Radiographic Evaluation of Lobar Atelectasis

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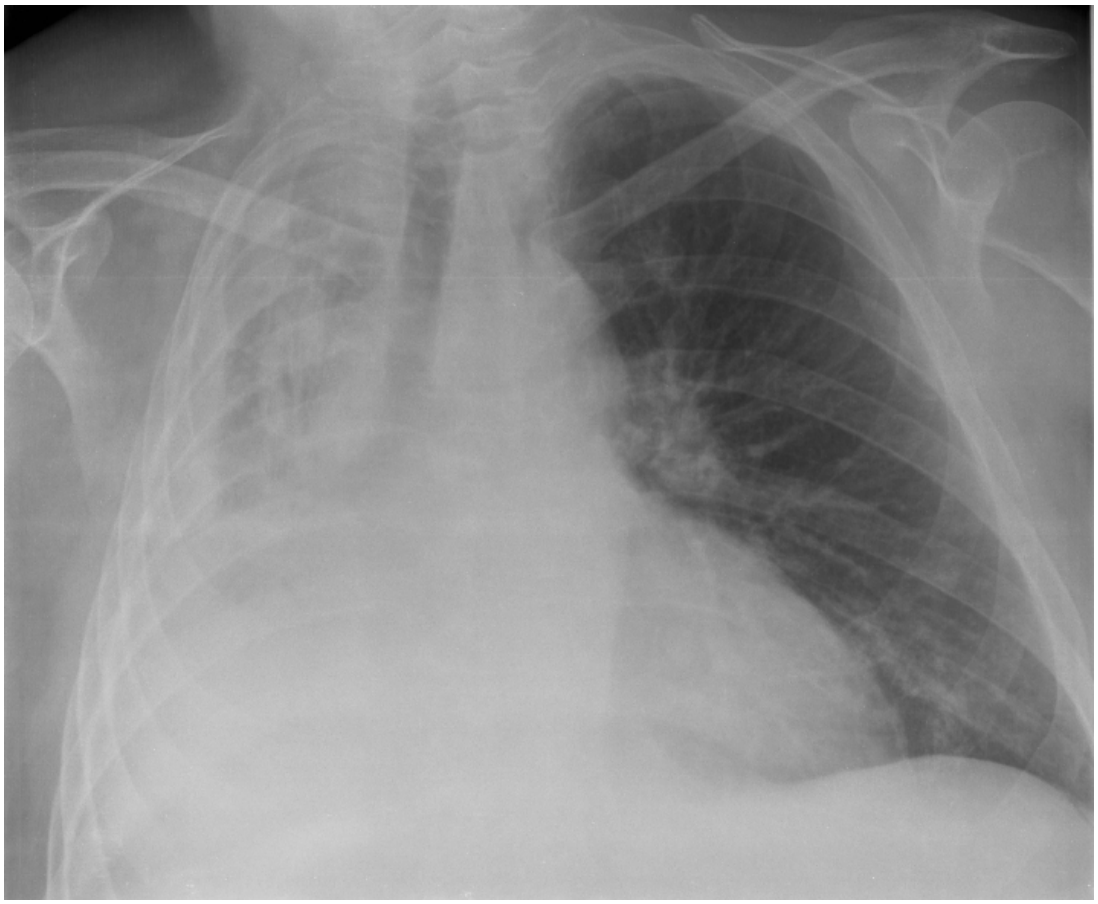
Atelectasis is a condition that is characterized by the collapse of the alveoli and eventually lobar lung collapse and complete obstruction. The causes, pathophysiology, and consequences of atelectasis where the air passages and alveoli are completely obstructed are different from partial airway obstruction. Partial airway obstruction is characterized by hyperinflation and air trapping.



Overview of Lobar Atelectasis

Atelectasis is **more common in children with hyaline membrane disease of prematurity,** in patients with acute respiratory distress syndrome and in the postoperative period. The common feature between these three conditions is either the absence of lung surfactant or surfactant dysfunction which is hypothesized to play a crucial role in the pathogenesis of atelectasis.

The postoperative period puts the patient at an increased risk of atelectasis because of the **inability to take deep breaths in due to chest pain** from an incision, prolonged faulty ventilation, or poor chest physiotherapy.

Epidemiology of Atelectasis

Children are at an increased risk of atelectasis because of the smaller diameter of their airways, and because the airways are more likely to collapse. **The chest wall is more compliant in children which also predisposes them to atelectasis**. Pulmonary surfactant absence or dysfunction are also two important risk factors for atelectasis in children.

Note: The estimated incidence of atelectasis is around 8 to 15% in children. The incidence of atelectasis in adults in the postoperative period is believed to be very high, but no official documentation is available to give an exact figure. Another peak in the incidence of atelectasis is seen in patients who are 60 years of age or more. Atelectasis is common in both sexes and has an equal likelihood in all races and ethnicities.

Etiologies of Atelectasis in Children

Atelectasis in children can be caused by four main mechanisms:

1. Resorption atelectasis is due to **bronchial obstruction**. The lumen of the bronchus can be obstructed by abnormal thick secretions such as in asthma or a foreign body.
2. **Abnormal bronchial wall changes** can also lead to an obstruction of the small bronchioles and subsequent atelectasis.
3. The **main bronchial abnormalities** that can lead to atelectasis are mucosal edema, inflammation, and smooth muscle tumors. Extrinsic compression of the bronchioles by a tumor can also lead to atelectasis.
4. **Direct compression on the lung parenchyma** can also cause atelectasis. This can result from cardiomegaly, massive pleural effusions, or a diaphragmatic hernia.

Prematurity can alter the lung surfactant coating of the alveoli. The absence of lung surfactant is associated with abnormal surface tension and the alveoli can collapse during expiration.

The **other causes** of atelectasis in children belong to two main categories:

1. Decreased compliance of the pulmonary parenchyma which can be due to depressed respiration in the post-operative period.
2. Decreased inspiration due to chest pain or chest muscle weakness. Guillain-Barre, spina bifida, and Duchenne syndrome can lead to atelectasis due to paralysis of the diaphragmatic muscles.

Pathophysiology of Atelectasis

The main pathologic change that can lead to atelectasis is an alteration in the surface tension of the alveolus. This can happen because of an **absolute deficit of lung surfactant which occurs in hyaline membrane disease,** or an alteration in the lung surfactant which can be induced when anesthetic agents are used. This latter mechanism of atelectasis is responsible for most cases of postoperative atelectasis.

Obesity, previous lung disease, duration of surgery, and pulmonary compression are also implicated in the pathogenesis of perioperative atelectasis. If a small bronchiole is

obstructed in the lungs, intra-alveolar pores (Kohn pores) and broncho-alveolar communications (Lambert's channels) can ensure adequate ventilation of the affected alveoli and limit the extent of atelectasis.

Note: The Lambert's channels and Kohn pores are poorly developed in infants, which explains the increased risk of atelectasis in the post-operative period in this age group.
If atelectasis happens, the oxygenation of the blood is altered. The lung parenchyma that has collapsed is usually not as compliant as the contralateral side. **Pulmonary vascular resistance tends to increase in the collapsed lung and pulmonary edema can occur**. The consequence of these functional changes is hypoxemia and hyperventilation of the adjacent alveoli. If the whole lung collapsed, hyperinflation of the contralateral lung is usually seen.

Clinical Presentation of Atelectasis in Children

If atelectasis happens during an exacerbation of asthma, bronchitis or bronchiolitis, the diagnosis can be missed. If atelectasis is extensive and involves multiple lung segments, the patient's condition might get worse.

The **main symptoms of atelectasis in the post-operative period are early fever, tachypnea, cough, and dyspnea**. Auscultation of the chest can reveal decreased breath sounds on the affected side. If atelectasis involves a large segment of the lung, a dull note to percussion might be elicited. Wheezing is also a common finding in auscultation of the chest over a collapsed lung segment.

Diagnostic Evaluation of Atelectasis in Children

Chest X-ray

When a patient presents with the previously mentioned symptoms, a chest X-ray is usually the first imaging modality to be ordered. Atelectasis is due to loss of lung volume and increases in density; thus, features seen on the chest X-ray include:

- Sharply defined opacifications of the lung lobe or segment that obscure vessels but there are no air bronchograms.
- The interlobar fissure is usually displaced.
- If atelectasis involves a large segment of the lung, the mediastinum might be shifted towards the affected side.
- Compensatory hyperinflation might be seen on the contralateral side.
- Foreign bodies may be visualized if they are the cause of atelectasis.

While a chest X-ray is useful in the identification of atelectasis, it **has limited utility in the differentiation of the different causes of atelectasis**. In fact, some doctors do not consider atelectasis as a diagnosis; therefore, once you see atelectasis on the chest X-ray, you should move on to identify the most likely etiology. Treatment of atelectasis, as we shall discuss later, is tailored towards the etiology.

Computed tomography

A computed tomography scan is **useful in the evaluation of the child with atelectasis** since atelectasis is visualized better on a CT scan and the scans provide a better view and localization ability of the lesions. Atelectasis is seen as volume loss on the lung computed tomography scan and appears with features of:

- Bronchial narrowing in the obstructive type.
- Change of shape of the lung lobe.
- V-shaped structure of the lesion.

If contrast was used, one would see hyper-attenuation of the affected segment of the lung. This sign is useful in the differentiation between lung consolidation due to pneumonia which does not enhance after the administration of intravenous contrast and atelectasis.

Laboratory investigations

Laboratory investigations, such as a complete blood count, are used in the evaluation of the feverish patient. Unfortunately, they do not add more certainty to the diagnosis of atelectasis. **Magnetic resonance imaging provides excellent three-dimensional images of the lungs** and might be helpful in the evaluation of atelectasis.

Treatment of Atelectasis in Children

Positive end expiratory pressure (PEEP)

Atelectasis caused by prolonged ventilation can be relieved by the application of positive end expiratory pressure (PEEP). **PEEP simply prevents the collapse of the alveoli** by not going to zero pressure during expiration. PEEP can also re-open the collapsed alveoli.

Chest physiotherapy

Chest physiotherapy, early ambulation, and bronchodilators can be used in the postoperative period to prevent or treat atelectasis. In infants, the use of bronchodilators and chest physiotherapy has been proven to be sufficient in treating atelectasis.

Use of DNase

Patients with infections complicated by atelectasis usually have a respiratory syncytial virus in the thick secretions plugging the bronchioles. The use of DNase has been shown to be effective in the treatment of atelectasis. Bronchiolitis-related atelectasis has been previously shown to improve two hours after the introduction of DNase by a tracheal cannula. **The condition completely resolved within 24 hours after starting treatment**.

Bronchoscopy

Patients with massive lung atelectasis can have a mucus plug or a foreign body obstructing the lumen of a major bronchus. Bronchoscopy with or without bronchoalveolar lavage might be helpful in these situations.

Further exercises

Frequent percussion, i.e. part of conventional respiratory physiotherapy, is not useful in children. Instead, one should **encourage the patient to cough and take deep breaths in**. These two exercises, which can also be considered as part of respiratory physiotherapy, were proven to be effective in the management of postoperative atelectasis in children.

Other forms

Treatment of the etiology of atelectasis should be initiated as soon as possible to prevent re-collapse of the lung parenchyma. For example, **appropriate antibiotics should be used if the child has an acute exacerbation of asthma** due to a bacterial lung infection. Bronchodilators and maybe steroid therapy might be needed in an asthmatic child to prevent atelectasis. Plasma electrophoresis and immunoglobulin antibody therapy might be a reasonable option for a child with Guillen Barre syndrome.

References

Atelectasis in der Pädiatrie: Mechanismen, Diagnose und Behandlung via dx.doi.or

Notes