).

4. Results

All patients presented with dyspnea, 15 cases had chronic productive cough, 5 cases had dry cough and 3 patients had fever.

PFT showed obstructive changes in all cases.

The study showed a variety of HRCT findings as shown in Table 4.

Mosaic attenuation pattern was seen in all patients, showing areas of hypo- or avascularity with low CT attenuation intervening with normal areas of higher density as shown in Figs. 1 and 2.

Table 4 Summary of HRCT findings.

HRCT findings	No. of cases	Percentage (%)
Mosaic perfusion/attenuation	20	100
Peribronchial thickening	15	75
Bronchiectasis	14	70
Bronchioles	10	50
Centrilobular nodules	3	15
Tree-in-bud pattern	2	10

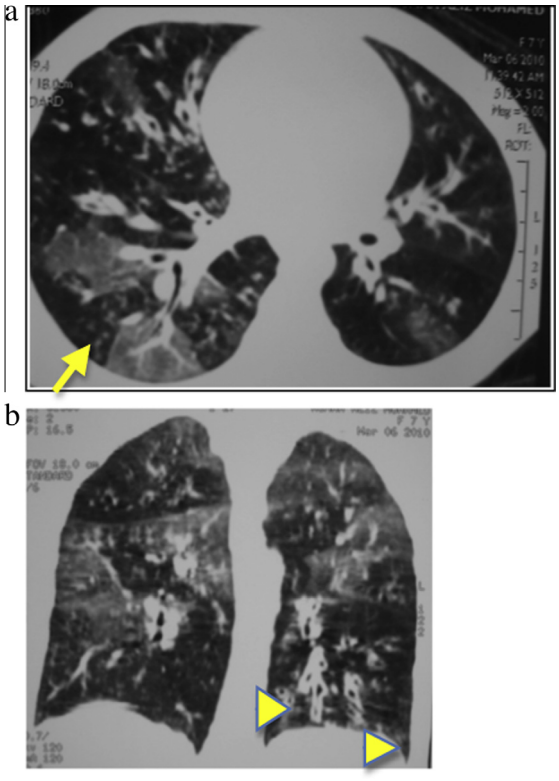

Fig. 1 (a,b) A-7-year-old female patient presenting with chronic productive cough, marked dyspnea and fever. HRCT showed: (a) Mosaic perfusion (arrow) (b) bilateral bronchiectasis, peribronchial thickening (arrowheads) and tree-in-bud pattern.

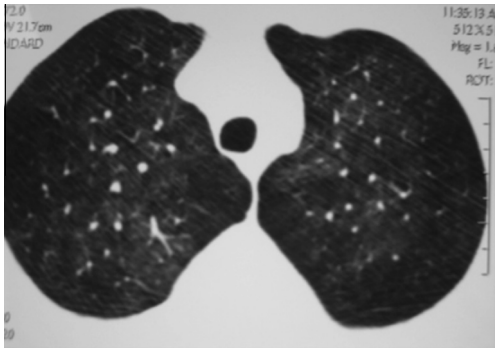

Fig. 2 A-43-year-old female patient presenting with chronic dry cough and progressive dyspnea. HRCT shows hyperinflation and mosaic pattern.

Air trapping was seen in minIP images in the VB scan done in the case of subglottic stenosis following the chlorine inhalation incident (Fig. 3a and b).

Bronchiectasis was seen in 14 patients (70% of cases) with predominantly lower lobar distribution Fig. 4 (Table 5). Ten cases had bronchoceles. Cases showing a tree-in-bud pattern

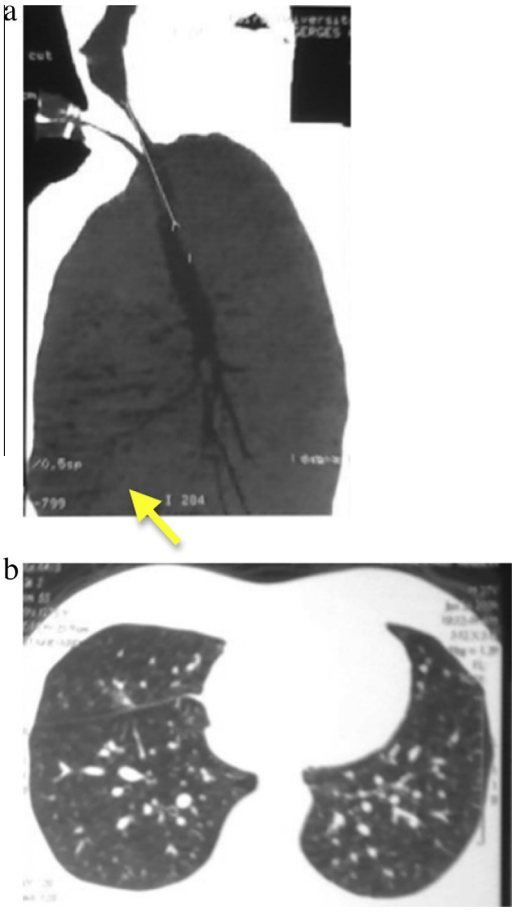

Fig. 3 (a,b) A-27-year-old male patient who had an industrial accident; inhaling chlorine. The patient had severe dyspnea and dry cough. HRCT and VB: (a) sagittal minIP image shows the subglottic stenosis and multiple areas of air-trapping (arrow) (b) HRCT images show mosaic perfusion pattern.

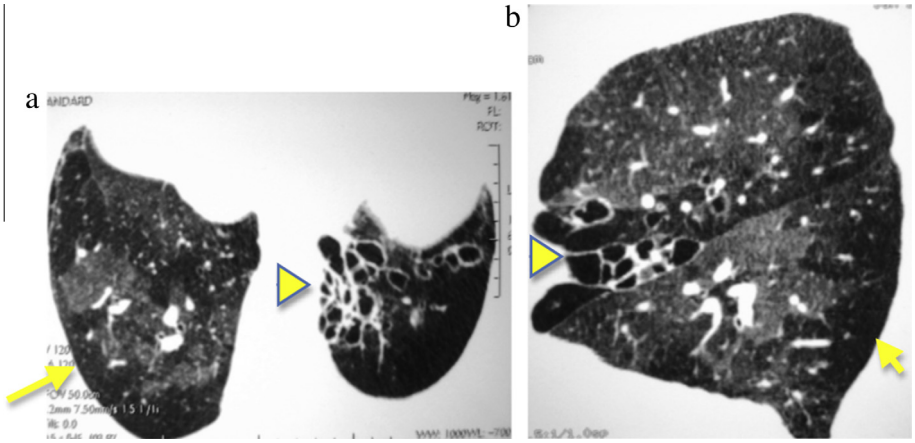

Fig. 4 (a,b) A-64-year-old female patient complaining of chronic productive cough and dyspnea. HRCT (axial and sagittal cuts) showed mosaic perfusion (arrow), left lower lobe bronchiectasis (arrowhead).

Table 5 Distribution of lesions in cases with bronchiectasis.

Distribution of lesions in bronchiectasis	No. of cases
Right lung	0
Left lung	2
Both lungs	12
Upper lobe involvement	7
Lower lobe involvement	11
Middle lobe involvement	3

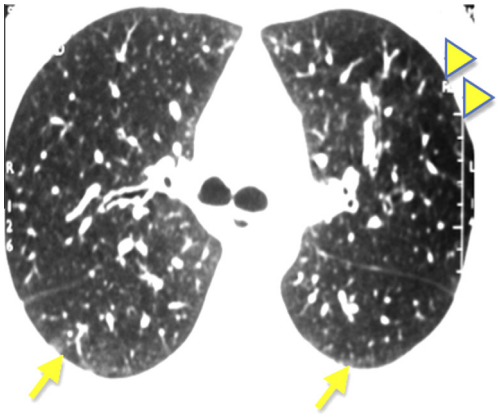

Fig. 5 A-30-year-old man presenting with dry productive cough and dyspnea. HRCT showed: minimal peribronchial thickening, few centrilobular nodules (arrows) and areas of mosaic perfusion (arrowheads).

Fig. 5 were feverish and sputum analysis was positive for infection.

Sputum analysis was positive for infection in six cases showing bronchiectatic changes.

None of the cases were proved to be tuberculous.

5. Discussion

Bronchiolitis obliterans (constrictive bronchiolitis) is defined histologically as concentric luminal narrowing of the membranous and respiratory bronchioles secondary to submucosal and peribronchiolar inflammation and fibrosis without any intraluminal granulation tissue or polyps (13).

Constrictive bronchiolitis can be postinfectious (mostly secondary to prior viral or Mycoplasma infection); or secondary to noxious fume inhalation, graft-versus-host disease, lung transplantation, rheumatoid arthritis, inflammatory bowel disease, and penicillamine therapy (13).

According to Pipavath et al. (8) mosaic attenuation, air trapping, and bronchial dilatation are the most common findings.

This study involved 20 patients; 14 females and 6 males, age range 7–64 years (average of 39.25 years). HRCT was done to all cases and one case also needed virtual bronchoscopy study. The main HRCT finding in our cases was the mosaic pattern. It was seen in all of our patients (100%), showing areas of hypo- or avascularity with low CT attenuation and intervening normal areas of higher density; i.e. mosaic perfusion pattern.

In the study done by Ooi et al. (14), on sixty Chinese patients (23 men, 37 women; mean age, 58 years) who received a clinical diagnosis of small airway disease (bronchiolitis obliterans) all patients underwent high-resolution CT of the thorax. Bronchiolitis was noted in all 60 patients and was present in both lungs in 49 (82%) patients and in one lung in 11 (18%) patients.

In our study the bronchiectatic changes were noted only in 14 of 20 patients (70%), seen in both lungs in 12 patients (60%) and unilateral in 2 cases (10%).

In a study done by Jensen et al. (10), to evaluate the HRCT findings of bronchiolitis obliterans involving 14 patients (10 females and 4 male) the results were as follows: expiratory air trapping in all of the 14 examinations that included expiratory images (100%), bronchial wall thickening was seen in 13 patients (93%), inspiratory decrease attenuation in 11 patients (97%) and mosaic pattern of lung attenuation in 7 patients (50%).

While in our study mosaic perfusion was noted in all patients, air trapping was detected in minIP images done in one case. In the rest of our study, HRCT was done in inspiratory phase of respiration. According to Pipavath (2005) (8), air trapping is an indirect sign of obstructive small airway disease and may be identified by the presence of mosaic attenuation on inspiratory CT that is accentuated with expiratory imaging (13).

A study was done by Knollmann et al. 2004 (15), using HRCT scanning for diagnosing bronchiolitis obliterans (BO) in lung transplant recipients. The study group included 52 lung transplant recipients (28 men, 24 women, age range 13 to 72 years; mean age 46). As our study the parenchymal inhomogeneity was the principal finding, with air trapping, bronchiectasis was found in 18 patients.

A study was done by Gunn et al. (16), on 33 patients who underwent hematopoietic stem cell transplantation and subsequently developed bronchiolitis obliterans, age range 11.8–66.8 years. HRCT was obtained and the principal finding in HRCT-related BO was air trapping, which was identified by persistent lucency of lung parenchyma during expiration in regions of the lung nit expected to demonstrate physiologic air trapping. Each lobe in each patient was also graded for bronchial wall thickening, bronchiectasis, and centrilobular opacities. Although bronchial wall thickening was observed in 24 (73%) of the patients, it was generally mild, significantly more bronchial wall thickening was observed in the lower lobes. Bronchiectasis and centrilobular opacities were present in 14 (42.4%) and 13 (39.4%) of patients, respectively, both were generally mild.

A retrospective study was done by Devouassoux et al. (17) on 25 patients who received a clinical diagnosis of bronchiolitis obliterans associated with RA patients (mean age 64 + 11 years). Bronchial wall thickening, lobular areas of decreased attenuation with mosaic pattern indicative of air trapping, and bronchiectasis were the most frequent HRCT findings, present in 96%, 42% and 40%, respectively.

So in this study the bronchial wall thickening was the principal finding unlike our study in which the mosaic pattern takes the upper hand finding. In our study peribronchial thickening was seen in 15 patients (75%), while 3 patients showed centrilobular nodules (15%).

6. Summary and conclusion

Bronchiolitis obliterans is a respiratory illness of the small airways that is important because of its fibrotic and irreversible nature.

It may be seen as irreversible sequel of an infection, inhalation of toxic fumes and gases, in patients with connective tissue diseases, particularly rheumatoid arthritis, in complications of bone marrow transplantation, and in heart–lung and lung transplantation. It is rarely idiopathic.

High-resolution CT is currently the imaging modality of choice in diagnosis of bronchiolitis obliterans being superior in demonstrating the presence and extent of abnormalities.

Many HRCT findings that confirm the diagnosis are divided into two categories; common findings (e.g.: decreased attenuation and vascularity, mosaic perfusion pattern, air trapping at expiratory images) and ancillary findings (e.g.: bronchiectasis and bronchiolectasis, bronchial wall thickening centrilobular nodules and tree-in-bud opacities).

However, the diagnosis of BO requires exclusion of other causes of chronic airway obstruction, including emphysema, chronic bronchitis, and asthma and the radiologist should know the radiological features of the differential diagnostic conditions.

Conflict of interest

The authors have no conflict of interest to declare.

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