Computerized Tomography of Thoracic Pathologies in the Pediatric Age Group: Pictorial Essay

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ABSTRACT

Aim of the study. The purpose of this study is to illustrate the imaging findings of the lung parenchyma and the thoracic wall pathologies in pediatric age group using Standard (CT) and High-Resolution Computed Tomography (HRCT). Results and discussion. We discuss and illustrate the following: Pleural hematoma, Pulmonary Contusion, Histiocytosis X, Tuberculosis, Right sided arcus aortae, Pectus excavatum, Operated Pectus excavatum, Morgagni hernia, Pleurisy, Right middle lobe syndrome, Pneumonia, Hydatid Cyst, Takayasu arteritis, Kartagener syndrome, Bronchiectasis, Bronchiolitis obliterans organizing pneumonia, and Osteomyelitis. We also discuss the diagnosis clues.

Key words: Pediatric Thoracic Diseases, Pediatric Tomography.

Even though chest X-ray is still the predominant first imaging test used to diagnose in pediatric cases, higher resolution anatomical detail, density measurements, and lesion characterization using contrast patterns makes CT a valuable diagnosis tool in diagnostics of parenchymal and chest wall diseases.

In this pictorial essay, we share our experience with 45 pediatric patients from 1 to 16 years old who are referred by Pediatric Medicine and Surgery Clinics to have their thoracic Standard and High-Resolution Computed Tomography (Somatom Emotion Duo Multislice CT, Siemens, Germany) images taken. 19 of our patients were admitted with Pneumonia, 5 with Tuberculosis or Bronchiectasis, 3 with Pleurisy, while Pleural Hematoma, Histiocytosis X, Right Arcus Aorta, Pectus Excavatum, Operated Pectus Excavatum, Morgagni’s Hernia, Right Middle Lobe Syndrome, Hydatid Cyst, Takayasu Arteritis, Kartagener Syndrome, Bronchiolitis Obliterans Organizing Pneumonia, Pulmonary Contusion, and Osteomyelitis are all only seen on 1 patient.

1. CONGENITAL DISORDERS

   Right Arcus Aorta: The most common arcus aorta anomaly, besides right arcus aorta with left subclavian artery and aberrant right subclavian artery with left arcus, and double arcus and cervical arcus aorta, is the Right-Sided Aortic Arch (1). Right arcus aorta in adults is considered asymptomatic (2), and in the case of tracheal or esophageal pressure, it could cause difficulty in breathing and dysphagia (3). Right arcus aorta can easily be diagnosed with chest X-ray. However, Computed-Tomography (CT) and Magnetic Resonance Imaging (MRI) both can reveal the anomalies related to right arcus aorta (Figure 1).

   Pectus excavatum: Pectus excavatum is the most common chest wall deformity. The sternal and lower costal cartilage collapsing backwards affect either lower half or two thirds of the sternum. Deformation angle of the lateral parts is larger than upper and lower parts. Symptoms rarely occur during early childhood and show themselves during early adulthood when the child experiences fatigue easily playing sports. Deformity in medium and higher degrees is more obvious since the heart is pushed towards left. The strength of pectus deformation can be measured with Haller Index, which is the ratio of the distance of the inside rib cage to the distance between the vertebras and sternum. A normal Haller index is around 2.5, while between 2.5 and 3.2 is considered medium, and above 3.2 is very high deformity. Both of our patients indices are bigger than 3.2 (Figures 2 and 3). A less invasive Nuss procedure is developed over the years to replace costal cartilage resection and sparing. Our patients have undergone this procedure and have their sternum elevated using a retrosternal bar.

   Morgagni’s Hernia: Diaphragm hernias are separated into two groups: congenital and acquired. Congenital hernias occur through embryologic defects and include Bouchdalek’s, Morgagni’s, and esophagus hernias while most of the acquired hernias are traumatic. Morgagni’s hernia is a very rare form of congenital anomaly, and can also be called anterior parasternal or...
retrosternal diaphragmatic hernia. It occurs due to congenital defects stemming from the sternum and costal elements of the crus of diaphragm not developing properly (4). Large proportion of the cases occurs on the right side, and it is mostly seen in girls than boys (5). Posteroanterior (PA) radiograph reveals either localized intestinal loops with equal air-fluid ratio at cardiophrenic angle or omentum fat tissue. CT can show the herniated organs at thoracic cavity in detail (Figure 4). Paraesophageal hernia occurs when fundus herniates to the thoracic cavity through pneumothoracic recess to the right of esophagus hiatus. Diaphragmatic hernias are sliding when gastroesophageal junction protrudes through the diaphragm. Bochdalek hernia is a congenital defect where intra-abdominal organs protrude into the thoracic cavity through a posterior defect (6). Blunt and penetrating traumas cause diaphragm hernias.

2. INFECTIOUS DISEASES AND TUBERCULOSIS

Pleurisy: Pleurisy is the inflammation of the membrane pleura that covers lungs. This inflammation looks parabolical in PA or lateral decubitus radiographs, and it causes an increase in diffuse opacity at hemithorax when AP (antero-posterior) radiograph is taken in supine position. It typically looks like a half moon or meniscoid shape in cross-sectional scan (Figure 5). Large amount of fluid causes passive atelectasis in adjacent lung parenchyma due to pressure on the lung (Figure 6).

Right Middle Lobe Syndrome: Right middle lobe syndrome is characterized by the atelectasis of the right middle lobe of the lung. It can be caused by extraluminal or intraluminal etiologies although it can also be seen when the lobar bronchi is open with no obstruction (Figure 7). This syndrome is reported as the pulmonary manifestation of the primary Sjogren's syndrome (7). Middle lobe syndrome is seen in children with history of asthma or atopy. Since it has no specific clinical definitions, it is best to visualize it radiological imaging to help with the diagnosis. Most patients report a history of persistent cough, intermittent wheezing, dyspnea, recurrent lung infection, and asthma or atopy. Poor collateral ventilation leads to atelectasis at right middle lobe and left lingual at the same time. Treatment is primarily determined by etiology and patients often respond to therapy. Although PA and chest X-rays are still used in diagnosis stage, CT is becoming the preferred imaging diagnosis method by doctors.

Tuberculosis: Tuberculosis (TB) is caused by inhalation of air droplets that contain the bacteria: Mycobacterium tuberculosis or Mycobacterium bovis. In primary TB disease, a person is not aware of the infection since there are no noticeable symptoms. In children, it is characterized by the swelling and parenchymal lesions in hilar and mediastinal or cervical lymph nodes. Its most frequent complication, lobar or segmental atelectasis, is seen in children under 2 years old. Absence of parenchymal lesions on chest radiographs of children does not necessarily mean the TB is not there. Here CT is especially useful to reveal the mediastinal lymph nodes. Parenchymal lesion can heal without leaving any sequel in primary TB. One third of the patients may have fibrous tissue and 15-17% may have calcified residue (Ghon focus) left. Some patients may have caseification in primary focus and lymph nodes. Caseification heals...
with calcification and becomes a calcified nodule. Tuberculosis granuloma is an oval shaped granuloma that is encased by a fibrous capsule and has acid resistant bacilli. It can be a symptom of both primary and secondary TB. Secondary TB is due to reinfection of the old lesions or gradual progression of primary TB. The lesions spread to apical and posterior segments of upper lobes and superior segment of lower lobe. It is characterized by disorderly nodular lesions with loose boundaries or homogeneous/patched consolidations (Figures 8-10). A cavity may exist in this non-homogenous consolidated area. The cavern walls may initially be thick and random, but transforms into thin and orderly contours. The presence of air-liquid levels is a sign of either abscess or secondary infection.

**Pneumonia:** Pneumonia is an inflammation of lung parenchyma. This inflammation is mostly due to infectious factors and is rarely due to physical and chemical factors. Basic clinical symptoms include cough, fatigue, chest pain, fever, and shaking chills. Alveolar or lobar pneumonia is characterized by an increase in homogeneous intensity profile of a lobe or segment in a radiograph (Figures 11-14). Air bronchogram is also visible. Interstitial pneumonia (viral or mycoplasma pneumonia) refers to inflammation of the lung interstitium. Atelectasis, peribronchial density increase and thickening, hilar lymphadenopathy, and interstitial thickening are observed. In mixed type pneumonia (Staphylococcus pneumonia and bronchopneumonia), both interstitial tissue and pleura of the lungs are affected. Mixed type is characterized by segmental and patchy consolidations.
Volume loss, parapneumonic effusion, empyema, and cavity formation inside consolidated areas are very common. Aspiration pneumonia is due to aspiration of colonized oropharyngeal. If the patients are in supine position, the material is likely to build up in the upper lobes and in superior segment of lower lobes. If they are in upright position, the material is usually accumulated in both lower lobes. Patchy consolidations are observed at lower lobe superior and basal segments (Fig. 15).

Hydatid Cyst: Hydatid Cyst is a parasitic disease caused by larvae forms of Echinococcus granulosus living in the carnivore’s small intestines. It is still common to see this disease in some parts of Turkey. Although liver is the most common organ involved, lungs follow after. Due to sponge-like texture of the lungs, this parasitic infestation may become much larger in size and reveal early symptoms. In children, lungs are the primary location. Non-complicated cysts are seen as oval or multilobular shapes with their contours in order, and look like homogeneous nodular lesions or in bulk form in PA lung radiography. Complicated cysts may not be differentiated from other fluid-filled cysts and abscess. CT shows the wall thickness of intact Hydatid cysts in 1mm to 1cm range, while its density is close to water. CT also clearly reveals the connection of bronchial tree with the cyst (Fig. 16).

3. DISEASES WITH NO ETIOLOGY

Histiocytosis X: Histiocytosis X is common among young smoking males, and is characterized by accumulation of atypical histiocytes. In the presence of fever, it resembles miliary tuberculosis, invasive fungal infections, and viral pneumonia. Radiograph may show diffuse symmetric reticules and reticulonodular lesions at upper and middle zones. Nodules have ambiguous boundaries. 1-15% of the cases have cystic lesions and honeycomb lung. Small sized lesions may cause destruction to parenchyma, and form bulous emphysema. Although pathological investigations and CT present cavity formation at nodular lesions and necrosis, it is hard to distinguish these in regular chest radiograph. CT scans demonstrate 3-10 mm pulmonary nodules, thin walled cysts, cavity nodules, and ground glass attenuation pictures in the lung parenchyma (Figure 17). Honeycomb appearance is detected in advanced stages. Most important symptom in HRCT is observation of cystic and nodular lesions combined together. The cystic lesion walls are as thin as 1-5 mm. Additional symptoms shown in HRCT are intermediate surface disorder and ground glass attenuation. Cystic lesions’ thin walls are a significant differentiating factor from emphysema. Even though cystic lesions are seen in lymphangioleiomyomatosis, nodular lesions are not present. Both Histio-
Kartagener syndrome: Kartagener syndrome is characterized by combination of the three: situs inversus, bronchiectasis and sinusitis (11). Electron microscopy shows abnormalities at epithelial cilia, microtubules, and radial spokes (12). CT scans show thoracic and abdominal situs inversus, bronchiectasis, sinus hypoplasia and mucosal thickening (Figure 19).

Bronchiectasis: Bronchiectasis is the irreversible widening or dilation of larger than 2mm in diameter bronchioli. Major causes are cystic fibrosis, early childhood viral infections, allergic bronchopulmonary aspergillosis, and pulmonary fibrosis. First diagnostic criterion on CT scans is the wider bronchial tubes with respect to pulmonary arteries. Other criteria include bronchioles being parallel to bronchial wall instead of branching into distal, and observation of bronchioles inside 1cm lung parenchyma neighboring costal pleura. A Bronchoarterial ratio of 1.5 is a reliable symptom of Bronchiectasis. If it is in the range 1-1.5, this should either be seen in few airways or bronchioles are still visible after getting smaller and do not terminate. Bronchial wall thickening is also another symptom. Bronchiectasis, according to Reid classification, is divided into three: cylindrical, varicose and cystic bronchiectasis (13). In cylindrical bronchiectasis CT scans, signet-ring appearance and bronchi being seen as parallel lines are common. In varicose bronchiectasis, bronchial cross section is seen as pattern of nodules when they are perpendicular to the CT scan plane. Cystic bronchiectasis is when the transverse bronchial diameter is greater than 1cm. Its final diagnosis is with HRCT (Figure 20).

BOOP: Bronchiolitis obliterans is characterized by obstruction of alveoli and bronchi with granulation/ fibrosis tissue or inflammation. Its causes may be viral infections and connective tissue disorders as well as exposure to toxic gases, and is also associated with chronic graft-versus-host disease (cGVHD). CT scans show low attenuation areas and lung tissue with lower vascularity com-
pared to normal one. Since abnormal symptoms occur during expiration, expiratory HRCT is very useful. Bronchialitis obliterans organizing pneumonia (BOOP) is also recognized as cryptogenic organizing pneumonia (COP). BOOP results in obstruction of bronchi and alveolar ducts with polypoid granulation tissue. Mononuclear cells and macrophages infiltrate the airways. CT scans reveal multiple peripheral consolidations areas and ground glass attenuation, and sometimes bronchial wall thickening and dilation (14) (Figure 20).

**Thoracic Traumas**

**Pleural Hematoma:** Pleural Hematoma is not clear on the chest radiograph taken right after blunt trauma. It appears as a 2-3cm well-shaped nodule after a few days. It becomes invisible in 2-4 weeks due to complete resorption. CT shows a hyperdensity specific to acute hematoma a Hounsfield Unit (HU) in between 40 and 60. While it classically appears as crescent shaped high-density area in acute phase, it may turn into circular shape with defined boundaries in chronic phase (Figure 21).

**Pulmonary Contusion:** Pulmonary Contusion is seen in 50% of the patients experienced with blunt chest trauma. Contusion is the blood collection in alveolar spaces due to microscopic cuts in lung parenchyma. Lung tissue looks rigid and edematous due to blood presence at interstitium and alveoli. Contusion may very well be due to the trauma in other organs (vertebrae, heart, and liver) besides blunt lung trauma. Radiographs show cloudy consolidations 6-8 hours after the lung contusion (Figure 22). Air bronchogram in contused areas is also a very common observation on CT scans.

**Thoracic Wall Diseases**

**Osteomyelitis:** Osteomyelitis is a progressive disease and an infection of the bone caused by microorganisms. Most common organism involved is Staphylococcus Aureus and gram-negative enteric bacilli follow after. In newborns, Streptococcus B and pneumonias are prevalent while pseudomonas are widely seen in people with drug addiction. While the infection is mostly in a local area, it can spread to medullary canal, periosteum, cortex, and surrounding soft tissue. In the early stages of Osteomyelitis, there are usually no radiographic findings in addition to local and systemic infection symptoms. Periosteal reaction, soft tissue inflammation, and disorganized trabecular osteolytic areas appear in the first 1-2 weeks. Later on, disorganized radiolucent areas in trabecular and cortical compartments become clearer, and opaque areas due to reactive sclerosis appear in neighboring areas. MRI can image bone marrow in a much earlier stage than X-ray and CT (15). CT, however, can reveal the clearer trabecular damage in medullary level (Figure 23).

**REFERENCES**