CONTRIBUTION OF BRONCHOSCOPIC EXAMINATION IN DIAGNOSIS OF CONGENITAL TRACHEO-BRONCHO-PULMONARY MALFORMATIONS

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Abstract: Diagnosis of congenital malformations of the trachea, bronchi and lung is often a stumbling block, even for experienced clinicians, given the rarity of some anomalies, many clinical masks and the complexity of investigational methods required to confirm such conditions. In current practice of an adult respiratory medicine service, in the congenital lung pathology, most often, physicians can meet cases of: pulmonary hypoplasia, intralobar pulmonary sequestration, tracheal strictures, abnormal division of the airways, air cysts, and rarely congenital lobar emphysema and pulmonary agenesis. Many of these malformations are discovered in newborn or infant, because of pulmonary and cardiovascular complications and frequent combination with other congenital anomalies. So, these anomalies should be included in differential diagnosis of lung or mediastinal disease, especially in young adult. No doubt, bronchoscopy is one of the basic tracks in the diagnosis of these malformations. Some are correctable if promptly recognized, others are incompatible with life, while probably the majority are symptomless, appearing as incidental findings at routine medical, surgical or post-mortem examination. Non-recognition of this lung disease group in current medical practice can lead to serious diagnostic errors. Basic concepts are presented in diagnosis of major malformations of trachea, bronchi and lung encountered in current medical practice and some examples of bronchoscopic aspects as experienced in several respiratory medicine services are given.
Keywords: malformations of the trachea, bronchi and lung, bronchoscopy, pulmonary practice

INTRODUCTION

Congenital lung malformations are a delicate chapter, without more holistic approach in the literature. Particularities of lung malformations are correlated with respiratory development stages.

Many of these malformations are discovered in newborn or infant, because of pulmonary and cardiovascular complications and frequent combination with other congenital anomalies. So, these anomalies should be included in differential diagnosis of lung or mediastinal disease, especially in young adult [1].

Etiological spectrum of lung malformations has seen many catalogings either by their origin during embryological development process either by anatomic structure involvement, etc. [2, 3]. Hereby we choose two variants, the most practical considered as clinical classification of these conditions:

Classification of congenital lung abnormalities devoted to Romanian literature [2,3]:

I. Fissure and bronchial anomalies and variations:
- Fissure and fissure variations
- Variations of bronchial division
- Tracheal bronchus
- Bronchial stenosis
- Tracheal dilation

II. Certain congenital – malformations of bronchi and lung:
- Pulmonary agenesis
- Pulmonary hypoplasia
- Pulmonary sequestration

III. Questionable – congenital malformations of bronchi and lung:
- Congenital lobar emphysema
- Giant bullous emphysema
- Hamartocondromas
- Airway cysts

Classification of congenital lung abnormalities - by Hollinger and Johnston [1]:

I. Anomalies of the trachea
A) Constrictions and enlargements: cartilage deformity, anomalous vascular compression, webs
B) Evaginations and outgrowths: tracheoceles, diverticulums, cysts, fistulae, tracheal lung
C) Abnormal bifurcation or deviation of trachea
II. Anomalies of bronchi and lungs
A) Agenesis and atresia
B) Constrictions and enlargements, webs, compression due to cardiovascular anomalies
C) Evaginations or outgrowths: bronchoceles, diverticulums, cysts and emphysematous lobes, fistulae
D) Sub numerous bronchi, lobes, fissures
E) Supernumerary bronchi, lobes, fissures
F) Anomalous bronchial and lung tissue attached to respiratory system.
G) Anomalous bronchial and lung tissue attached to tissue other than respiratory system.
H) Other gross anomalies - situs inversus.

Bronchoscopy is one of the most important investigations useful in the diagnosis of tracheo-broncho-pulmonary malformations, so we focus on endoscopic aspects described in these conditions.

As we make a review of the main entities of this group of diseases, we will exemplify some of these conditions with clinical cases from current pneumology practice.

1. Congenital agenesis of the trachea is a rare disease, almost incompatible with any life. It may occur alone or with other associated anomalies: broncho-esophageal fistula, renal defects, vertebral, radial, anal atresia and cardiac anomalies, due to a defective development from the foregut during the third and fourth weeks of gestation. Clinical features that might indicate tracheal agenesis include antenatal polyhydramnios, severe respiratory distress, absence of an audible cry, failure to advance an endotracheal tube beyond the larynx, a palpable distal trachea, clinical improvement after esophageal intubation, and radiological absence of a tracheal air column with an abnormal position of the carina [4].

Bronchoscopy will often reveal normal epiglottis and vocal cords, but total absence of the trachea. There are several forms of agenesis of the trachea: in type I there is a short segment of distal trachea arising from the esophagus, type II, the carina may be identified with a barely visible segment of trachea attached to the esophagus and in type III, the trachea is absent, and bilateral main bronchi communicate directly with the esophagus. Survival is short, about 6 weeks after surgical treatment and emergency tracheotomy is salutary, if one cannot provide ventilation through esophageal intubation [5,6].

2. Tracheomalacia is a condition of the neonatal and infant airway characterized by weakness of the supporting tracheal cartilage and widening of the posterior membranous. It appears to incomplete developping cartilage rings (rings fragmented - eliptical forms, the absence of rings) or occurs after surgery for compressive tracheal disease (tumor or vascular rings) [7].

Together, these factors cause tracheal collapse especially during times of increased airflow, such as coughing, crying, or feeding. Tracheomalacia most commonly affects the distal one-third of the trachea and can be associated with a variety of congenital anomalies including cardiovascular defects, developmental delay, gastro-esophageal reflux, and tracheoesophageal fistula. Such disease is defined as the collapse of at least 50% of the airway lumen under conditions of expiration, coughing or breathing spontaneously or report of cartilage/membranous tracheal wall of <3:1 [8].

Bronchoscopy reveals a large trachea, transverse diameter of 40-45 mm

and various aspects of the mucosa, atrophied areas alternating with hypertrophic, inflammatory areas and transversal folds or tracheal diverticulum with stagnant consistent secretions. The classic triad consists of loss of the normal semicircular shape of the tracheal lumen, forward ballooning of the posterior membranous wall and anterior-posterior narrowing of the tracheal lumen [9].

3. Tracheal strictures – the most common tracheal anomalies appear as deformed folds or a fusiform stenosis, absence of the membranous portion of trachea. It may accompany an esophageal atresia, tracheo-esophageal fistulas or cardiovascular abnormalities: a large vessel or heart may compress the trachea during embryonic development. Symptoms may occur: respiratory failure, dyspnoea, stridor, recurrent chest infections. Bronchoscopic examination recognizes these changes and allows inspection of modified cartilage, or of the area of stenosis. Possible therapeutic intervention in order to repair the tracheal wall can be done by bronchoscope, but sometimes it may precipitate the existing obstruction [3].

4. Tracheoesophageal fistulas are rare anomalies that develop as a result of a barrier in embryonic development.

Two varieties are known:

- *Tracheoesophageal fistula with esophageal atresia*, in which a portion of the middle esophagus is absent anteriorly to the carina and abnormal esophageal tips communicate with the trachea. These abnormalities are present at birth and determine salivation, thick oro-pharyngeal secretions, cough, dyspnoea and cyanosis

- *Tracheoesophageal fistula without esophageal atresia* are small, located in the cervical portion, and bronchoscopic diagnosis can be difficult. Recurrent pulmonary infections may occur frequently in the right upper lobe (3.9).

5. Congenital absence of tracheal cartilage causes dyspnoea, inspiratory stridor, specific cry and recurrent episodes of pulmonary infection. Bronchoscopic inspection to a newborn will confirm the diagnosis (1).

6. Tracheal diverticulum, tracheoceles – can develop from tracheal buds or accessories lobes [1]. Diverticulums are usually located on dorsal right side of the trachea. Diagnosis is based on bronchoscopic examination and eventually tracheography.

7. Abnormal tracheal bifurcation and deviations

In a routine bronchoscopic examination it is shown that the right main bronchi emerge from the medial wall of the left bronchus opposite the orifice of the left upper lobe. This bronchus, called "bridging bronchus" has smaller sizes with differences of caliber because of vicinity vascular compressions.

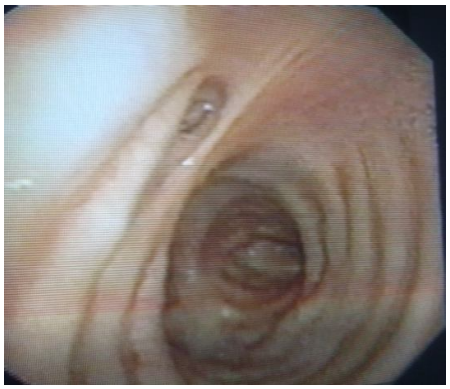

Fig. 1. Bridging bronchus (3).

Sometimes, both right and left upper bronchi originate directly from the trachea, and both lungs will have three lobes [1].

8. Abnormalities of bronchial division

These anomalies are the result of bronchial division in the development of pulmonary disorders involving either an inadequate number of lung buds or the fact that they are detached from a different level than normal [10].

Most frequently, such anomalies are encountered on the right side and the most common clinical forms are revealed by careful bronchoscopic examination as tracheal bronchus or segmental supernumerary right upper bronchus [11].

They are grouped as follows:

- Supernumerary lobar or segmental bronchi – accessory cardiac bronchus - arising from the inner wall of the right main bronchus or intermediate bronchus opposite to the origin of the right upper lobe bronchus;
- Abnormal origin of lobar or segmental bronchi – right tracheal bronchus (tracheal origin of right upper lobar bronchus);
- Bronchial isomerism (*mirrored-lung)*, dextro-isomerism (with 3 lobes on each side), bronchial levo-isomerism;
- Supernumerary bronchi - origin in the lower wall of the right main bronchus or in the intermediate bronchus.

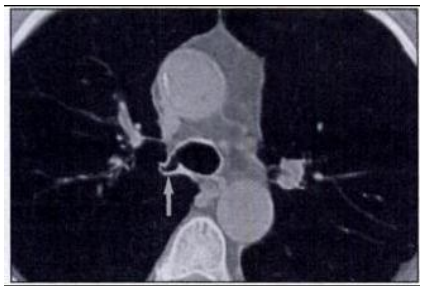

Fig. 2. Axillary bronchus – CT aspects (3).

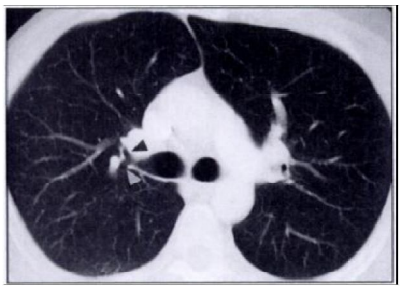

Fig. 3. Tracheal bronchus – CT aspects (3).

Tracheal bronchus is an aberrant bronchus arising mostly from the right lateral wall of the trachea, and supplies either a segment of the right upper lobe or the whole right upper lobe (Fig. 4).

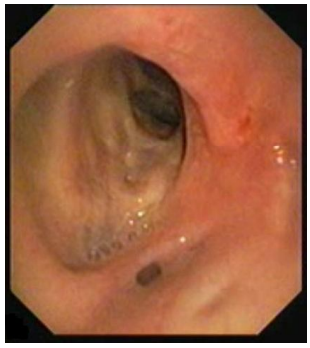

Fig. 4. Tracheal bronchus – bronchoscopic aspects – Clinic of Pulmonary Diseases Iasi.

This condition usually is an incidental finding during bronchoscopy performed for other indications, with non-specific clinical picture [1]. With a length of 0.5-3.5 cm and a maximum size of 1 cm, it is often divided into 2-3 other smaller

branches. Tracheal bronchus has been described also in association with other congenital anomalies in the VACTERL syndrome (an acronym reuniting the vertebral defects, eso-tracheal fistulas, anal atresia, radial and renal anomalies, cardiovascular anomalies) [12].

9. The mirrored lung (bronchial isomerism) anomaly is described endoscopically as a symmetric bronchial branching in both lungs and it is often accompanied by vascular abnormalities. There are two types: left type - most commonly both lungs have two lobes and the right type, more rare, to contain three lobes, bilaterally.

Coexistence of congenital arterial anomalies (pulmonary artery as a double system: right upper lobe and external segments of lower lobe are served from pulmonary artery and the basal and medial segments from branches of aorta) and venous abnormalities (partial abnormal venous return in inferior cave vein and azygos vein), this type of anomaly is accompanied by coughing, dyspnoea and cyanosis as a result of arterio-venous shunt and hematosis disorders. Additional tests are required for confirmation of diagnosis (thoracic CT, etc.) [1, 3].

10. Congenital bronchial stenosis

This condition has loud symptoms (cough, dyspnoea, cyanosis) that start at birth and increase by efforts. There are two types:

- *intrinsic stenosis*: membranous diaphragms crossing the tracheal lumen which is reduced accordingly. Bronchoscopies highlights the barrier and may help to resolve it;
- *extrinsic stenosis:* due to external compression, most often determine vascular, respiratory symptoms. In addition to the above, dysphagia, regurgitations, syncope or tachycardia are added, depending on adjacent organ involved (2).

11. Eso-bronchial fistulas are bronchoscopic findings particulary observed when left primitive bronchial stenosis associated. Such anomalies are more rare than eso-tracheal fistulas [2].

12. Bronchial atresia associated with mucous cysts

This is a rare congenital abnormality associated with regional hyperinflation of the airways, bronchial mucous cysts, and sometimes paranasal sinus mucous cysts developed by sinus obstruction. Bronchial atresia is often asymptomatic. The most frequently affected is the dorso-apical bronchus of the left upper lobe. It can be revealed by dyspnoea or more frequent respiratory infections and it can be accidentally discovered by radiological hypertransparency persising during expiration. Also, juxtahilar linear opacities, ovalare or divised are seen and sometimes cysts (mucous cysts). Bronchoscopy confirm diagnosis in young adults [3].

13. Pulmonary agenesis

Unilateral pulmonary agenesis is a rare condition, which may accompany other abnormalities of the muscle, cardiovascular, gastrointestinal and urogenital system. Rarely diagnosed in adults – usually when it is not associated with other malformations, this is a finding of childhood or neonatal period and consists of total absence of carina, the primitive bronchial, pulmonary and vascular tissue for these structures [13].

Bilateral pulmonary agenesis, a very rare entity, is absolutely incompatible with any survival [14].

Chest x-ray appearance is relevant: no shadow of lungs or trachea and its mediastinum deviation, narrow intercostal spaces to a hemithorax, while there is a hyperinflation and widening controlateral intercostal spaces – compensatory (Fig. 5). Laborious investigations, such as pulmonary angiography, chest computed tomography or nuclear magnetic resonance

will confirm the diagnosis. Bronchoscopic examination reveals the trachea located in continuation of primitive bronchus and the absence of carina. Also are described airway oriffices belonging to bronchi in the controlateral lung, with a posterior and lateral deviated trajectory most frequently [13].

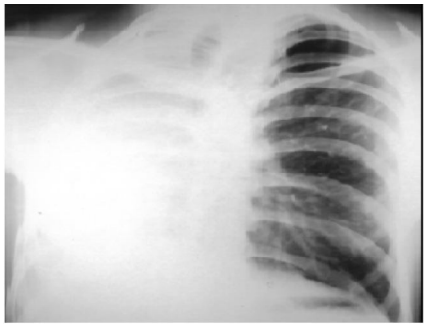

Fig. 5. Radiological aspect of right pulmonary agenesis (3)

14. Pulmonary hypoplasia

The so-called "small congenital lung" or "underdeveloped lung", is the most common broncho-pulmonary malformation with a certified congenital origin and among the few malformations compatible with a normal life to old ages [15,16]. Rarely diagnosed in practice (0.05-0.18% of broncho-pulmonary malformations and 0.02-0.03% of the general malformations), pulmonary hypoplasia (PH) can be a primary condition, by way of intrinsec defect of lung development, or a secondary one, grouped together with other congenital anomalies.

The diagnosis of pulmonary hypoplasia is suggested by medical history (reccurent episodes of pulmonary suppuration in childhood with a constant radiologic topography).

Chest x-ray shows thoracic asymmetry, the sick hemithorax is of small volume, with horizontalised ribs; the hemidiaphragm and the "lung" is represented by a homogeneous opacity with cystic cavities and clear areas, while the controlateral healthy lung is compensatory hypertrophied (Fig. 6).

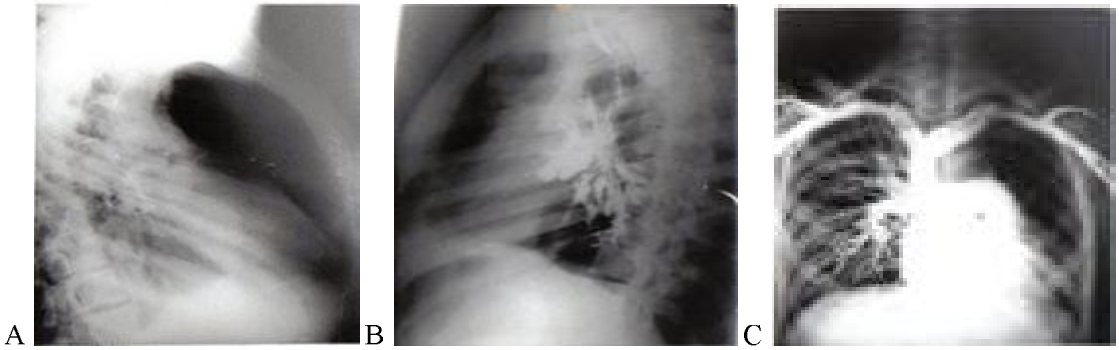

Fig. 6. Pulmonary hypoplasia (PH) - Clinic of Pulmonary Diseases Iasi: A. Radiologic aspect: Right pulmonary hypoplasia; B. Bronchography: Left pulmonary hypoplasia; C. Angiographyc aspect: Left pulmonary hypoplasia

The profile chest X-ray in Figure 6 shows the retrosternal and retrocardiac herniation of the controlateral lung.

Bronchoscopic examination reveals the deviation of the trachea towards the ill part, carina rotating around the tracheal axis, and the bronchi of the hypoplastic lung as small, atrophic, cystic processed structures.The whole malformated bronchial tree is posteriorly moved. The controlateral lung is hypertrophied, with changes in bronchial topography, subsequent to the hernia through the weak spots of the mediastinum that remained unoccupied, due to the affected hemithorax. Modern imaging examinations (thoracic CT, MRI) provide additional details concerning the absence of pulmonary circulation in the underdevelopded lung and the hypervascularization of the healthy lung, complementing the diagnostic picture of this rare clinical condition [15,16].

Depending on the involved lung territory, there are bilateral PH (severe, with poor survival), total unilateral PH (affecting one lung) and partial PH (lobar, bilobare and segmental hypoplastic territory).

15. Pulmonary sequestrations

Pulmonary sequestrations comprise a complex of broncho-pulmonary-vascular-phrenic-digestive anomalies and are classified into intralobar types (more common in older children and adults, usually independent of other abnormalities) and extralobar (other malformations associated in 65% of cases, most commonly found in newborn, infant) [17]. Sequestration is individualized as a non-functional lung tissue, which is unrelated to the bronchial tree and pulmonary arteries. It has arterial vascularization derivated from systemic circulation – usually branch of abdominal aorta, and venous drainage is into either pulmonary or inferior cava vein, azygos system eventually.

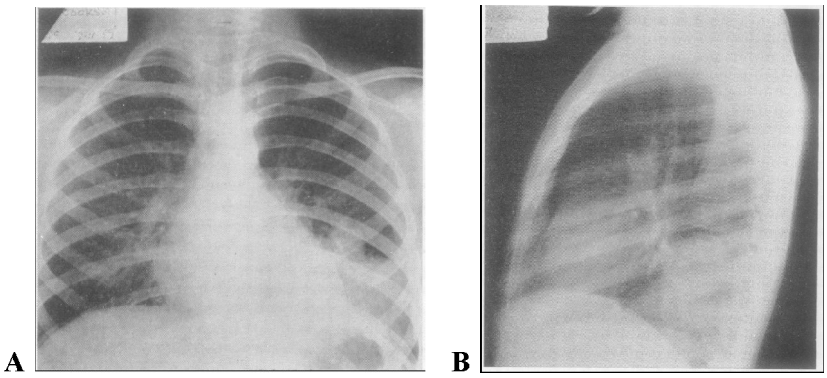

Fig. 7. Chest X-ray appearance of an extralobar sequestration (3):

A. Standard thoracic radiography; B. Left profile thoracic radiography

Whether extralobar sequestrations (Fig.7A, B) - basal opacity in contact with the diafragm, separated by lung paranchyma, with own pleural covering and a positive Doppler systemic circulation, or intralobar sequestrations – often associated with a lung following infection, abnormal tissue which is contiguous with the lung parenchyma,

pleural covering being common - these common aspects facilitate diagnosis:

- systemic vascularisation present in a normal lung, usually inferior lobes;
- coexistence of other anomalies;
- no connection of the abnormal mass of tissue with bronchial tree and pulmonary arteries [18].

The contribution of bronchoscopic diagnosis in useful in the context of related extensive explorations such as: angiography, MRI, thoracic computed tomography.

16. Airway cysts are of several categories, not all of congenital origin.

Besides parenchymal cysts, also called emphysema bubbles and pneumatoceles, all cystic structures of acquired cause - except giant bullous emphysema - bronchogenic cysts are also described. It can develop intrapulmonary (in this case development defect occured early during embryogenesis) or mediastinally. Intrapulmonary cysts have respiratory epithelium and contain about two thirds of air content, the rest being eventually clear or a mucoid secretory material. So, cysts have endoscopic bronchial expression, whereas it communicate or not with the bronchial tree. Chest x-ray shows opaque ovalare structures, containing air, solid, or fluid level, thin walled, fine, regular, uniloculate, and frequently located in the lower lung lobes [14].

17. Diffuse congenital cystic disease of the newborn is a rare disease and it is known under different names: fetal cystic bronchial adenoma, idiopathic diffuse bronchiestasis, congenital lobar emphysema, congenital pulmonary lymphangiectasia, adenomatous congenital cystis malformation of the lung, congenital hamartoma.

At bronchoscopy, polypoid structures of the mucosa of small bronchi and bronchioles, developed from a cystic parenchyma, can be seen. Increased proportion of elastic tissue in bronchus and small bronchi wall cystic dilated structures are described. Pulmonary alveoli covered with mucus-producing cells are also frequent [3, 19].

CONCLUSIONS

Diagnosis of congenital malformations of the trachea, bronchi and lung is often a stumbling block, even for experienced clinicians, given the rarity of some anomalies, many clinical masks and the complexity of investigational methods required to confirm these conditions. No doubt, bronchoscopy is one of the basic tracks in the diagnosis of these malformations. Some are correctable if promptly recognized, others are incompatible with any life, while probably the majority are symptomless, appearing as incidental findings at routine medical, surgical or post-mortem examination. Non-recognition of this congenital category of disease in current medical practice can lead to serious diagnostic errors.

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