Monaldi Arch Chest Dis
2004; 61: 1, 28-34

ORIGINAL ARTICLE

The prevalence of congenital bronchial atresia in males

K. Psathakis[1], S. Lachanis[2], C. Kotoulas[3], V. Koutoulidis[2], P. Panagou[1], K. Tsintiris[1], S. Loukides[1]

ABSTRACT: ***The prevalence of congenital bronchial atresia in males. K. Psathakis, S. Lachanis, C. Kotoulas, V. Koutoulidis, P. Panagou, K. Tsintiris, S. Loukides.***

Background. **Congenital bronchial atresia is a rare anomaly, which usually occurs in adulthood as an incidental finding on routine chest radiograph.**

Methods. **The purpose of the study was to retrospectively evaluate the cases that were diagnosed in our hospital, from January 1995 to March 2003, to estimate the prevalence of this disorder and to determine the diagnostic studies of choice, according to the existing literature. Since the main portion of the male population of our country is referred to our hospital for screening soon after their enrollment in the army, epidemiological data can be easily estimated for many congenital anomalies occuring in adulthood, such as bronchial atresia.**

Results. **We found seven patients with Congenital Bronchial Atresia and the prevalence of this disorder was estimated at 1.2 cases per 100,000 in males. The chosen diagnostic procedure is computed tomography of the chest with high-resolution scans. Bronchoscopy would only exclude serious alternative diagnosis and prevent unnecessary surgical interventions.**

Conclusions. **Congenital bronchial atresia is a rare anomaly, with a mild clinical course. The diagnosis is made radiologically, the HRCT of the chest being the procedure of choice. Bronchoscopy should be performed to exclude any endobronchial lesion due to a different disease entity and to prevent unnecessary surgical intervention in an otherwise asymptomatic individual.**

Monaldi Arch Chest Dis 2004; 61: 1, 28-34.

Keywords: Congenital bronchial atresia, prevalence, computed tomography, bronchoscopy.

Pneumonology[1], Radiology[2] and Thoracic Surgery[3] Depts., Army General Hospital, Athens, Greece.

Correspondence: Kostas Psathakis, Liakataion 15, Gyzi 114 74, Athens, Greece; e-mail: kpsazakis@hol.gr

Introduction

Bronchial Atresia is a rare congenital anomaly characterized by a mucocele (or bronchocele) resulting from a mucus-filled, blind-terminating subsegmental, segmental or lobar bronchus, at or near its origin, and hyperinflation of the isolated lung parenchyma. Just over 100 cases have been reported in English literature since 1953, when the abnormality was first described [1].

In this study we present our experience with seven cases of bronchial atresia, one of the largest cohorts in the literature. We reviewed our patients' data and estimated, for the first time, the frequency of anomaly in males. We also reviewed the existing literature and presented the appropriate diagnostic modalities, the differential diagnosis and possible therapeutic options and recommendations.

Methods

From the hospital archives we reviewed the files of patients diagnosed with congenital bronchial atresia, from January 1995 to March 2003. The data concerned was age, sex, cause of admission, present symptoms, previous history, location of the anomaly, other concomitant abnormalities, the clinical evaluation that had been made and the management that had been followed.

In all cases the laboratory investigation had included pulmonary function tests [PFTs, i.e. forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) using a dry spirometer (Vicatest, Mijnhardt, Holland), as well as total lung capacity (TLC) using the helium dilution technique (Gould 2400, Bilthoven, Holland)], arterial blood gases, a chest-X-ray on inspiration and expiration, and high-resolution computed tomography (HRCT) of the chest (GE 9800 Highlight advanced). Two radiologists reviewed both the chest radiographs and the CT scans separately. Even though our patients were mainly recruits and the armed forces require complete documentation of any abnormal findings on chest radiograph, not all of them had been submitted for a complete evaluation by bronchoscopy, ventilation-perfusion lung scans, pulmonary angiography or magnetic resonance imaging of the chest. This was due to the fact that some of the patients denied further investigations when they were informed of the benign nature of their disorder.

Our hospital is a referral tertiary army medical centre, where the majority of the male population

are evaluated for any health disorders. Since enrollment in the army is compulsory for males in our country, and all of the recruits had a chest radiograph as a routine, we were able to provide an estimate of the prevalence of bronchial atresia in males from the index cases out of the population enrolled during the same time period.

Results

Seven cases with a diagnosis of congenital bronchial atresia were found. All of them were males, aged 19 to 57 years. Six of them were recruits at the time of diagnosis (aged 19 to 24 years). During the period of the study, 489,876 recruits were evaluated, giving an estimated prevalence of bronchial atresia of 1.2 cases per 100,000 in males (6 cases out of 489,876 males).

The clinical features and the laboratory evaluation of each of our patients are described as follows and are summarised in table 1:

Case 1:

A 19 year-old male was admitted to the Pneumonology department for clinical evaluation after two episodes of pneumonia; 9 and 6 months ago. He had heterozygous β-thalassemia as a concomitant disorder and was asymptomatic at the time of the admission. The findings on physical examination were normal. The chest radiograph revealed hyperlucency of the left upper and middle lung fields. The HRCT of the chest showed hyperlucency of the upper segment of the left lower lobe with reduced size of the pulmonary vessels and a mucocele. PFTs and arterial blood gases were normal. Fiberoptic bronchoscopy revealed absence of the apical bronchus of the left lower lobe (LB6). The posterior bronchus of the left lower lobe (LB10) was laterally directed. A perfusion lung scan showed a defect of the apical segment of the left lower lobe and a sub-segmental defect of the left upper lobe. Pulmonary angiography showed decreased perfusion at the same area with a normal pattern of the pulmonary vessels.

Case 2:

A 24 year old male was admitted to the Pneumonology department for evaluation of an abnormal routine chest X-ray. He described recurrent acute bronchitis and one episode of pneumonia in the past. He had mild dyspnea on exertion (1/4 in MRC dyspnea scale) and episodes of persistent cough. On physical examination he had decreased breath sounds and decreased fremitus over the upper part of the left anterior chest wall. The chest radiograph showed a small nodular shadow by the left hilum and emphysematous appearance of the left upper lobe (figure 1). The chest radiograph on expiration revealed air trapping of the left upper lobe and mediastinal shift to the right (figure 2). The HRCT of the chest revealed a mucocele and emphysematous appearance of the left upper lobe (hyperlucency and reduced size of the pulmonary vessels). The PFTs were compatible with a mild restrictive disorder (FEV1= 68% of predicted value, FVC= 74% FEV1/FVC= 97% and TLC= 75% of the predicted value). Arterial blood gases were normal. Bronchoscopy did not reveal any abnormal findings. A perfusion lung scan showed a defect at the left upper and middle lung fields. A subsequent ventilation lung scan showed a defect in the same area.

Case 3:

A 20 years old male was admitted to the Pneumonology department for evaluation of an abnormal routine chest X-ray. His past history was negative. He had no symptoms and had normal findings on physical examination. His chest radiograph showed two nodular shadows on the left upper lobe with air-trapping on expiration. The HRCT of the chest showed a mucocele and hyperlucency of the anterior segment of the left upper lobe with reduced size of the pulmonary vessels at the affected area (figure 3). PFTs and arterial blood gases were normal. The patient refused further investigations.

Case 4:

A 20 year old male was admitted to the Pneumonology department for evaluation of an abnormal routine chest-X-ray. His past history was neg-

Table 1. - Characteristics of seven patients with bronchial atresia*

Case no	Age (yr)/Sex	History	Location of atresia	PFTs - ABGs	FFB
1	19 /m	Pneumonia	LLL	Normal	Absence of LB6
2	24/m	Pneumonia, DOE,	LUL	Mild restriction, ABGs=Normal	Normal
3	20 /m	Asymptomatic	LUL	Normal	Not performed
4	20 /m	Asymptomatic	LUL	Mild restriction, hypoxemia	Not performed
5	21 /m	Pneumonia	RUL	Normal	Absence of RB3b
6	57 /m	Asymptomatic	LUL	Normal	Normal
7	22 /m	Asymptomatic	LUL & LLL	Normal	Normal

*: All the patients had an abnormal chest radiography and a HRCT of the chest that was diagnostic of bronchial atresia.
yr: years, **m:** male, **DOE:** dyspnea on exertion, **LUL:** left upper lobe, **LLL:** left lower lobe, **RUL:** right upper lobe, **PFTs:** pulmonary function tests, **ABGs:** arterial blood gases, **mild restriction:** TLC= 60-80% of the predicted, **FFB:** flexible fiberoptic bronchoscopy, **LB6:** apical bronchus of the left lower lobe, **RB3b:** sub-segmental b of the anterior bronchus of the right upper lobe.

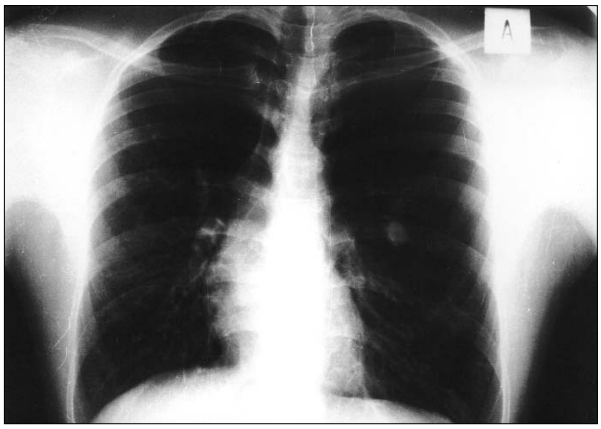

Fig. 1. - Chest-X-ray of the patient presented in case 2, showing a nodular shadow by the left hilum with emphysematous appearance of the left upper lobe.

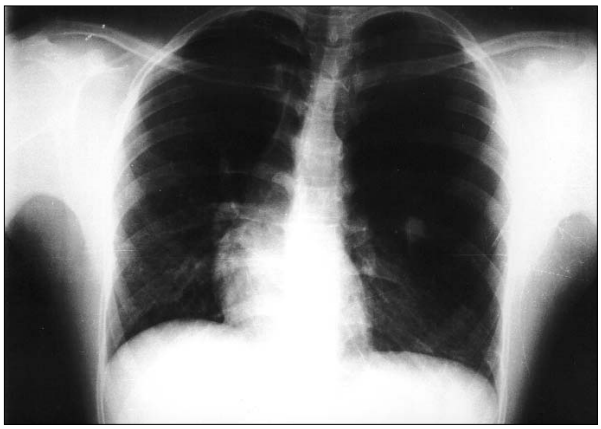

Fig. 2. - Chest-X-ray of the same patient on expiration shows the air trapping at the left upper lobe and the contralateral mediastinal shift.

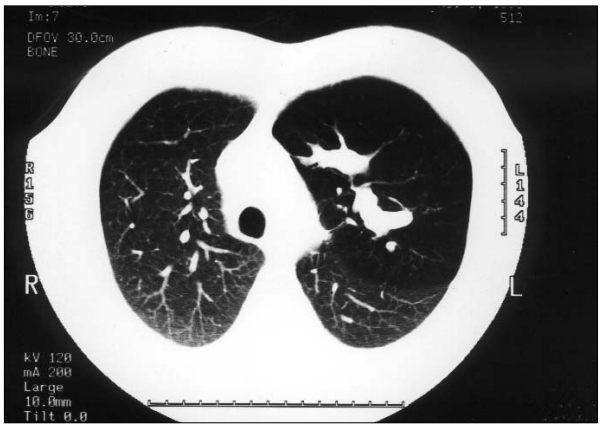

Fig. 3. - HRCT scan of the chest of the patient presented in case 3, showing the branching mucocele and the hyperlucency of the left upper lobe anteriorly, along with air trapping and reduction of the size of the pulmonary vessels at the same area.

ative and he had no symptoms. Physical examination revealed decreased breath sounds and decreased fremitus over the upper part of the left anterior chest wall. The chest radiograph showed two nodular shadows at the left middle lung field with air trapping and mediastinal shift to the right on expiration. The HRCT of the chest showed a mucocele and hyperlucency of the left upper lobe with reduced size of the pulmonary vessels at the affected area. The PFTs were compatible with a mild restrictive disorder (FEV1 = 67% of predicted Value, FVC = 63%, FEV1/FVC = 94% and TLC = 68% of the predicted value) and the patient was hypoxemic (pO_2 = 75 mm Hg). The patient refused further investigations.

Case 5:

A 21 year old male was admitted to the Pneumonology department for evaluation of an abnormal routine chest-X-ray. He mentioned three episodes of pneumonia in the past. He had no symptoms and had normal findings on physical examination. His chest radiograph showed a shadow of 3 cm in diameter in the right upper lung field with areas of hyperlucency at its upper border. The HRCT of the chest showed an ovoid shadow (mucocele) with air-fluid level and hyperlucency of the anterior segment of the right upper lobe with reduced size of the pulmonary vessels at the same area. PFTs and arterial blood gases were normal. Fiberoptic bronchoscopy revealed absence of the sub-segmental b of the anterior bronchus of the right upper lobe (RB3b).

Case 6:

A 57 year old male was admitted to the Pneumonology department for evaluation of an abnormal routine chest-X-ray. His past history was negative. He had no symptoms and had normal findings on physical examination. His chest radiograph showed a shadow by the left hilum extending to the subclavicular area. The HRCT of the chest revealed a mucocele and hyperlucency of the left upper lobe with reduced size of the pulmonary vessels at the affected area. PFTs and arterial blood gases were normal. Bronchoscopy did not reveal any abnormal findings. Magnetic resonance imaging (MRI) of the chest revealed the convergence of the bronchi, that were dilated by the mucus, to the point of atresia (figure 4).

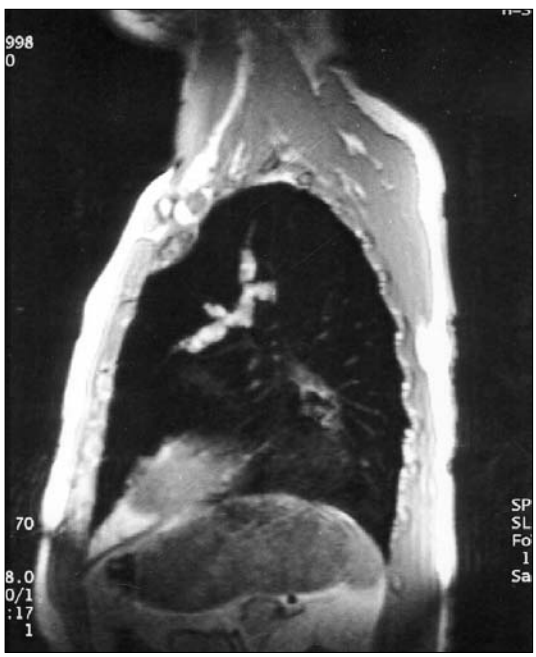

Fig. 4. - MRI of the chest on a sagittal plain, of the patient presented in case 6, showing the convergence of the dilated bronchi to the point of the atresia. The increased signal intensity of the mucocele is due to its increased protein content.

Case 7:

A 22 year old male was referred to the Thoracic Surgery department of our hospital because of a history of multiple rib fractures in the past at the left hemithorax and a concomitant abnormal chest X-ray. The rest of his past history was negative. He had no symptoms and had normal findings on physical examination. The chest X-ray revealed a ramified shadow (mucocele) with hyperlucency of the upper and middle lung fields. The HRCT of the chest revealed nodular and fusiform branching opacities at the left upper lobe, representing mucus plugs converging towards the atretic bronchus. There was hyperlucency of the lung parenchyma with diminution of the pulmonary vessels. A second area of emphysematous lung parenchyma with a mucocele was observed at the left lower lobe. Spiral CT of the chest showed two different areas of hyperlucency, one on the left upper lobe and the other on the left lower lobe, representing a double bronchial atresia (figures 5, 6). PFTs and arterial blood gases were normal. Bronchoscopy did not reveal any abnormal findings.

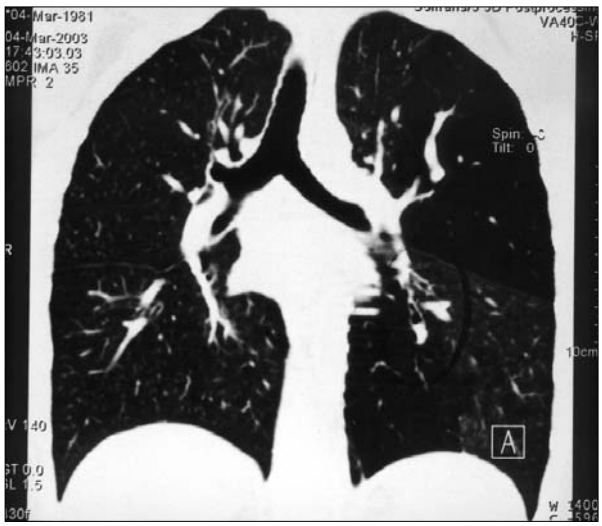

Fig. 5. - Coronal Multiplanar Reformation of the chest of the patient presented in case 7.

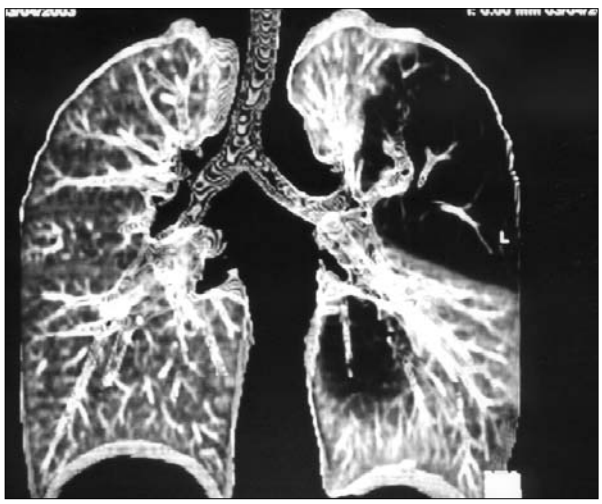

Fig. 6. - Volume Rendering with use of a tissue transition projection (case 7), shows two different areas of hyperlucency, one at the left upper lobe and the other at the left lower lobe, representing a double bronchial atresia. Note the compression of the adjacent parenchyma.

All of the patients were followed up without any specific intervention.

Discussion

Bronchial atresia is a congenital anomaly where the lumen of a bronchus is interrupted at or near its origin. The lung parenchyma that is to be supplied by the affected bronchus is usually emphysematous, non-compressible, non-inflamed, and minimally anthracotic because it does not communicate directly with the environment. Its size does not vary with respiratory movements and the arterial supply, while normal in configuration, is often attenuated. The air that exists in the affected parenchyma is the result of the collateral ventilation through the pores of Kohn, the bronchoalveolar channels of Lambert or via interbronchiolar channels. The process of hyperinflation may occur shortly after birth with the start of respiration, since the proposed pathways for collateral ventilation favour the movement of air into the obstructed segment by a check-valve type mechanism. These pathophysiological features are compatible with the findings on ventilation/perfusion scan and pulmonary angiography. At the root of the involved tissue, a mucus filled cystic structure (the mucocele) with finger-like projections represents the atretic bronchus, which is isolated from the proximal bronchial tree and is dilated by the accumulated mucus. Microscopic examination reveals that while no lumen unites the cyst with the proximal bronchus, rudimentary connections of thin, fibrous strands or membranes may be present. The mucocele is lined by normal respiratory epithelium of ciliated cuboidal or columnar cells and plentiful goblet cells. The submucosa is free of mucus glands. Cartilage with an abnormal configuration has occasionally been identified in the cyst wall [2, 3, 4,]. The bronchial pattern distally to the mucocele is usually normal; this suggests a late development of the atresia, occurring after the completion of bronchial development, i.e. after the 16th week of gestation. Nevertheless, the possibility of an early development of the anomaly at the time of the appearance of the segmental bronchi (i.e. at the 5th week of gestation) can not be excluded, since there is no clear answer to the question whether normal distal bronchial development can take place in the presence of abnormal proximal bronchi [2, 5, 6].

The pathogenesis of bronchial atresia remains unknown. Clements and Warner proposed a wheel theory to classify and explain all lung congenital anomalies (pulmonary malinosculations) [7]. According to the authors, the timing and severity of a non-specific injury on any component of the developing lung (airways, arterial supply etc), will determine the morphology of the consequent lesion. This is the base of the recent theory of the haphazard branching patterns, which suggests an independent and incidental occurrence of any dysmorphogenesis of the respiratory primordium and the pulmonary vessels [8]. The reduction, migration and selection theories (the main embryogenic

hypotheses for congenital bronchial abnormalities), could also give an explanation for the anomaly [9]. The pathogenic mechanism of congenital bronchial atresia that is widely accepted, is an "accident" to the nutrient artery of the bronchus that leads to ischaemia and atresia of the bronchus [2].

Bronchial atresia is usually diagnosed in the second or third decade of life. The precise prevalence of this entity is unknown because it is a rare congenital anomaly and the existing data come from the sporadic cases that have been previously reported. According to our data it can be estimated that the disorder has a prevalence of 1.2 cases per 100,000 in males.

We do not know any sex ratio but it seems that the anomaly is more frequent in men. Meng has reviewed 36 cases since 1978 and found a similar appearance of the disorder in both sexes (20:16) [3]. In a later review, in 1986, Jederling evaluated 86 cases, including the cases described by Meng, and a male predominance was found (55:31) [4].

It is possible that the prevalence of bronchial atresia in the general population may be underestimated since the disorder causes mild or no symptoms in the majority of cases. The insidious course of the disorder explains its late detection in some patients. Fusonie reported a 44-year-old female with bronchial atresia [10]. In our study we found a man of 57, which implies that not all the cases are diagnosed. The left upper lobe is the most frequently affected area (64%), a fact that was observed in our patients too. An explanation for this may be the recognition of the left upper lobe as an area of embryonic instability occurring late in development [4].

About half to two thirds of the reported patients had been asymptomatic before diagnosis. Recurrent pneumonia have been reported less frequently, which is surprising in view of the poor drainage of secretions from the affected areas. It seems from the reported cases, that the hyperlucent parenchyma, which corresponds to the atretic bronchus, and the adjacent normal lung areas (which may become compressed or displaced by the non-compressible, affected lung), may be susceptible to infections [2, 3, 4,]. Less reported symptoms have been dyspnea, cough and haemoptysis. Concurrent bronchial asthma has been described in some cases, but this coexistence is probably irrelevant [4, 11, 12]. Four of our patients had no symptoms before admission, three of them reported episodes of pneumonia in the past and one complained of mild dyspnea, which did not affect his daily life.

The decreased breathing sounds on auscultation above the affected area is the most frequently described clinical finding (60-71%) [3, 4]. It was found in only two of our patients, and this implies that the disorder can be easily missed on physical examination.

Pulmonary function tests are not considered particularly helpful for this disorder. In our patients functional studies were consistent with the mild clinical course of the disease.

On chest radiograph the typical findings of the mucocele vary, including a spherical or ovoid nodule, a linear or a mass like shadow, with or without the presence of an air fluid level, or a multilobular branching shadow. This shadow is close to the hilum, with well-defined margins, and usually forms the apex of a roughly triangular zone of hyperlucency of the lung parenchyma, which is due to oligemia and overinflation. Air trapping with contralateral displacement of the mediastinal structures is more profound on expiratory films. The synchronous appearance of both the mucocele, as described above, and the lung hyperlucency, on the same radiograph, is not always visible (69%) [4].

Computed tomography (CT) of the chest has now replaced bronchography and conventional tomography for the diagnosis of bronchial atresia. CT can display exquisitely the characteristic features of the mucocele and is more sensitive for the demonstration of the oligemia and the hyperinflation of the lung parenchyma. In our group of patients, the CT revealed the branching shadow of the mucocele in cases where it was not evident on the conventional chest radiograph. Chest CT, especially using high resolution technique (HRCT), can also depict the reduced size of the pulmonary vessels better than the conventional chest radiograph [12, 13].

Spiral CT has the quality to scan a complete three-dimensional area of the lung, providing excellent multiplanar reformation (MPR). It permits a full and correct evaluation of the tracheobronchial tree malformations, as well as its associated anomalies and has been proposed as the preferable technique for the study of these disorders [14]. In case 7, spiral CT revealed excellent images of the extremely rare condition of a second concurrent congenital bronchial atresia at the same lung. For the moment, this advanced technique is not available in most hospitals and conventional CT remains the procedure of choice for the diagnosis and study of congenital bronchial atresia.

Bronchoscopy and bronchography would appear to be rational choices for the diagnosis of bronchial atresia since they could reveal the closed bronchus. However, this has not been proven in the existing literature. Bronchography has been currently abandoned in most centres, and even when it was in use, it was not diagnostic in all cases. Bronchoscopy may identify a blind-ending bronchus, but it may be normal as well. In clinical practice however, any absence of a segmental or sub-segmental bronchus that is found by chance during bronchoscopy, in the absence of the characteristic radiographic features, is considered as a normal anatomic variance of the bronchial tree rather than a bronchial atresia. From this point of view, congenital bronchial atresia remains a radiological diagnosis, in cases where surgical excision is not performed and the involved lung parenchyma is not examined histologically.

The other tests such as pulmonary angiography or ventilation – perfusion scans show a lung area of reduced perfusion and ventilation. They are usu-

ally unnecessary for the diagnosis, time-consuming and expensive. They are useful in the evaluation of other causes of pulmonary oligemia.

Magnetic resonance imaging can display the mucocele as a branching structure radiating from the hilum that is hyper-intense on T1 and T2 weighted images. It might be possible that some cases of bronchial atresia may reveal different combinations of signal intension than that observed in our case, since the intension is related to the protein concentration of the mucocele, which may vary from case to case. However, MRI can not reveal the pulmonary oligemia and hyperinflation distally to the atresia [15]. The only reason to perform an MRI on these patients is to display arteriovenous malformations of the lung.

Recently, the possibility of early detection of congenital bronchial atresia by fetal ultrasonography, has been reported [16].

Bronchial atresia must be differentiated from other causes of pulmonary oligemia and/or mass-like shadows presenting close to the hilae, such as Swyer-James syndrome, pulmonary artery agenesis, congenital lobar emphysema, scimitar syndrome, large bullae, congenital bronchial cysts, intralobar bronchopulmonary sequestration, arteriovenous malformations, pulmonary embolism, and bronchial stenosis by enlarge lymph nodes, endobronchial tumors or foreign bodies [17]. In most of these disorders, the clinical evaluation combined with simple tests such as chest radiograph and CT scan, can lead to the correct diagnosis [4, 5, 18, 19].

Another condition that may mimic mucocele on chest radiograph is the bronchial mucus impaction in allergic bronchopulmonary aspergillosis, but this entity has a distinct clinical picture and well-defined diagnostic criteria [20].

There is growing evidence that congenital bronchial atresia can be diagnosed only by a chest CT. The pathognomonic findings are the presence of mucocele, the occlusion of bronchi central to mucocele and emphysematous changes of the peripheral lung fields [21]. Felson found that other conditions, such as bronchial or metastatic carcinomas, bronchial adenomas, tuberculosis, broncholithiasis, intralobar sequestrations and intrapulmonary bronchogenic cysts can also produce a mucocele. However, the radiographic sign of pulmonary hyperaeration was only evident in congenital bronchial atresias, pulmonary sequestrations and bronchogenic cysts [22]. Nevertheless, the combination of both signs, mucoid impaction and peripheral lung hyperaeration, can not definitely exclude other conditions, such as bronchial adenoma or carcinoma [23, 24]. The role of bronchoscopy in such cases is to exclude these disorders and demonstrate the patency of central bronchi. It is a simple, well-tolerated and low risk procedure and is still recommended for the workup of congenital bronchial atresia, particularly in less typical cases [12, 25].

Therapy for bronchial atresia is considered when the patient is symptomatic or there are complications as a result of the anomaly. Surgical segmentectomy or lobectomy is the preferred procedure. There is a tendency to operate even the asymptomatic cases when they are found in childhood, in order to prevent the inhibition of development of the normal lung by the hyperinflated lung. We believe that some of these operations were performed in the past because the surgeons were not familiar with this condition [3, 4, 5, 11]. In our series none of our patients were clinically affected to such a degree that could justify surgical treatment. Asymptomatic adults should be left untreated, due to the benign nature of the disorder.

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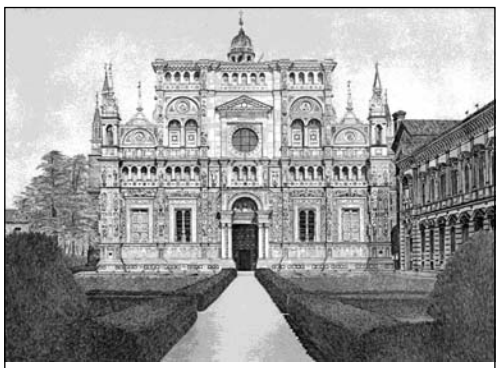

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