PNEUMONIA IN CHILDREN: ETIOLOGY, DIAGNOSIS AND TREATMENT

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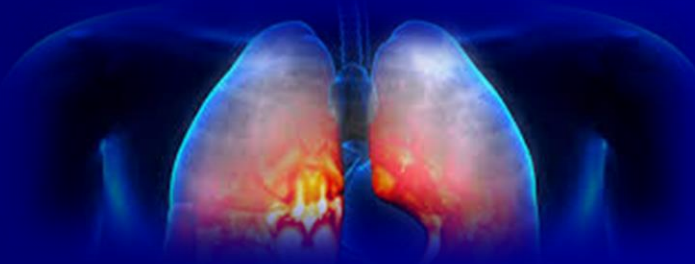
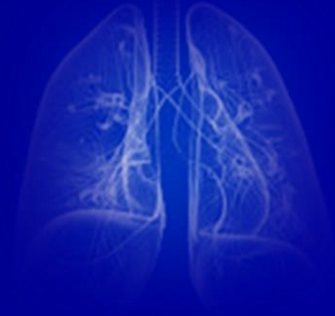
Pneumonia in pediatric patients

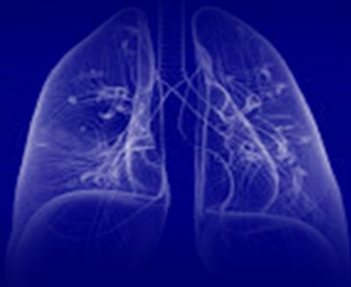
- Pneumonia is a polyetiological infectious disease of respiratory system lower parts with alveolar exudation which is confirmed by radiological method (European pulmonological society).



Pneumonia in pediatric patients

Pneumonia is a fairly common childhood condition, affecting 150 to 156 million children under the age of 5 each year.



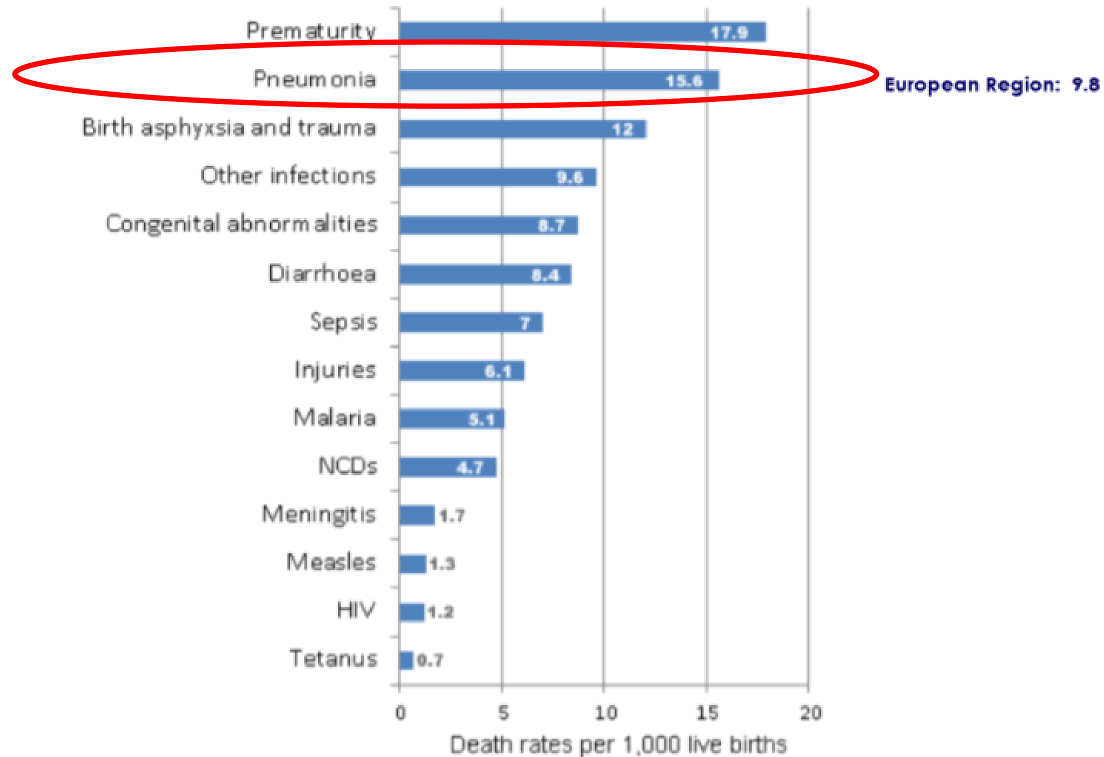


Morbidity per year is 15-20 upon 1000 children of the first year of life and around 5-6 upon 1000 children above 3 years old.

Morbidity and mortality

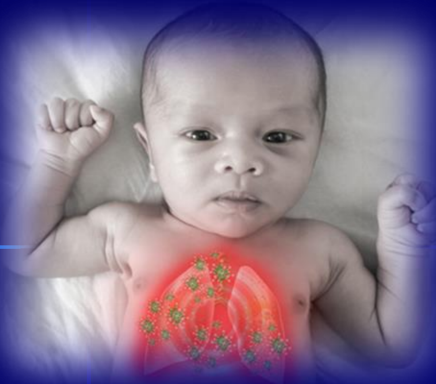
- Childhood pneumonia remains an important cause of morbidity and mortality in developing world – 4 million deaths annually in the developing world;
- About 20% of all deaths in children under 5 years are due to Acute Lower Respiratory Infections (ALRIs - pneumonia, bronchiolitis and bronchitis);
- 90% of these deaths are due to pneumonia.
- Mortality rate < 1/1.000 in the U.S.

Causes of death among children under 5 years, globally



WHO-MCEE methods and data sources for child cause of death 2000-2016. Global Health Estimates Technical Paper WHO/HMM/IER/GHE/2018.1.

Pneumonia ranks second in the world among deaths in children under 5 years old



Significant risk factors

- Younger age (0-6 months)
- Prematurity
- Concomitant diseases (malnutrition, CHD, anemia)
- Weaning from breast feeding earlier than 6 months
- Smoking at home

Predisposing factors

- Severe perinatal pathology
- Rickets
- Anemia
- Hypotrophy
- CHD
- Congenital anomalies of respiratory system
- Hereditary diseases
- Diathesis
- Chronic foci of infection
- Recurrent bronchitis
- Cooling
- Depressed immunity
- Surgical interventions
- Staying at ICU (Intensive Care Unit)
- Long staying at the department before surgery
- Artificial ventilation of lungs

Pneumonia

can occur at any age, although it is more common in younger children. Different age groups tend to be infected by different pathogens, which affects diagnostic and therapeutic decisions.

There are 3 ways of pulmonary contamination with pathogens:

- aspiration of oropharyngeal contents (microaspiration in sleep - physiological phenomenon, especially at early age);
- droplet / inhalation (droplet transmission occurs when bacteria or viruses travel on relatively large respiratory droplets that people sneeze, cough, drip, or exhale);
- hematogenous dissemination of pathogen from extrapulmonary focus of infection;

Etiologic factors of pneumonia

In out-of –hospital (home) Infection –

pneumococci and intracellular causative agents (viruses, mycoplasma, chlamydia, legionella)

In nosocomial (hospital) Infection-

aerobian gram-negative flora (blue pus and hemophilus bacilus, klebsiella, proteus), staphylococcus aureus, associated flora

Normal host	Immune compromised host
RSV	cytomegalovirus - CMV
parainfluenza	*pneumocystis carinii* - PCP
adenovirus	staphylococcus
Mycoplasma	pseudomonas
metapneumovirus	fungus (aspergillus)
pertussis	tuberculosis
pneumococcus	
tuberculosis	

Infectious causes of pneumonia

Age	Causative organisms
Perinatal + 4 weeks - ***Neonates***	Group B haemolytic streptococci *Esherichia coli* and other gram negative enteric organisms - *Klebsiella pneumoniae* Listeria monocytogenes *Chlamydia trachomatis*

Etiology
Age-dependent

Children 1-12 mo - infancy

Viruses - RSV, parainfluenzae, influenzae, adenoviruses,
Strep. Pneumoniae (Pneumococcus),
Hemophylus influenzae

Esherichia coli, Klebsiella pneumoniae;
Chlamydia trachomatis, Mycoplasma pneumoniae

Etiology
Age-dependent
2 -5 years

Strep. Pneumoniae - 50 %
Viruses - parainfluenza, influenza, adenovirus, rhinovirus, coronavirus, herpesvirus, human metapneumovirus
Hemophylus inf. type β - 10 %
Mycoplasma pneumoniae - 10 %
Chlamydophila pneumoniae
St. aureus

Etiology
Age-dependent

5-18 years

Strep. Pneumonie - 35-40 %

Atypical pneumonia (Mycoplasma pneumoniae) - 30-50 %

Moraxella catarrhalis, Hemophylus influezae

Viruses

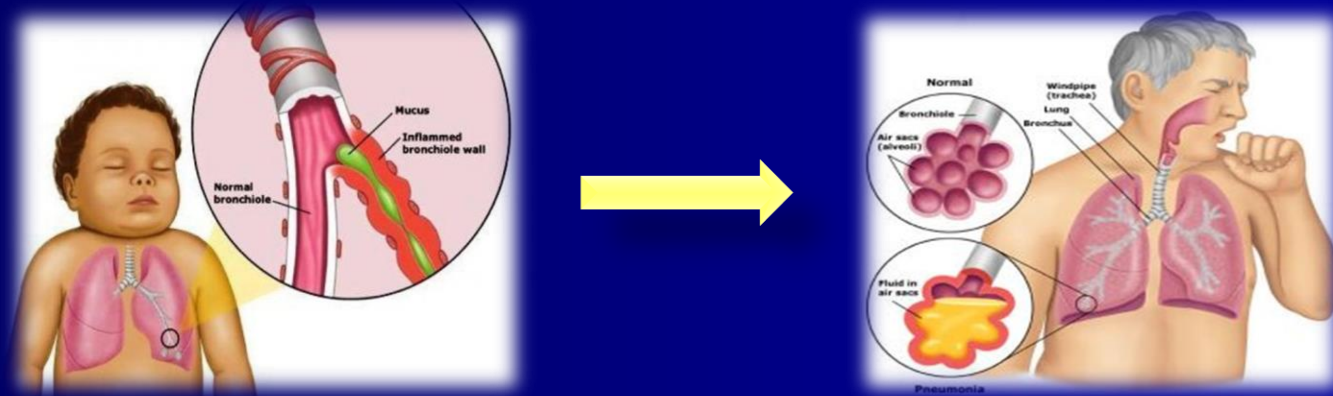
- **hospital (nosocomial)**
  - Ps. aeruginosa, Proteus;
  - Kl. pneumoniae, St. aureus,

PATHOGENESIS

- Initial inflammatory changes in lungs are detected predominantly in respiratory bronchioles.
- This is explained by the fact that just in this place microbes trapped in the lungs are arrested due to the presence of an ampoule-like expansion of the bronchi, the absence of a ciliary cylindrical epithelium, and less developed muscle tissue.
- Infectious agent, spreading beyond the bronchioles, causes inflammatory changes in the lung parenchyma, i.e. pneumonia.

PATHOGENESIS

- When coughing and sneezing, the infected exudate from the inflammatory focus gets into the large bronchi, and then, spreading into other respiratory bronchioles, causes new inflammation foci.



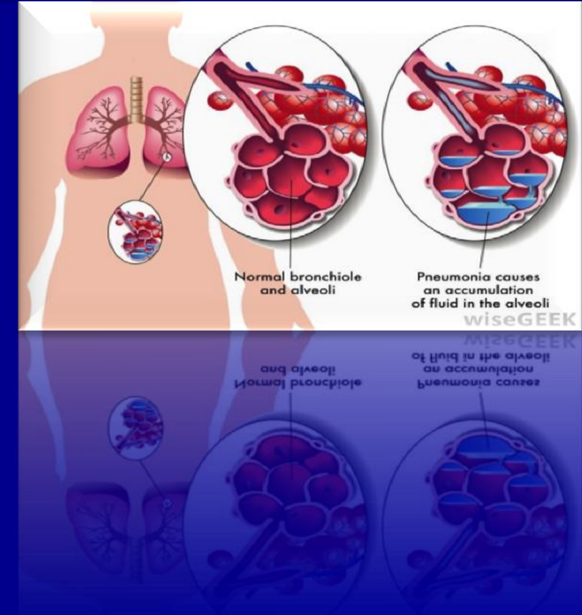
PATHOGENESIS

- When the spread of infection is limited by perilesional inflammatory reaction around the respiratory bronchioles, **focal** pneumonia develops.
- In the case of the spread of bacteria and edematous fluid through the pores of the alveoli within the same segment and blockage of the segmental bronchus with infected mucus, **segmental** pneumonia occurs (usually on the background of atelectasis), and with a more turbulent spread of the infected edematous fluid within the lung lobe - **lobar pneumonia** .

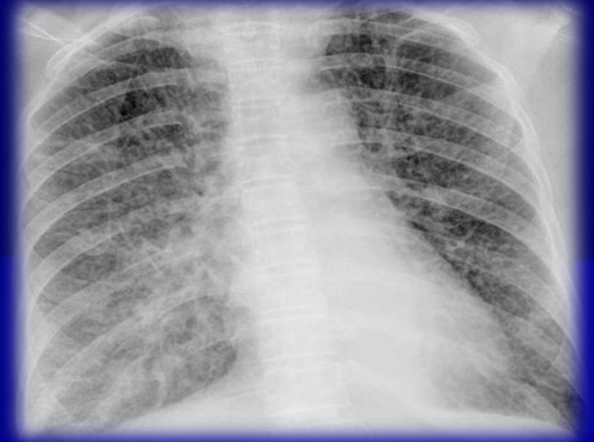
Pathophysiology

Inoculation of the respiratory tract by infectious organisms leads to an acute inflammatory response in the host that typically lasts 1-2 weeks.

This inflammatory response differs according to the type of infectious agent.



Pathophysiology

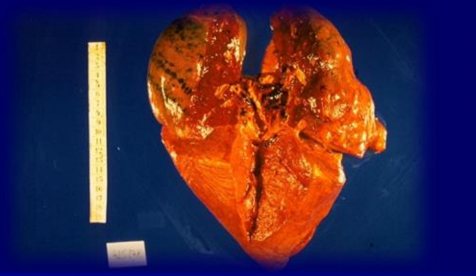


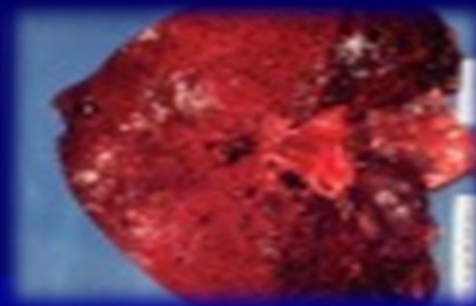
Viral infections

are characterized by the accumulation of mononuclear cells in the submucosa and perivascular space, ***resulting in partial obstruction of the airway***.

Patients with these infections present with **wheezing and crackles**.

Pathophysiology

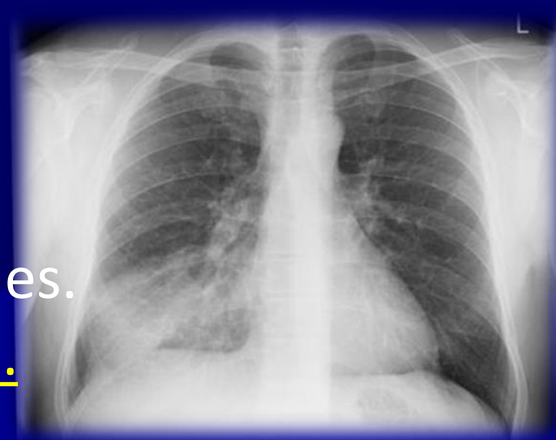




Bacterial infections

The alveoli fill with proteinaceous fluid, which triggers a influx of red blood cells (RBCs) and polymorphonuclear cells (red hepatization) followed by the deposition of fibrin and the degradation of inflammatory cells (gray hepatization).
During resolution, intra-alveolar debris is ingested and removed by the alveolar macrophages.
This consolidation leads to decreased air entry and dullness to percussion.

Pathophysiology



Bacterial infections

Inflammation in the small airways leads to crackles.

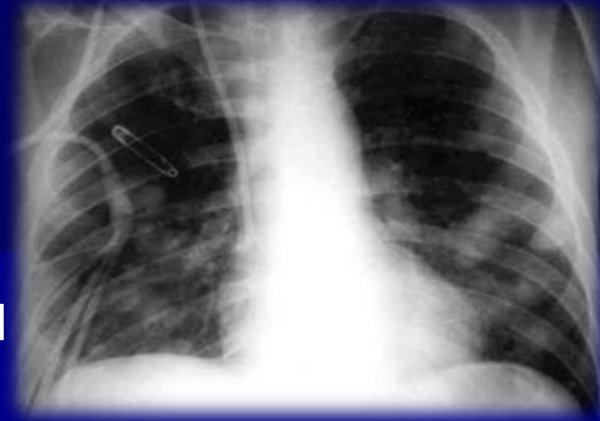
Wheezing is less common than in viral infections.

The inflammation and pulmonary edema lead to stiffness of lungs and less distensible, decreasing tidal volume.

The patient must increase his or her respiratory rate to maintain adequate ventilation.

Tachypnea and hypoxia are common.

Pathophysiology



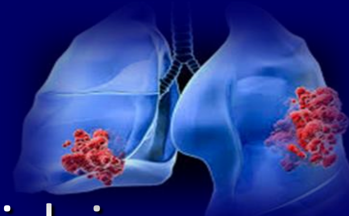
Fungal infections

Fungal infections are unusual and are typically found in patients with inadequate immune function *(e.g., patients with acquired immunodeficiency syndrome [AIDS], patients who have undergone chemotherapy, newborn infants).*

The pathology may be a diffuse infiltrate of organisms or focal areas of fungal growth.

- Chest radiograph shows multiple pulmonary nodules.
- Patchy infiltrate, nodules, consolidation, cavitation, or pleural effusion may be observed.

PATHOGENESIS

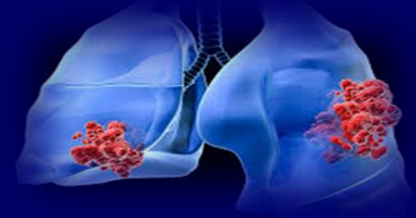


- Changes in **cardiovascular system** are observed, which is caused by both CNS disorders, and RI, pulmonary congestion, toxicosis. In severe cases, congestive heart failure develops;

- **digestive** (decreased activity of enzymes of digestive juices, disorders of motility of the gastrointestinal tract and frequent development of meteorism, dysbiosis in children of early age);

- **endocrine** (increased secretion of corticoids, catecholamines, vasopressin);

PATHOGENESIS



excretory (phase changes in filtration, reabsorption and secretory function of the kidneys, decrease in urea-forming and desamidizating functions of the liver);

immunological reactivity of the organism (increase in the blood of indices of nonspecific immune defense - complement titer, properdin, lysozyme, bactericidal ability of blood, phagocytic activity of neutrophils, and the level of immunoglobulins M, G, B-lymphocyte count).

PATHOGENESIS

Regularly in children with pneumonia, metabolic processes are disturbed:

- **acid-base state** (acidosis, of either metabolic or mixed respiratory-metabolic character with a decrease in buffer base capacity, the accumulation of under-oxidized products),
- **water-salt** (the delay in the body of fluid, chlorides, sodium, hypokalemia, etc.),
- **protein metabolism** (dysproteinemia with a decrease in the level of albumins and an increase in the level of α-2 and γ-globulins, an increase in the ammonia, amino acids, urea in the blood, etc.),

PATHOGENESIS

- **carbohydrate** (pathological sugar curves, in severe pneumonia - hypoglycemia);
- **lipid** (hypocholesterolemia, increase in total blood lipids against the background of a decrease in the content of phospholipids, etc.);
- **pigmentary metabolism** (an increase in urobilinogenuria, etc.).

CLASSIFICATION:

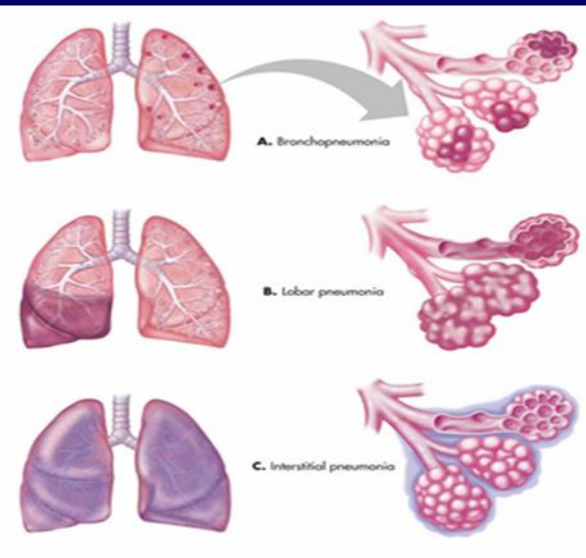
- Etiology
- Morphological class
  - Focal pneumonia
  - Segmental pneumonia
  - Lobar pneumonia
  - Interstitial pneumonia
- Congenital pneumonia

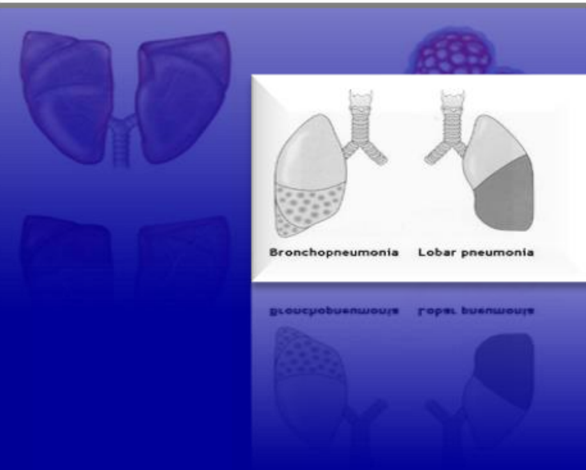
  Community acquired pneumonia

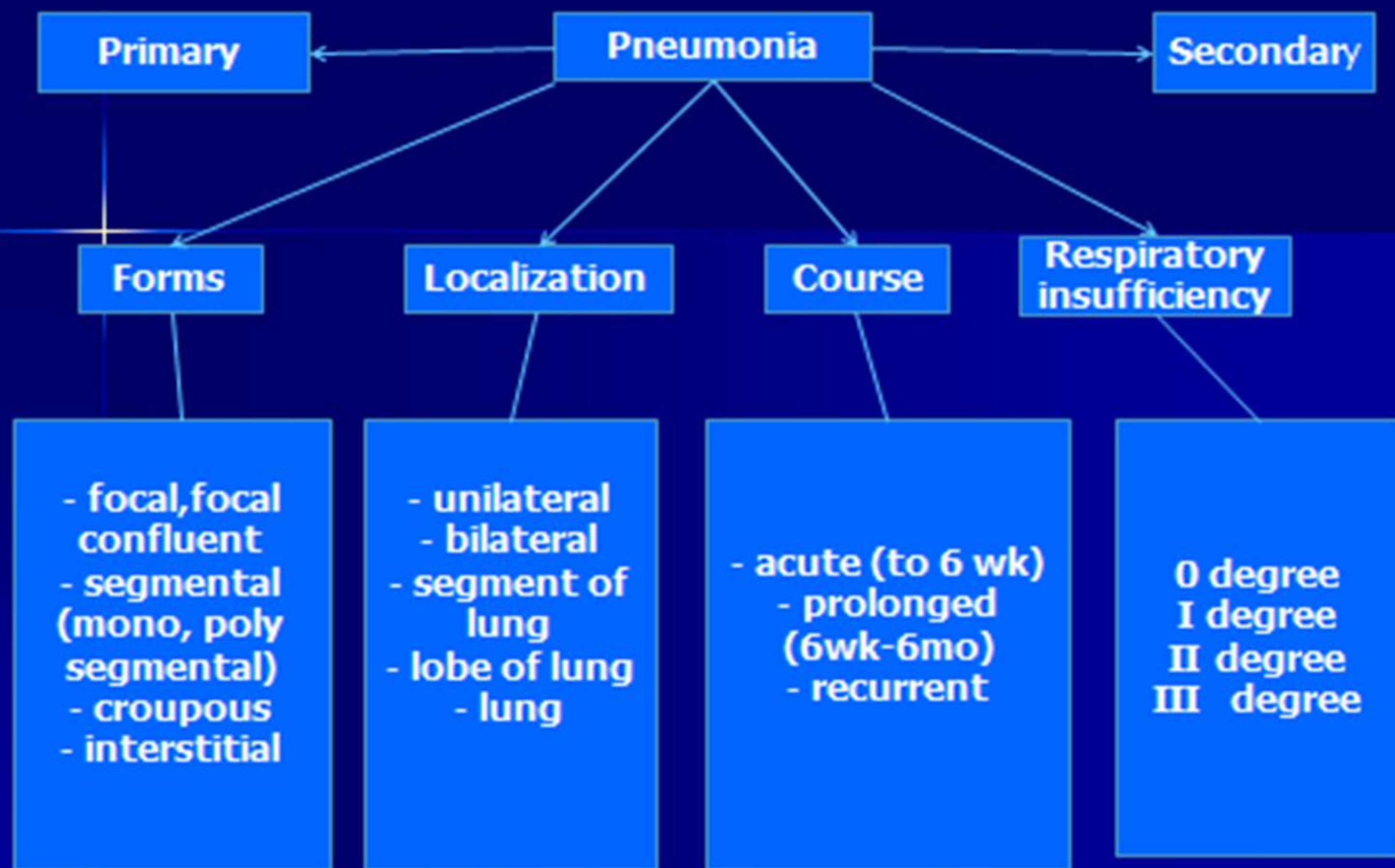
  Nosocomial (hospital acquired) pneumonia

  Aspiration pneumonia
- Non complicated pneumonia

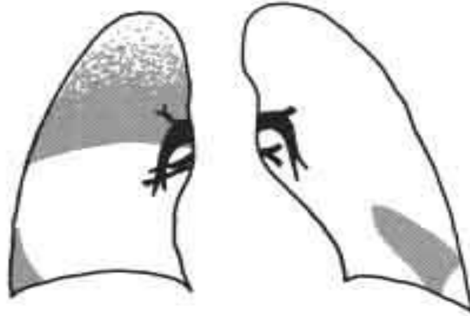
  complicated pneumonia



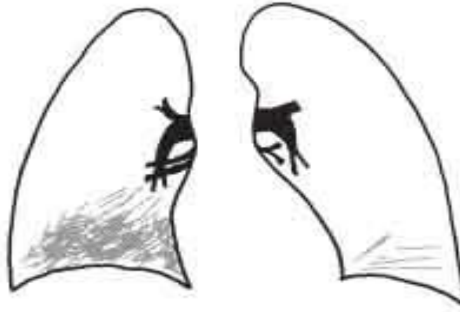



Primary
Pneumonia
Secondary
Forms
Localization
Course
Respiratory insufficiency
- focal,focal confluent
- segmental (mono, poly segmental)
- croupous
- interstitial
- unilateral
- bilateral
- segment of lung
- lobe of lung
- lung
- acute (to 6 wk)
- prolonged (6wk-6mo)
- recurrent
0 degree
I degree
II degree
III degree

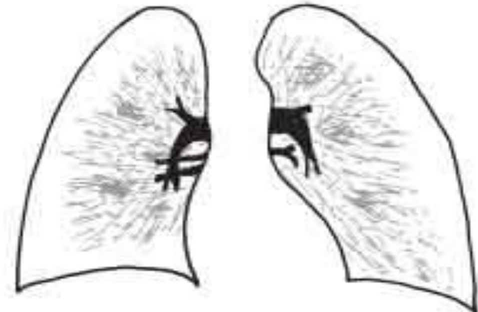
Pneumonia forms



Lobar pneumonia:
Lobar and/or segmental consolidation with air bronchogram and accompanying pleural effusion



Bronchopneumonia:
coalescing areas of consolidation in a predominantly basal distribution



Interstitial pneumonia:
reticular pattern in a predominantly central distribution

Classification

Pneumonia

- **Uncomplicated**
- **Complicated**

General disorders

- Toxic-septic state
- Infection-toxic shock
- DVS (disseminated intravascular coagulation syndrome)

Pulmonary purulent process

- Destruction
- Abscess
- Pleurisy
- Pneumothorax

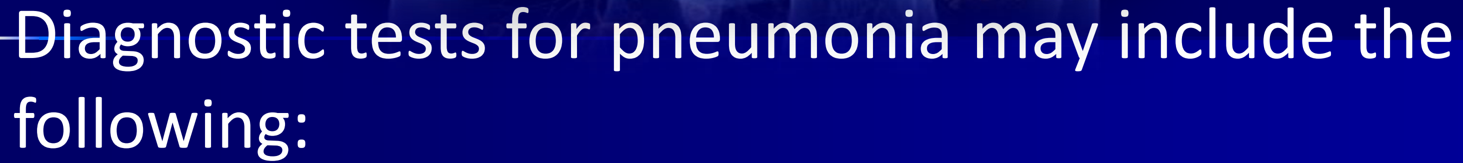
Inflammation of different organs

- Sinusitis
- Otitis
- Pyelonephritis
- Meningitis
- Osteomyelitis

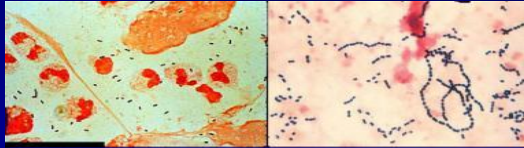
The signs and symptoms of pneumonia are often nonspecific and widely vary based on the patient’s age and the infectious organisms involved

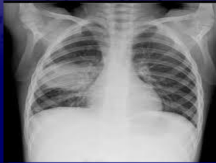
Criteria of diagnostics (WHO, 1997)

- Local physical signs of pneumonia
  - shortening of percussion sound in the zone of affection,
  - weakening of breathing,
  - bronchophony,
  - bubbling rales, crepitation etc.
- Asymmetry of bubbling rales
- Dyspnea in absence of bronchial obstruction
  - RR more than 60/min in children younger than 2 mo.,
  - more than 50/min in children of 2 – 12 mo.
  - and more than 40/min in children of 1 – 15 year
- Temperature more than 38,0ºC during 3 and more days
- Toxicosis.



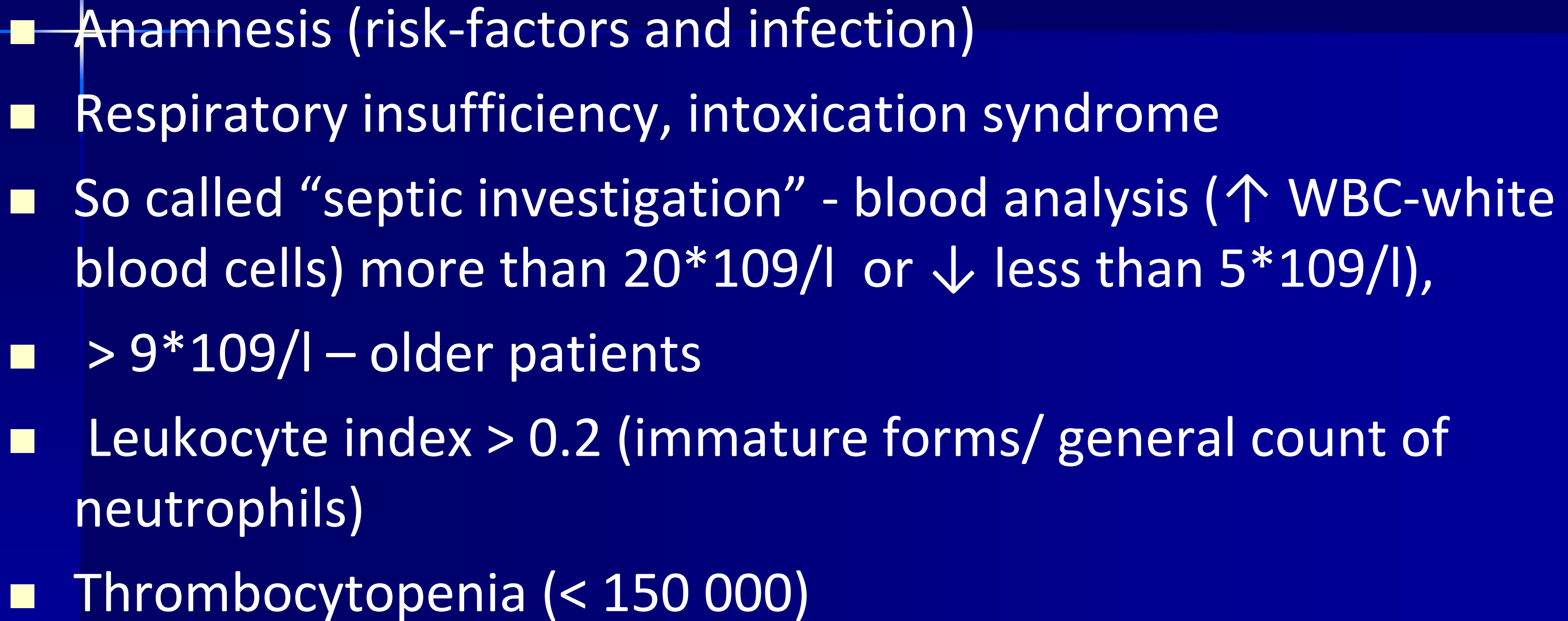
Diagnostic tests for pneumonia may include the following:





- Pulse oximetry
- Complete blood cell (CBC) count
- Sputum and blood cultures
- Serology *(serologic tests for common lung pathogens, such as M pneumoniae, Chlamydophila species, and Legionella.)*
- Chest radiography
- Ultrasonography

Diagnosis



Diagnosis

- ↑C-reactive protein
- Bacteriological blood investigation (golden standard) or tracheal content
- Acidosis
- Chest X-ray

Radiologic patterns of pneumonia

- diffuse peribronchial
- lobar / segmental consolidation
- interstitial
- nodular or multifocal

Radiologic / pathologic patterns

- Bronchiolitis
  - infants
  - viral
  - hyperinflation
  - + / - peribronchial cuffing

- Bronchopneumonia
  - viral or bacterial
  - peribronchial cuffing
  - peribronchial infiltrate
  - segmental atelectasis

Focal pneumonia

In children of preschool and school age, clinical manifestations consist of

- **"pulmonary" complaints,**
- **symptoms of intoxication,**
- **signs of RI,**
- **local physical changes.**

The onset of the disease can be either gradual, with a slow development of local symptoms at the end of the first - the beginning of the second week of the disease, or a sudden one, in which the clinical picture allows diagnosing pneumonia already in the first 3 days.

Symptoms of intoxication

- In the first variant, the symptoms of intoxication appear or reappear in a child with acute respiratory disease, even against a background of a short-term improvement of the condition: an increase in body temperature, a headache, deterioration of well-being and appetite, lethargy and apathy or anxiety, sleep disturbance, coated tongue, tachycardia inadequate to degree of fever.

"Pulmonary" complaints

"Pulmonary" complaints intensify against the background of improved upper respiratory disease and worsening of a moist cough, shortness of breath, sometimes pain in the side appears.

- Dyspnea may occur during exercise or at rest.
- Pallor of the skin with normal mucous membranes color,
- sometimes perioral cyanosis,
- participation of auxiliary muscles in the act of breathing (flaring of the wings of the nose on the side of the lesion and retraction of the supraclavicular fossa and intercostal space) is typical.

Above the lungs local physical changes are noted:

- shortening of the percussion tone in the interscapular area on one side or at the angle of the scapula, in the axillary region,
- weakened or hard breathing at the same place,
- crepitation and sonorous constant small bubbling râles.

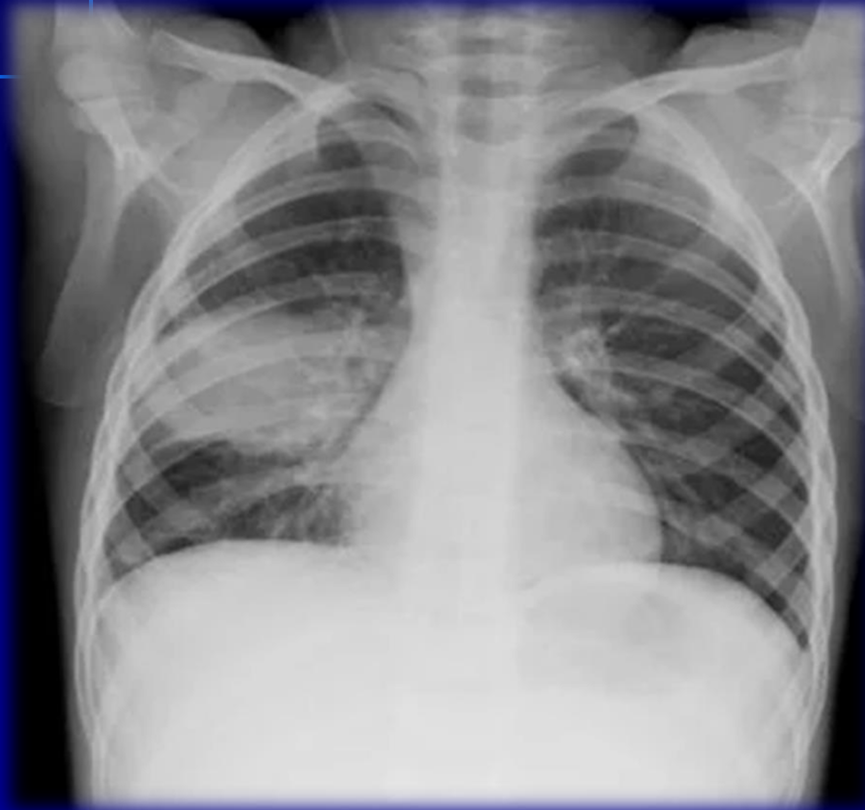
! Resistance of local symptoms is characteristic for pneumonia.

- Leukocytosis, neutrophilia, shift to the left, increased ESR are found **in CBC.**
- **X-ray** reveals focal infiltrative shadows in one of the lungs.

- The course of focal pneumonia is usually benign, antibiotic-dependent, because it is caused more often by pneumococcus.
- Recovery occurs both clinically and radiologically in 3-4 weeks.

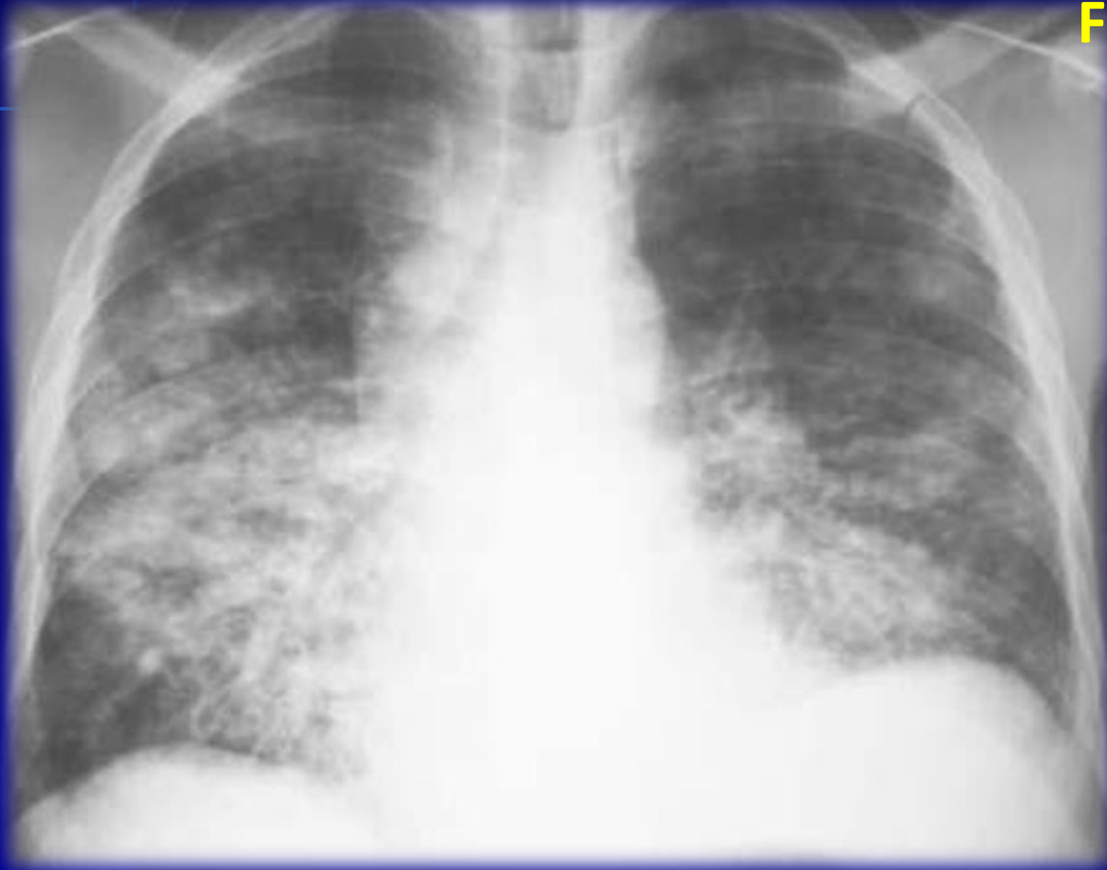
- In the clinical picture of focal pneumonia **in infants**, the signs of RI are most prominent, and local physical changes in the lungs are revealed later, the process is sometimes bilateral.

Chest Radiography



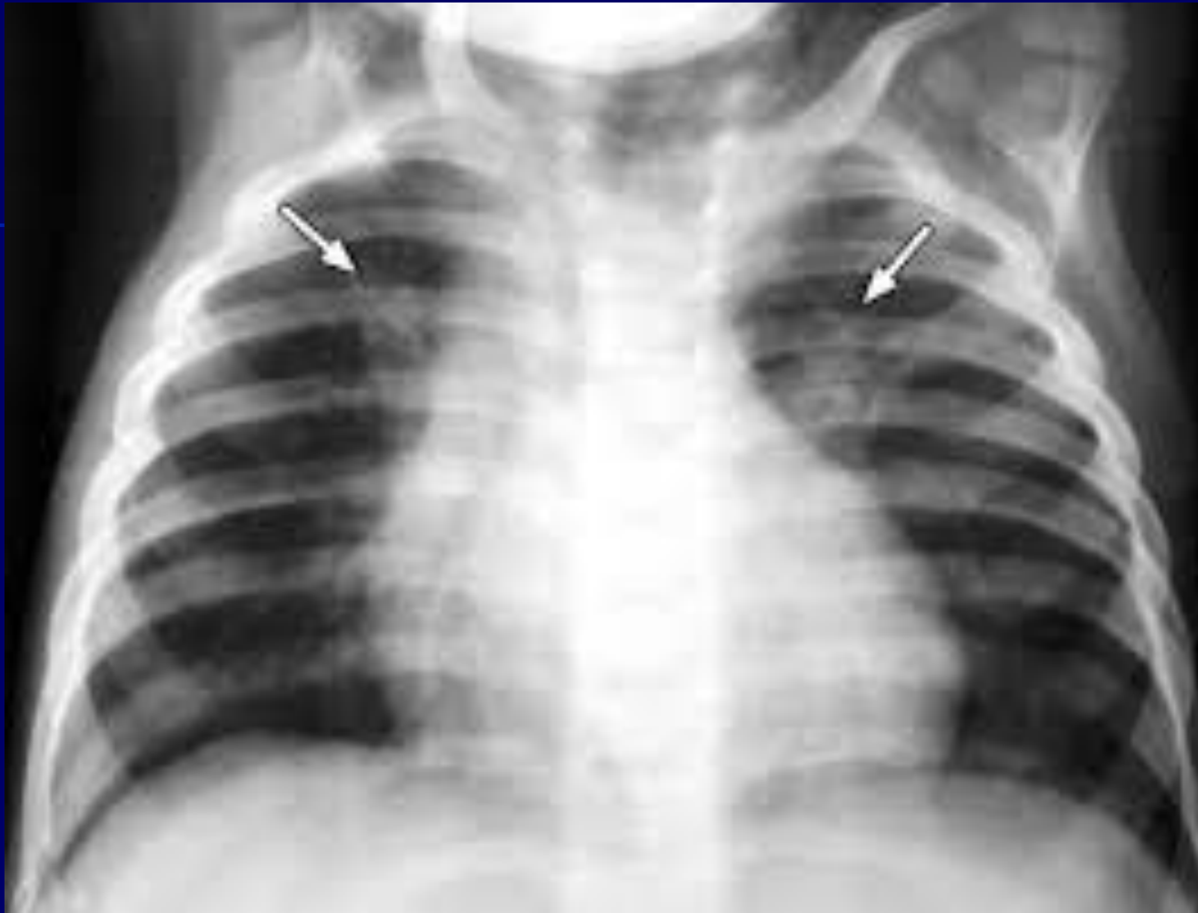
Focal pneumonia on chest radiographs should raise suspicion that the disease has a bacterial etiology, and particularly, that *Streptococcus pneumoniae* or *S aureus* is the causative agent.

Chest Radiography



Focal-confluent pneumonia

In the X-ray, multiple small opacities are seen, which appear patchy and confluent. The inflammation patches are separated by normal lung tissue. The distribution is bilateral and asymmetric.



Focal bilateral pneumonias

Segmental pneumonia

- **Focal pneumonias occupying one or more segments are called segmental ones.**
- The clinical course of segmental pneumonia is in most cases benign. Often they are not even diagnosed, because focal changes last only a few days, and respiratory insufficiency, intoxication, sometimes even coughing in patients is absent, and the **diagnosis is possible only with radiography**. This is probably segmental pulmonary edema in viral infections (the first variant).

Segmental pneumonia

- The second variant of the course of segmental pneumonia is practically similar to the clinic of croupous pneumonia with sudden onset, fever and cyclic course of the disease. Pain in the abdomen and chest can be symptoms of this type of segmental pneumonia.

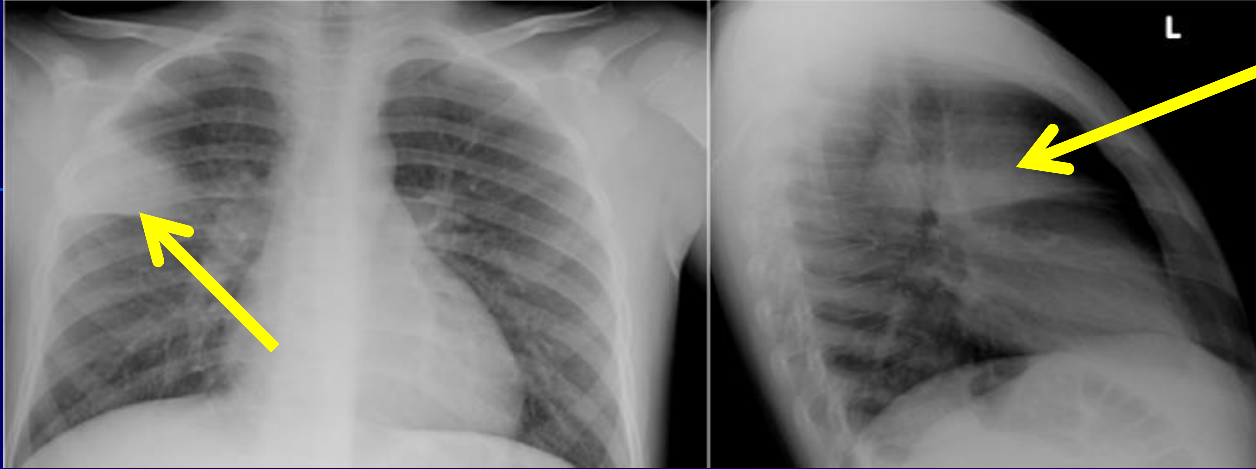
Segmental pneumonia

- In the third variant, the segmental shadow is not formed immediately, but only at the end of the first - in the second week of the disease.

- The clinical picture in these cases completely corresponds to what was described above in case of focal pneumonia in preschool children and schoolchildren, but as a rule, **only a weakened and harsh breathing is auscultated**, with complete absence of wheezing. **The percussion clearly reveals induration of the lung tissue**. Pleural lesions (in half of children) and atelectasis (in the majority) are frequent.

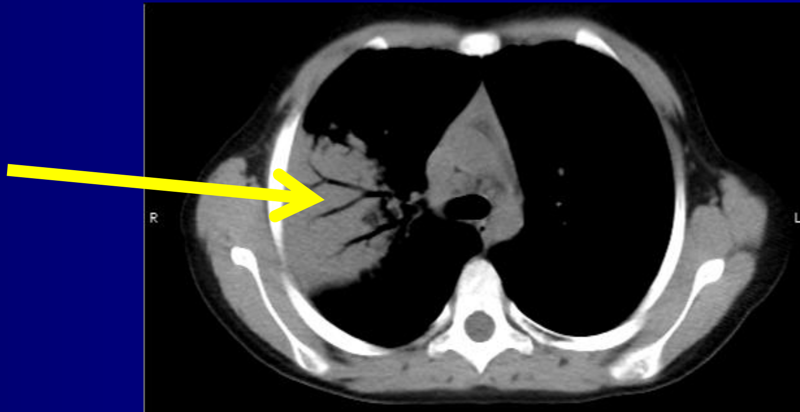
- High propensity to abscess, destruction, and lingering course is present.

Segmental pneumonia

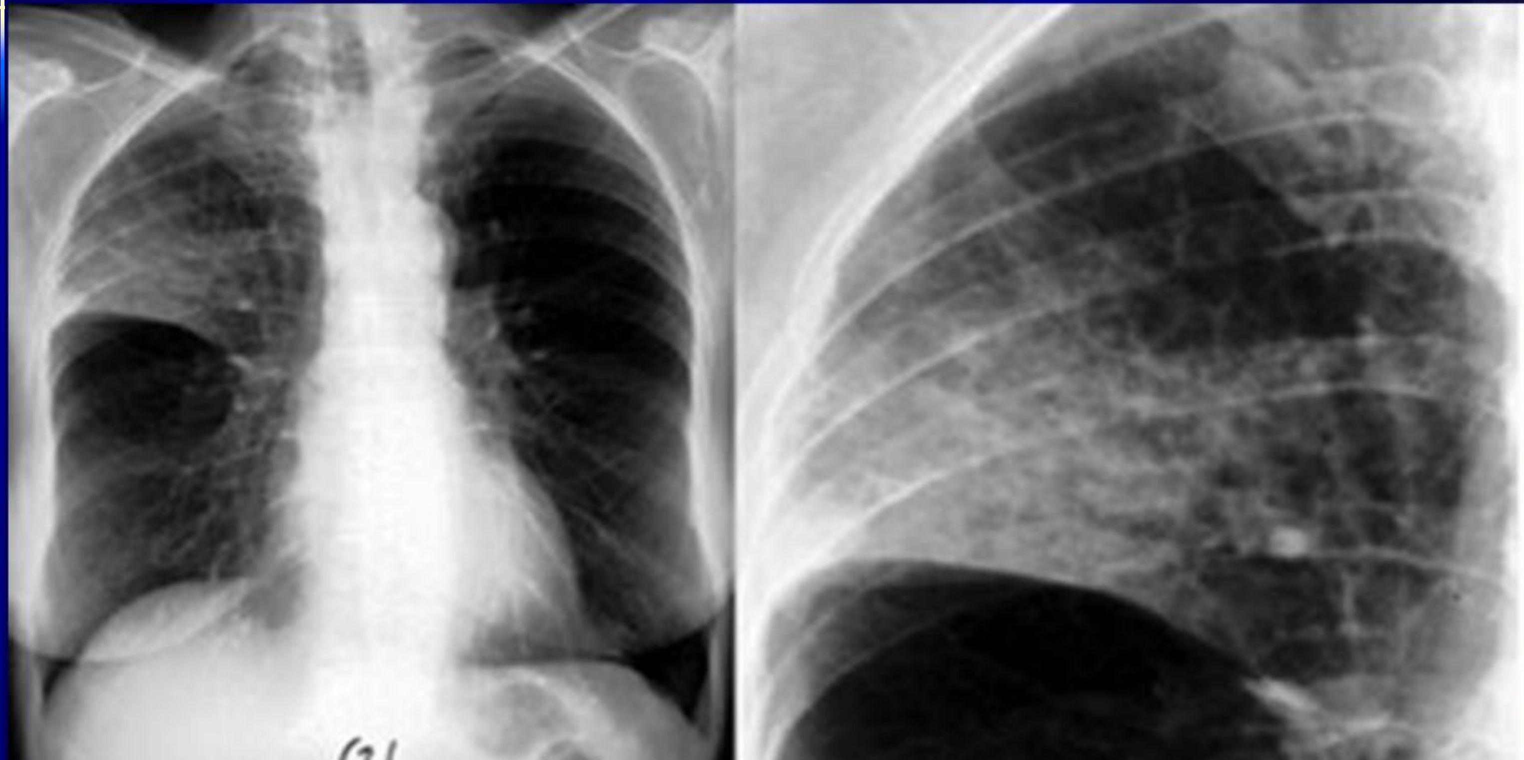


Frontal and lateral x-rays revealing right upper lobe consolidation.

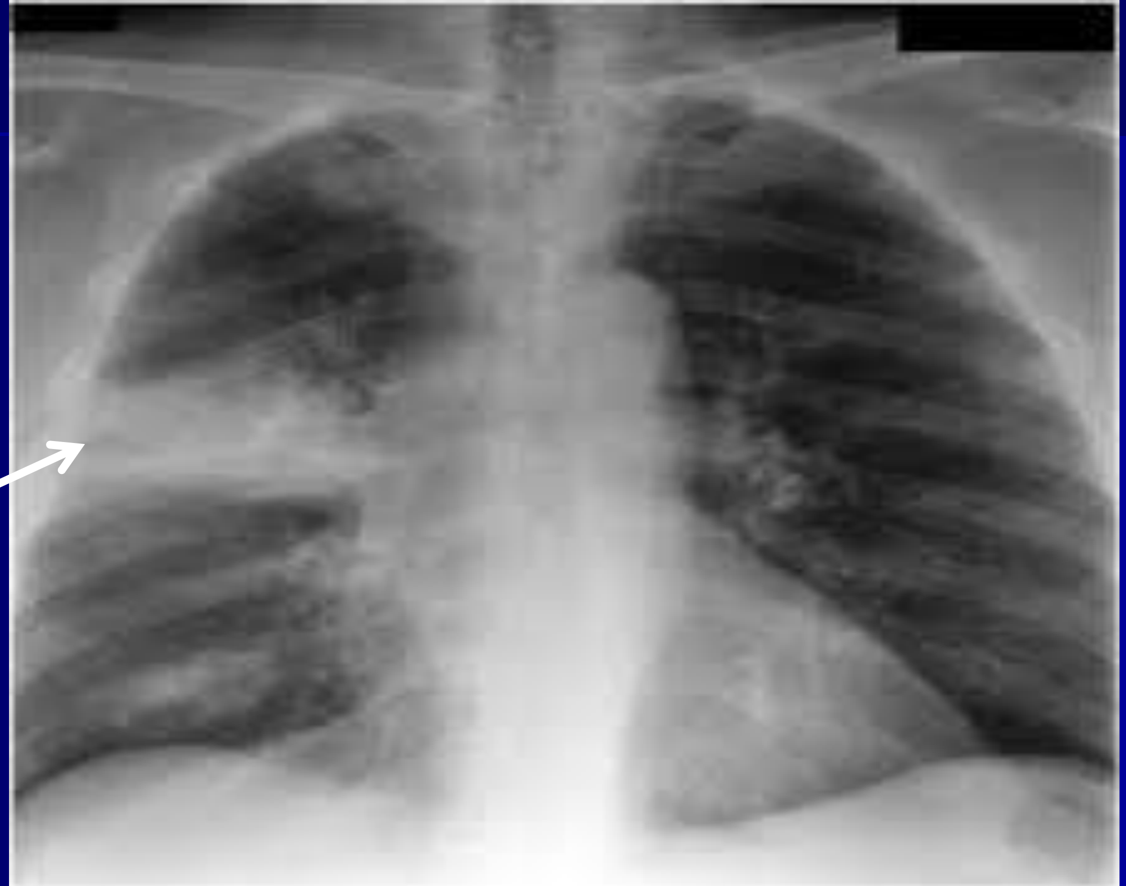
Chest CT scan demonstrating consolidation involving the posterior segment of the right upper lobe.



Segmental Pneumonia Right Upper lobe

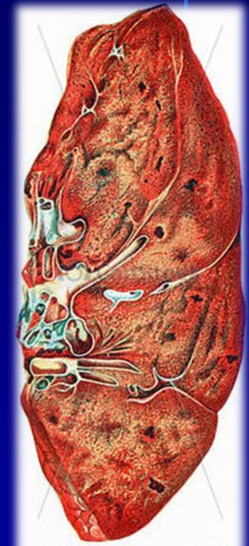


Segmental pneumonia



This is the triangular shadow of the upper lobe of the right lung

Croupous pneumonia



- A typical course of croupous pneumonia is observed **in children of preschool and school age**, rarely - at the age of 1-3 years and as an exception - in the first year of life.

- In the pathogenesis of croupous pneumonia, an important role belongs to allergic reactivity, which develops in a pneumococcal sensitized organism prone to hyperergic reactions.

- The most common localization of croupous pneumonia in children is the upper or lower lobe of the right lung.

Morphologic Changes in Lobar Pneumonia

- A classic example of acute inflammation.
- It involves FOUR STAGES:

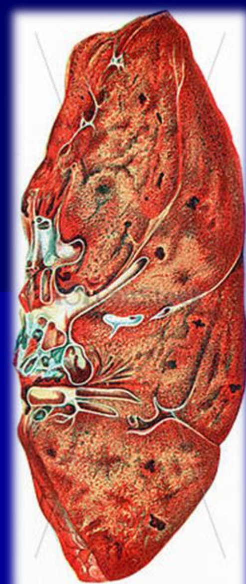
1st STAGE: STAGE OF CONGESTION: This stage lasts for about 24 hours and represents the outpouring of a protein rich exudate into alveolar spaces, with venous congestion. The lung is heavy, oedematous and red

2nd STAGE: STAGE OF RED HEPATIZATION: It last for a few days. In the alveolar spaces there is massive accumulation of neutrophils together with macrophages and lymphocytes. Numerous red blood cells are also extravasated from the capillaries. The lung is red, solid and airless, with a consistency resembling fresh liver.

3rd STAGE: GREY HEPATIZATION: It lasts a few days and represents further accumulation of fibrin, with destruction of white cells and red cells. The lung now is gray brown in colour and solid.

4th STAGE: RESOLUTION: It occurs at about 8 – 10 days in untreated cases and represents the resorption of exudate and enzymatic digestion of inflammatory debris, with preservation of underlying alveolar wall architecture

Croupous pneumonia

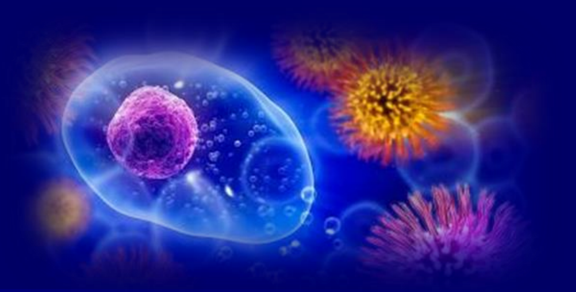

an Stock Photo - csp28125

- The disease begins with a **sudden increase in temperature to 39-40ºC, headache, acute disorder of the general condition (up to delirium, confusion), the appearance of a cough with "rusty" sputum, pain in the chest.**
- Many patients at the beginning of the disease complain of **pain in the right iliac region or near the umbilicus**. At the same time, **vomiting, bloating, diarrhoea are noted,** which urge a doctor to think about appendicitis, acute gastritis or peritonitis ("appendicular" form).

Croupous pneumonia
"appendicular" form

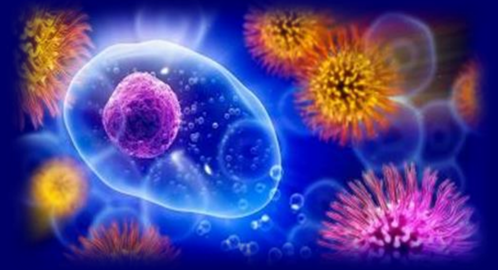
- Such a course of pneumonia is typical for its localization in the lower lobe of the right lung and is caused by viscero-visceral reflex.
- However, the unusual nature of dyspnea, the correspondence of the increase in heart rate to a rise in temperature, a certain delay of one half of the thorax when breathing, free abdominal excursions and the absence of a clear stiffness of the abdominal wall direct the doctor's thought to the right path.

Croupous pneumonia



In older children, the "appendicular" form is rare, and they usually complain of chest pain from the very beginning of the disease, often with irradiation in the back, shoulder, hypochondrium.

Croupous pneumonia
"meningeal" form



- In some children of preschool age, at the beginning of the disease, **delirium, neck stiffness, clonic convulsions join the high temperature, headache, vomiting,** which resembles the clinical symptoms of meningitis **("meningeal" form).**
- Such a course of pneumonia occurs more often with its localization in the upper lobe of the right lung. It is suggested that the genesis of this form is associated with the affection of the vagus nerve.

Croupous pneumonia

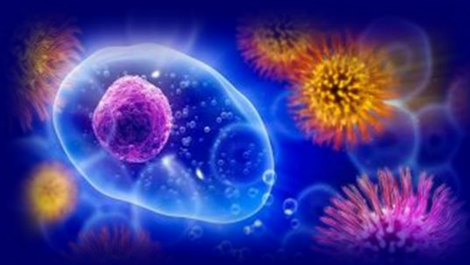
- When examining patients at the onset of the disease, attention is drawn to some of their depression, the pallor of the skin with red cheeks (usually only on the side of the lesion), shiny eyes, dry lips, herpes on the lips and wings of the nose (also on the side of the lesion), dyspnoea with participation of auxiliary muscles in the act of breathing (tension of the wings of the nose, inspiratory retraction of the jugular fossa).

- On the side of the beginning pneumonia, in comparison with a healthy one, the supraclavicular fossa appears deeper, and the shoulder is displaced forward and medially, that presents an impression of a shortening of the shoulder.

Croupous pneumonia

- When examining we reveal a **delay of one half of the chest in the act of breathing and limiting the mobility of the lower edge of the lung, swelling of the skin and a shortened tympanic sound over the lesion.**
- In the first hours of the disease, **moaning breathing occurs**, a **short and painful cough with a small amount of viscous, vitreous sputum**, which soon becomes "**rusty“.** During deep inspiration, the child has pain in the side.

Croupous pneumonia



- Clinical analysis of blood in patients with croupous pneumonia is characterized by
- **significant leukocytosis,**
- **neutrophilia with pronounced shift to the left,**
- **increased ESR.**
- **X-ray** examination reveals a **focus of infiltration, occupying the whole lobe or part of it.**

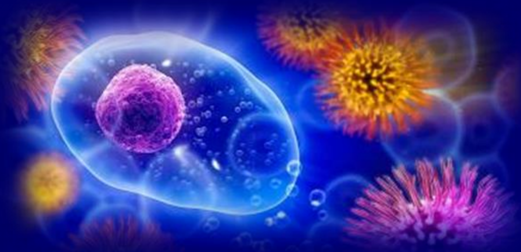
Croupous pneumonia

The duration of the disease in children depends on the nature of therapy and the reactivity of the organism.

In the pre-antibiotic era, high fever decreased either critically or lytically on 5-7-9 days of the disease.

It was regarded as the beginning of recovery.

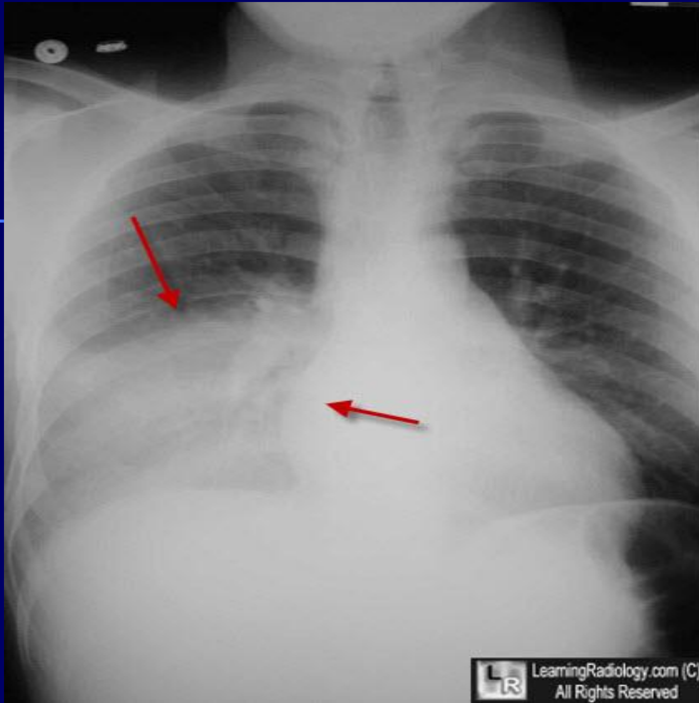
Croupous pneumonia

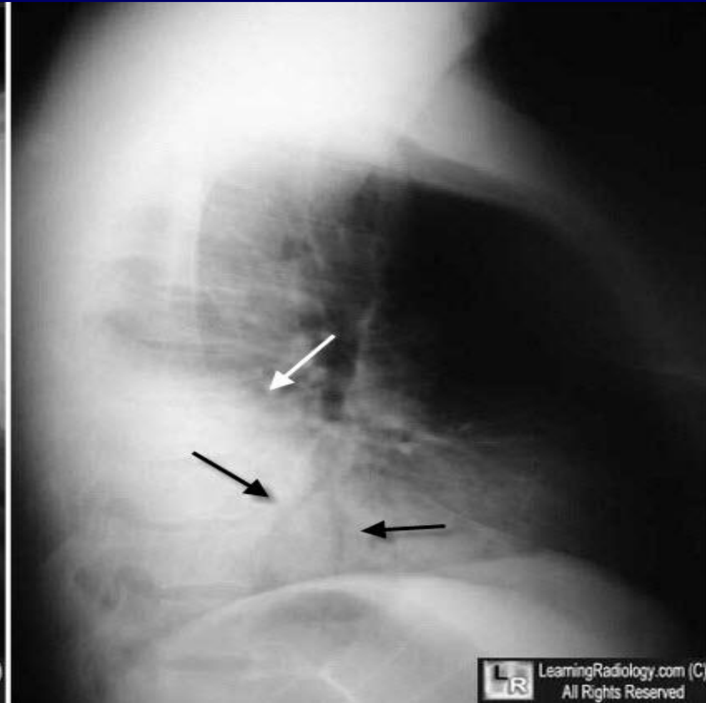


With treatment of antibiotics, this pattern is not noted: the temperature can decrease at an earlier time.

The patient's condition gradually improves, the cough becomes more moist, but cough with "rusty" sputum which is typical for adults is rare in children.

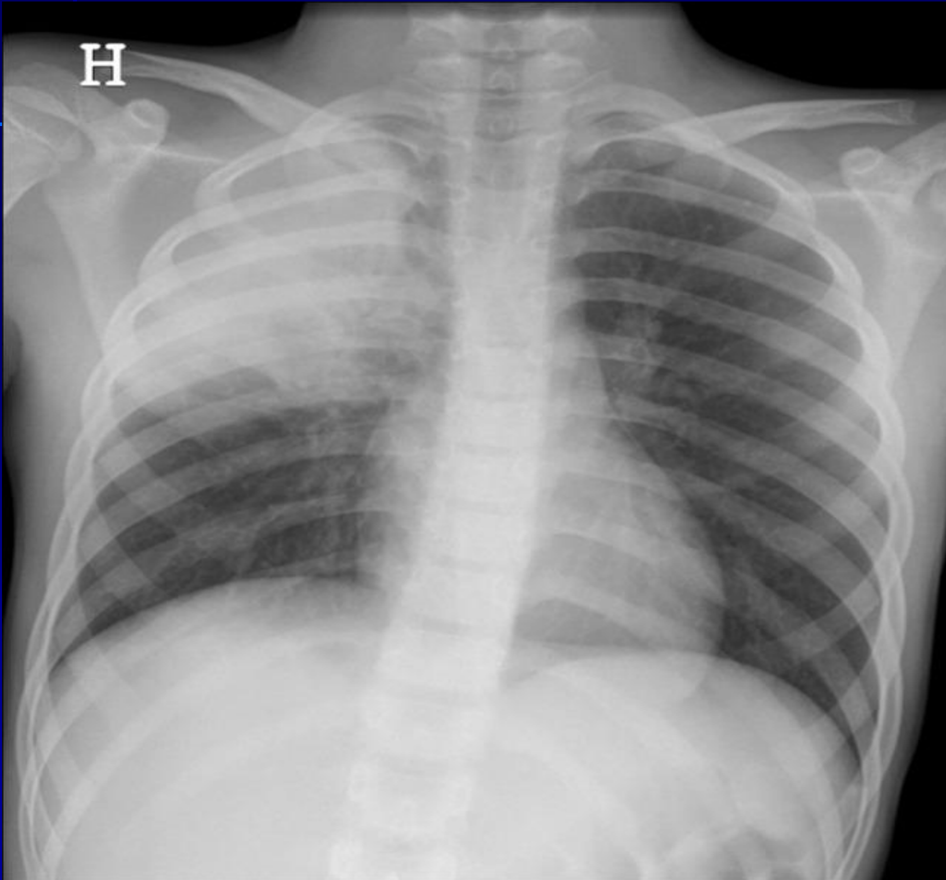
Crepitation which was heard at the beginning of the disease (crepitatio indux), disappears and then reappears at the time of resolution of pneumonia (crepitatio redux).





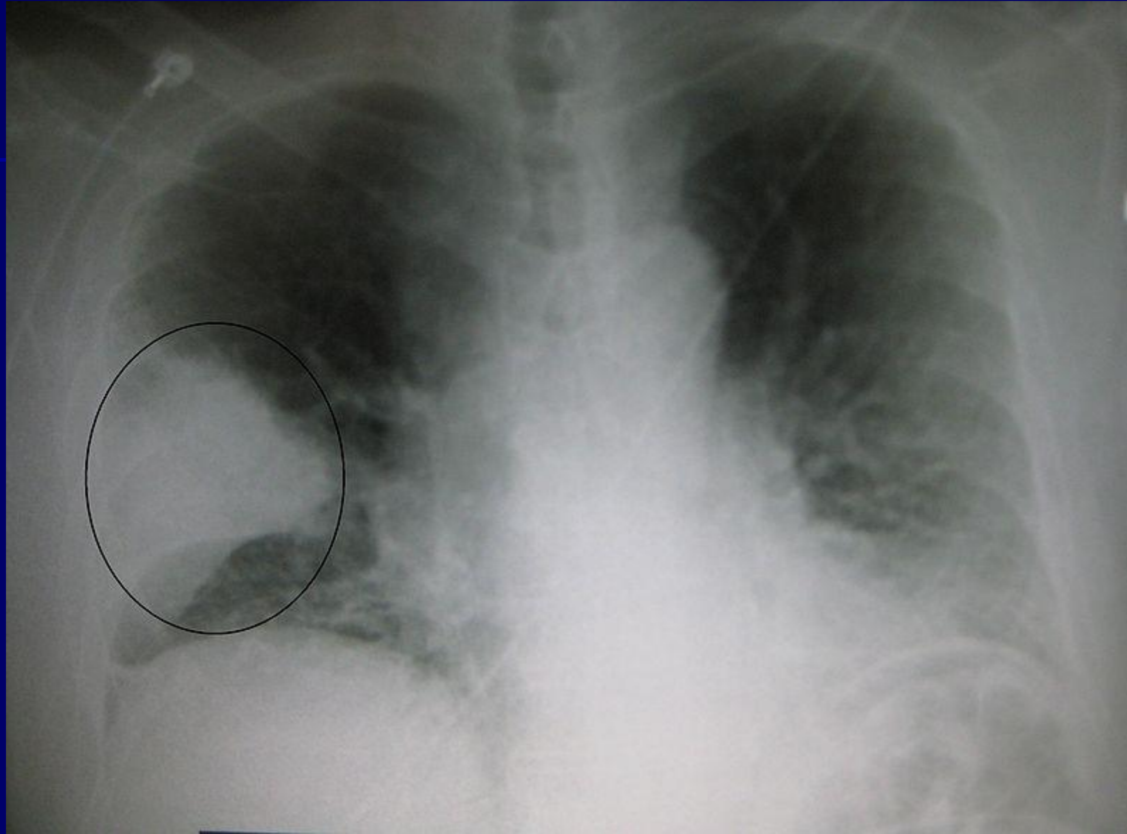
Right Lower Lobe Pneumonia. The frontal view shows an airspace density in the right lower lung field (red arrows) that has a distribution corresponding to the location of the right lower lobe. The lateral view confirms the pneumonia is posterior (white arrow), and contains two, black-branching structures that are air bronchograms (black arrows)

Croupous pneumonia



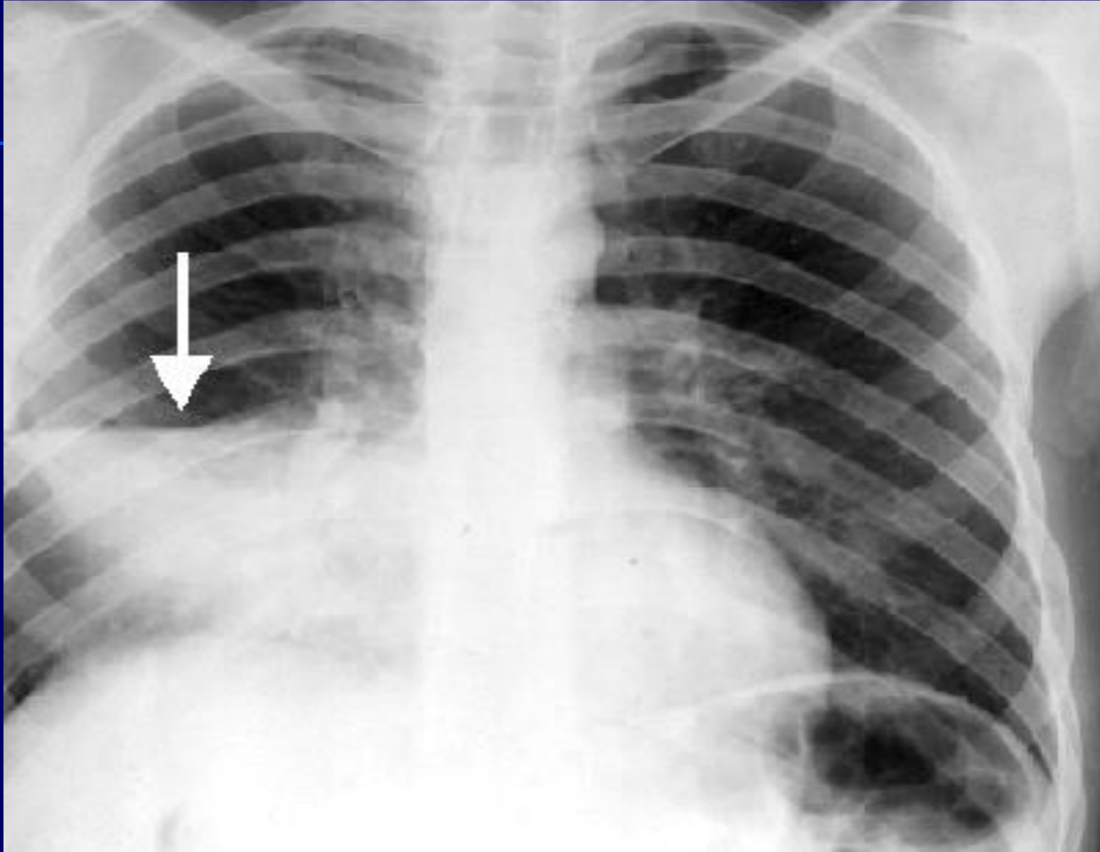
Chest radiography of a 9-year-old boy. Lobar opacity without volume reduction in the right upper lobe

Croupous pneumonia



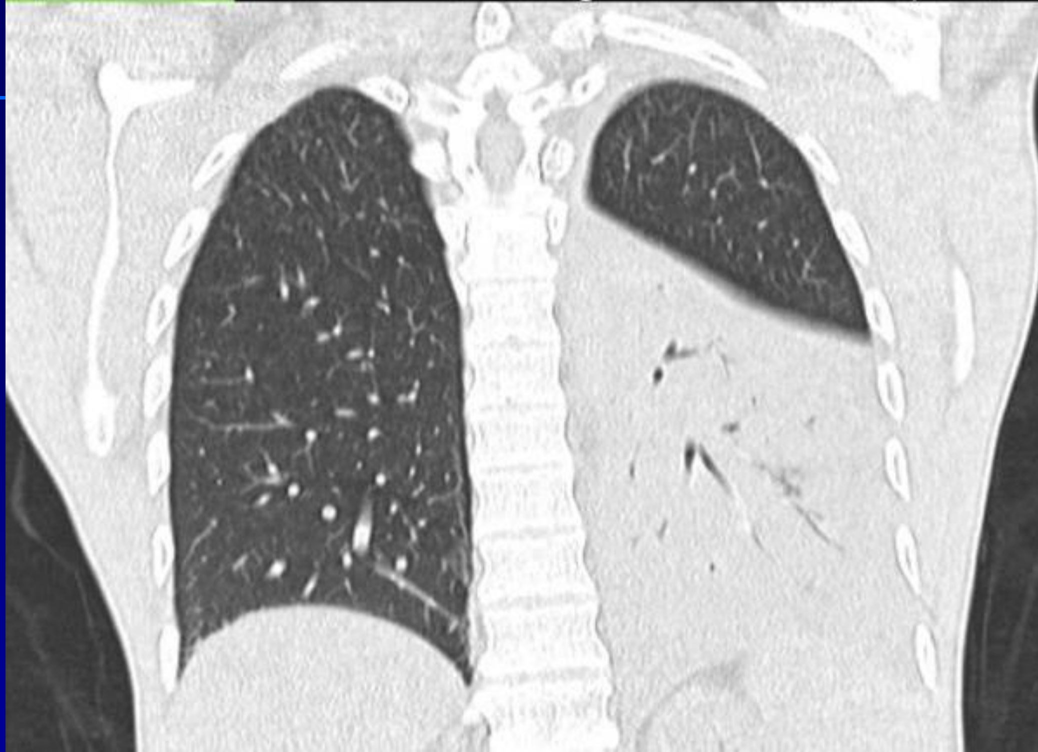
Lobar pneumonia of the middle lobe.

Croupous pneumonia



Lobar pneumonia of the lower lobe

Croupous pneumonia



CT

Strongly dense pulmonary tissue with positive aerobronchogram in a patient with pneumonia in the upper lobe

Interstitial pneumonia

- **Etiology**

In pneumonias, with radiological interstitial type, the etiology is different.

It is caused by

- **viruses,**
- **pneumocysts,**
- **pathogenic fungi,**
- **streptococcus,**
- **and isolated from the patient virus not always can be identified (giant cell interstitial pneumonia).**

Interstitial pneumonia

Pathogenesis

- Most acute interstitial pneumonia should be attributed to the toxic forms of focal pneumonia (cardiovascular form).

In such patients, the following stages of pulmonary involvement are noted:

1 - generalized spasm of arterioles,

2 - local thrombohemorrhagic syndrome,

3 - surfactant deficiency and alveolar collapse, leading to the development of lung microatelectases.

There are 2 types of interstitial pneumonia.

1. **Manifest, acute type.**

- It occurs in children of early and preschool age with allergic diathesis.
- The disease begins severely, with symptoms of neurotoxicosis and respiratory failure (sudden dyspnea with a respiratory rate of up to 80-100 per minute, cyanosis of the nasolabial triangle, nails, and if anxiety is present - generalized cyanosis, tension of nasal wings, intercostal retraction), fever, appearance of frequent and painful cough.

Catarrhal phenomena in the lungs are indistinct:

- single unstable high dry rhonchi **are auscultated**, less often crepitation, and only with the accompaniment of bacterial infection - wet râles.

- **On percussion**, tympanic sound is noted, low position of the edges of the lungs, narrowing of the borders of relative cardiac dullness, dilatation of the pulmonary hilus, more often one-sided. Shortening of the percussion tone is not typical.

2. Oligosymptomatic, subacute type.

It is observed more often in schoolchildren.

After acute respiratory disease, **complaints** of lethargy, fatigue, poor appetite, subfebrile temperature, headache, cough, weakness are preserved.

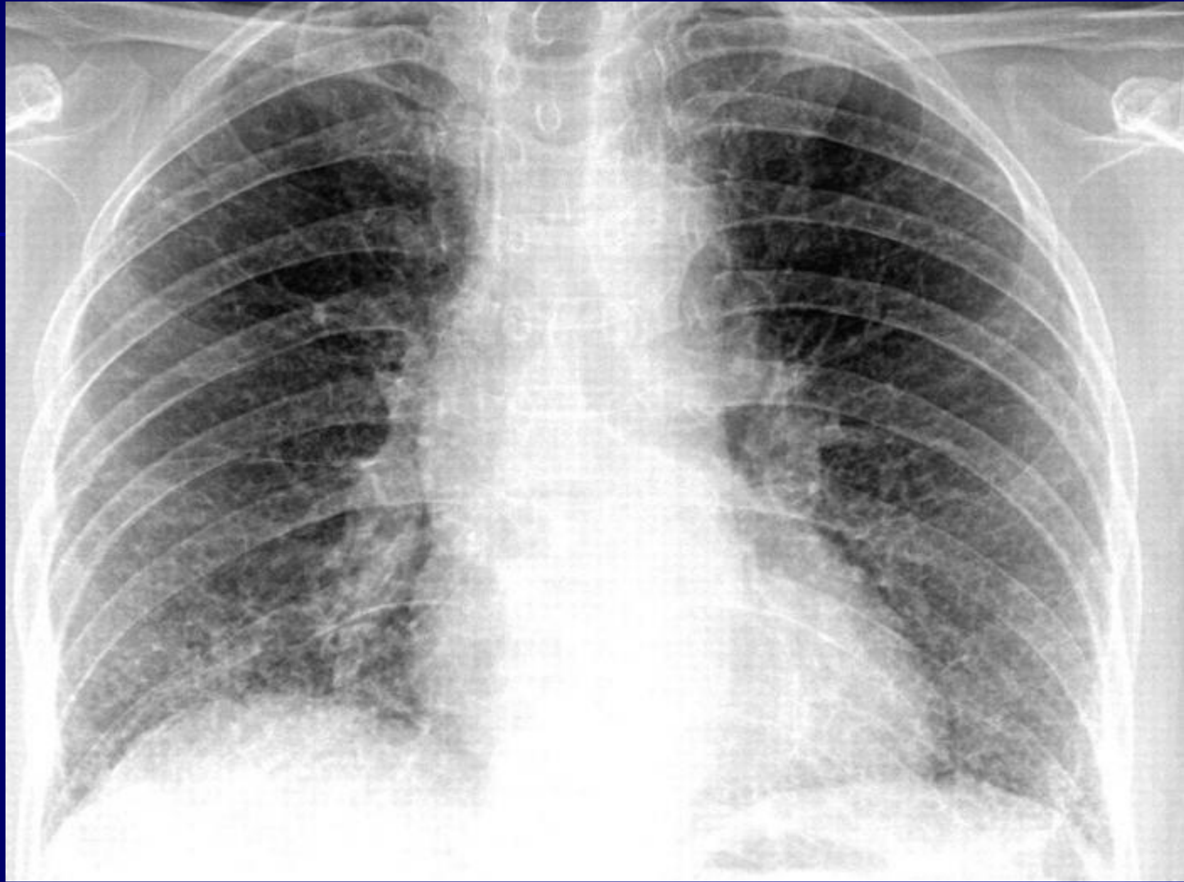
Physical data in these patients are scanty: moderately expressed signs of intoxication, shortness of breath after slight load, band box sound, sometimes dilatation of the pulmonary hilus, single dry râles. However, on chest X-ray there is convincing evidence of interstitial pneumonia.

Prognosis

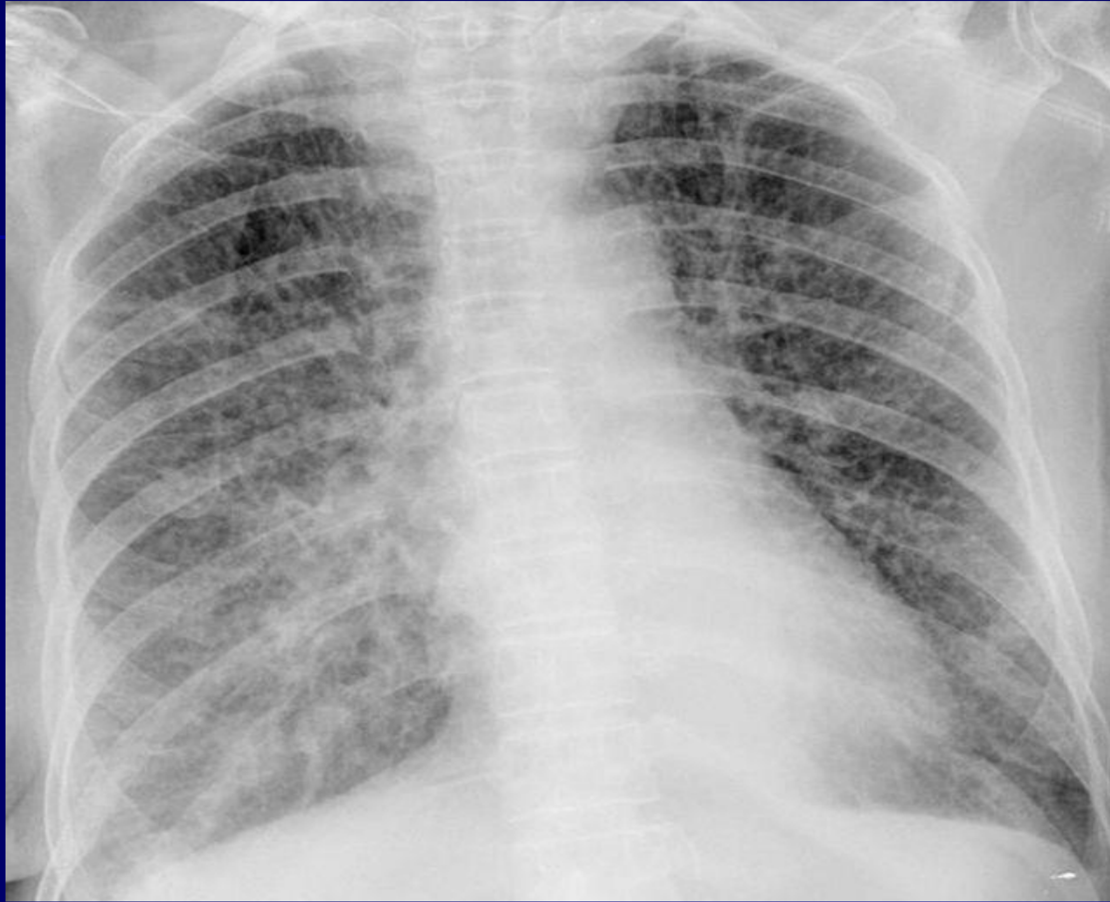
Prognosis of interstitial pneumonia of acute type is serious

Sometimes at the height of intoxication children die due to specific viral encephalitis and affection of internal organs by virus. Even with a favorable course of the disease, radiologic changes in the lungs last for 6-8 weeks or more.

The outcome of interstitial pneumonia can be pneumosclerosis and formation of bronchiectasis.



The chest x-ray reveals bilateral interstitial infiltrates.



CXR showing typical findings of bilateral interstitial infiltrates

Complications of pneumonia

Extrapulmonary

General disorders

- Toxic-septic state
- Infection-toxic shock
- DVS (disseminated intravascular coagulation syndrome)

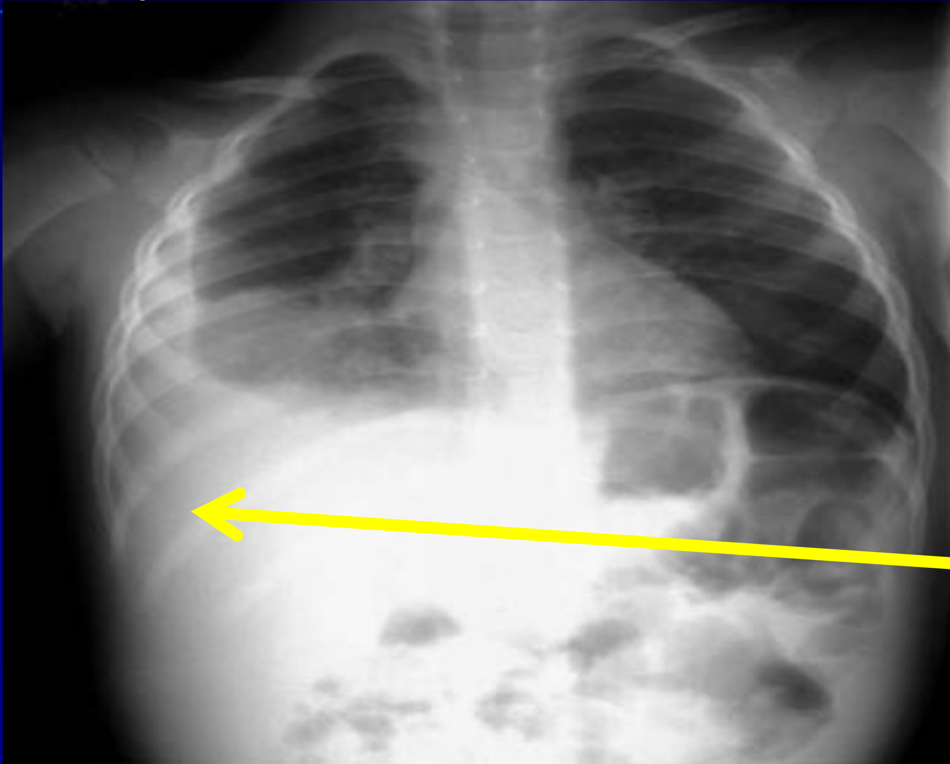
Inflammation of different organs

- Sinusitis
- Otitis
- Pyelonephritis
- Meningitis
- Osteomyelitis

Pulmonary complication of pneumonia

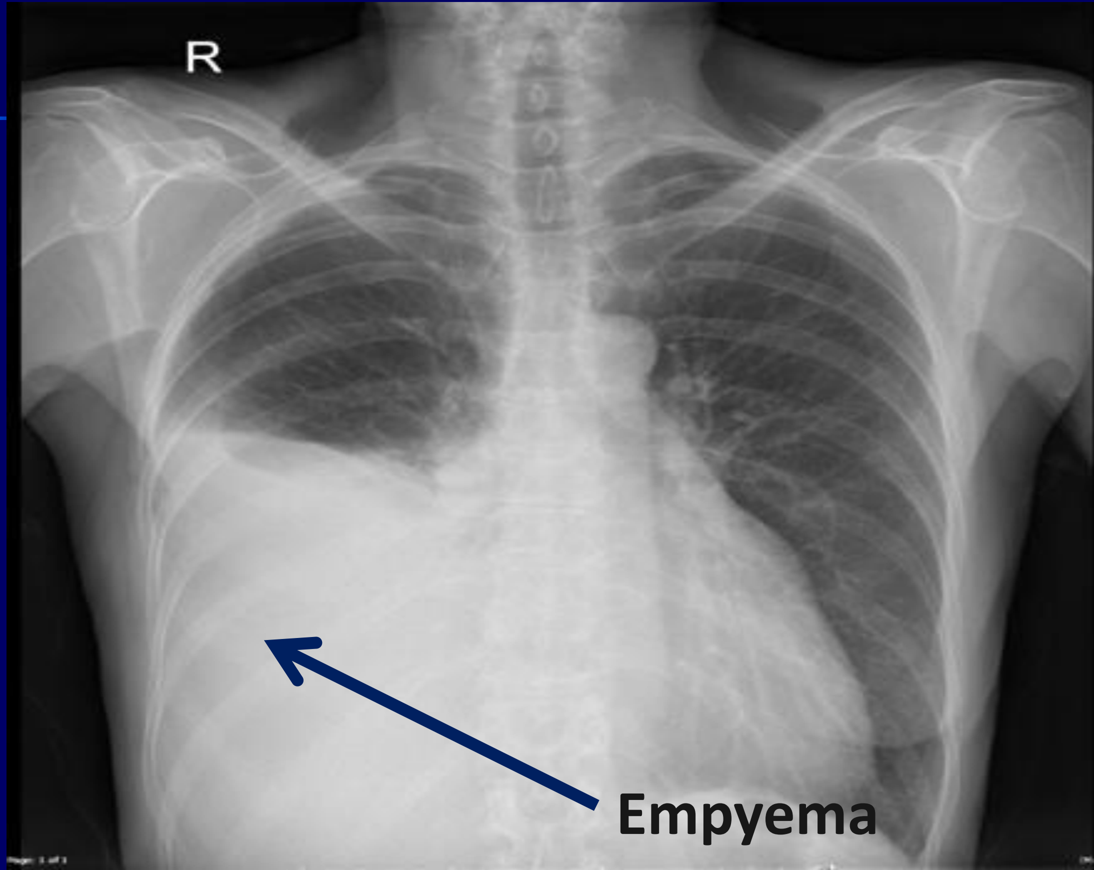
- Destruction
- Abscess
- Pleurisy
- Pneumothorax

Pulmonary complication of pneumonia

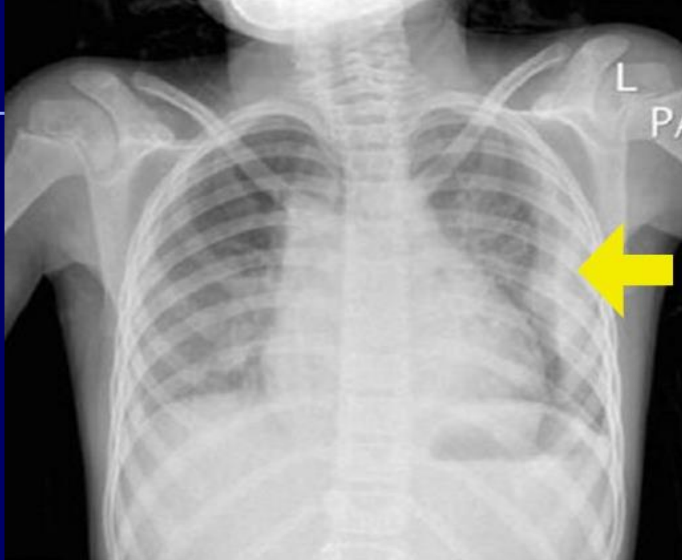


This radiograph reveals pneumonia into the right middle lobe and the development of **a large parapneumonic pleural effusion.**

Pulmonary complication of pneumonia

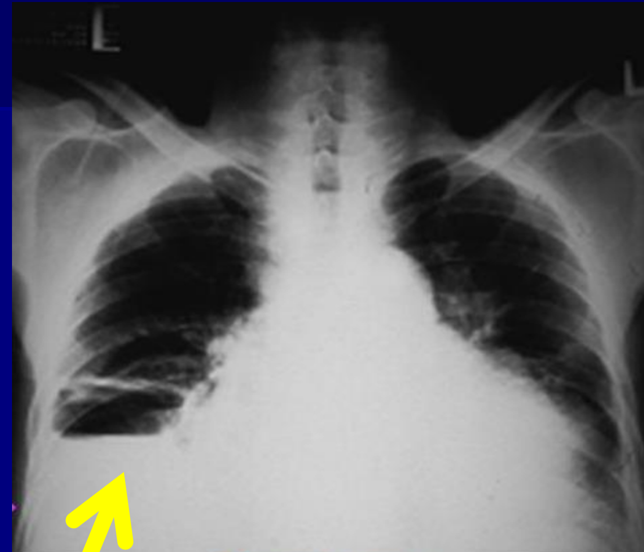


Pulmonary complication of pneumonia



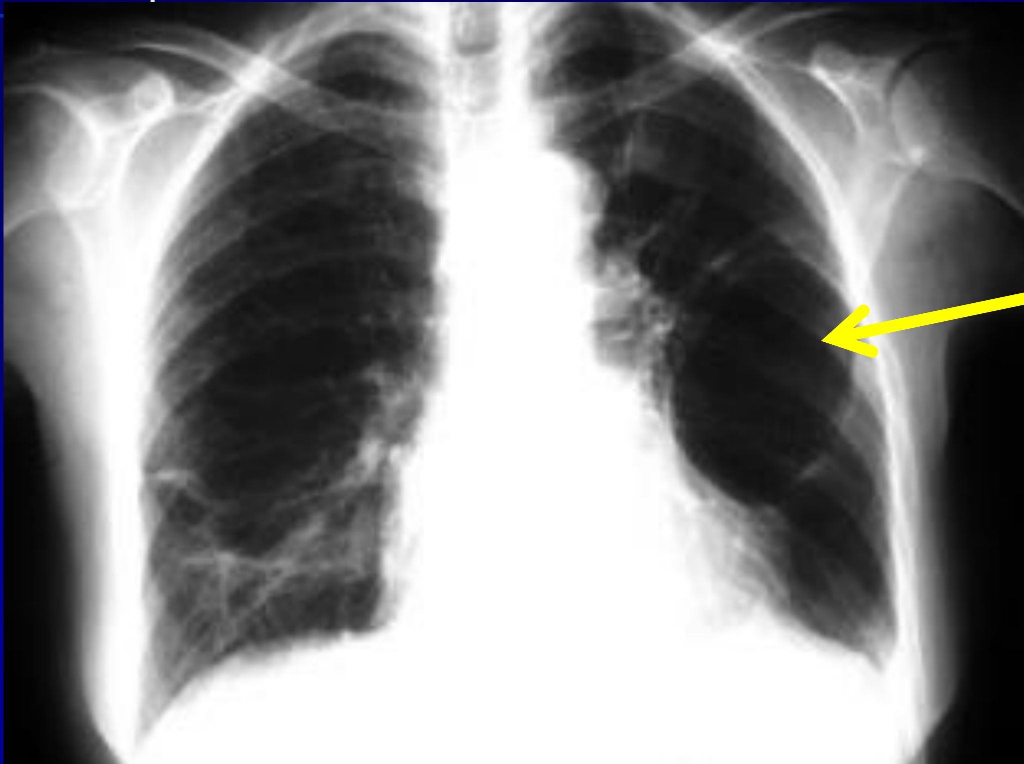
Pleural effusion

The radiograph shows parietal (paracostal) effusion.



The radiograph shows the filling of the lower pleural sinus.

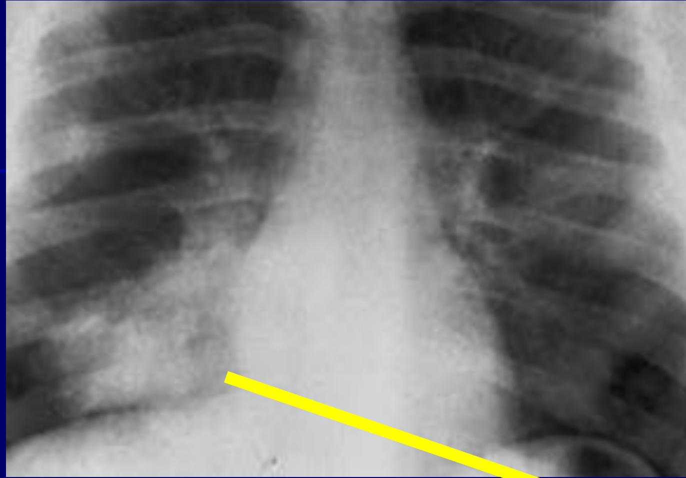
Pulmonary complication of pneumonia

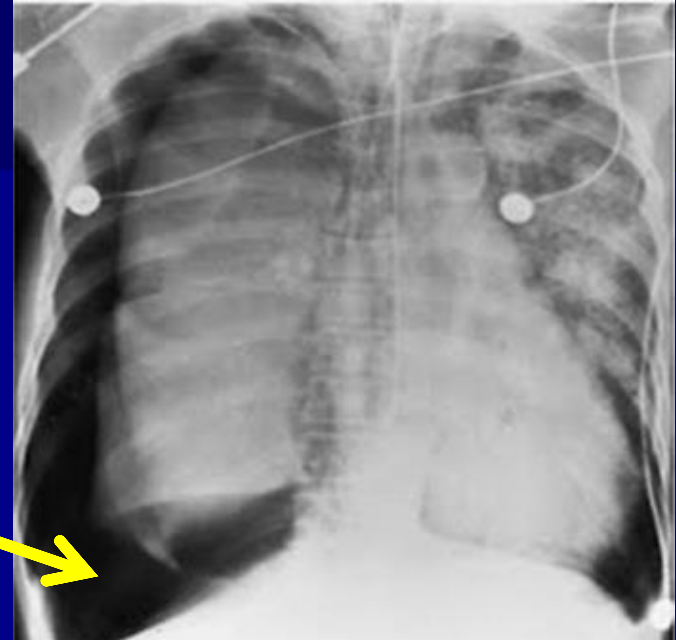


Chest X-ray after one week treatment, no longer showing consolidated area in the lung.
Although the **cystic image (pneumatocele)** is still visible in the left hemithorax.

Pulmonary complication of pneumonia

A





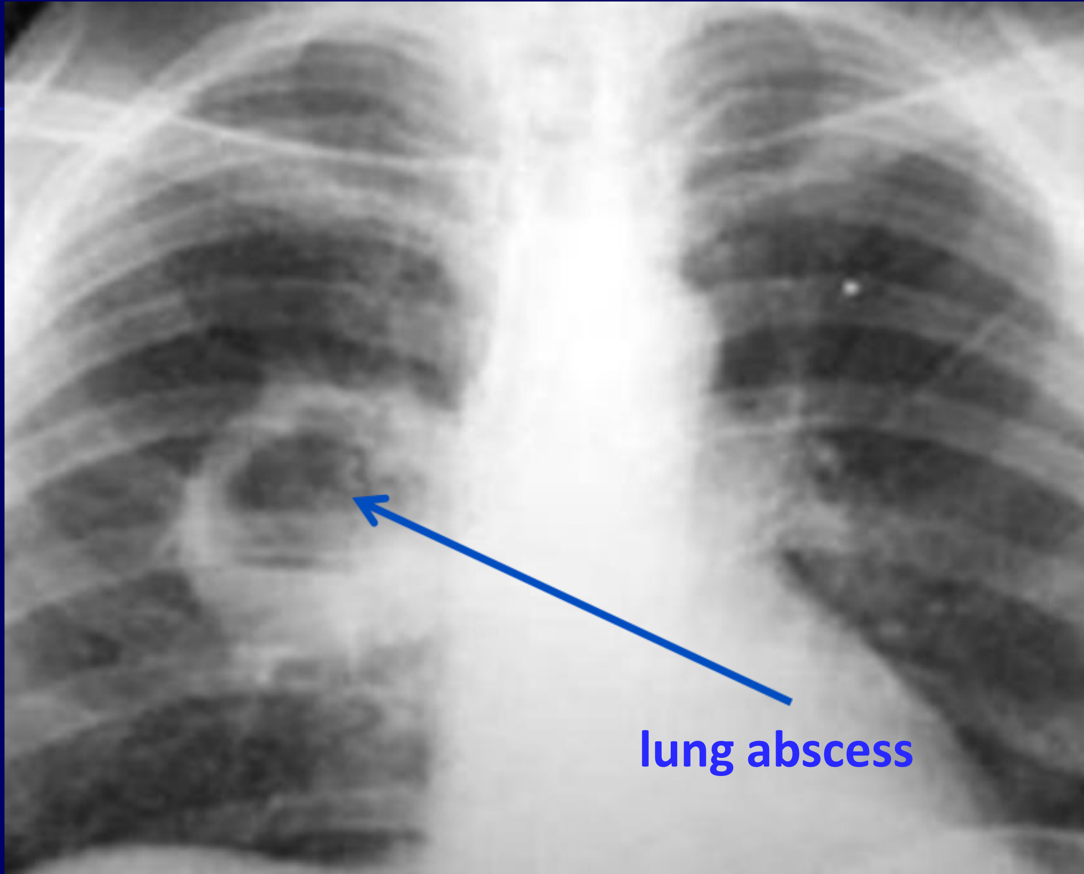
B

Staphylococcal pneumonia.

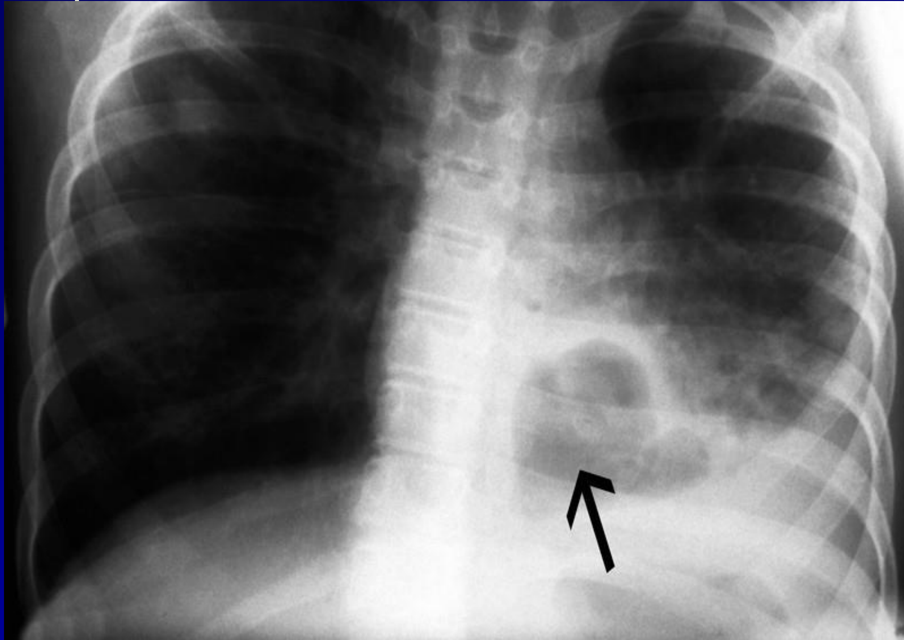
A - defined bronchopneumonia at the right base.

B – There is consolidation in the left upper lobe and entire right lung with a moderate **right pneumothorax**. The extensive consolidation presents further collapse of the right lung. The pneumothorax was due to the rupture of a pneumatocele.

Pulmonary complication of pneumonia

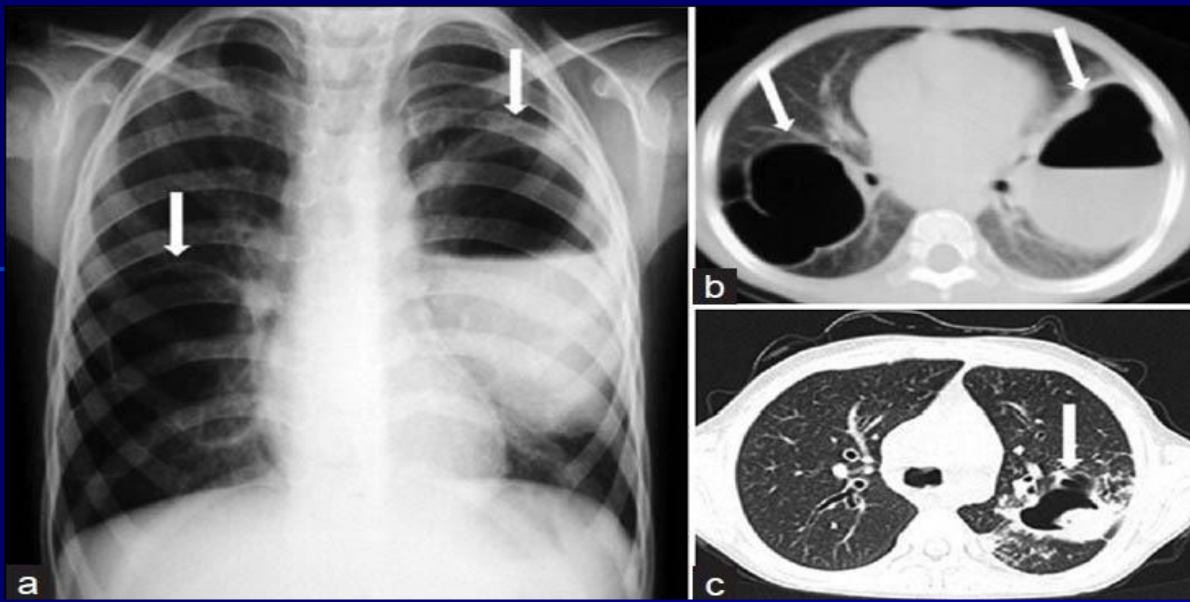


Pulmonary complication of pneumonia



This is chest x-ray of a young girl with an **aspiration pneumonia**.
The girl also had with a neurodevelopmental disability.

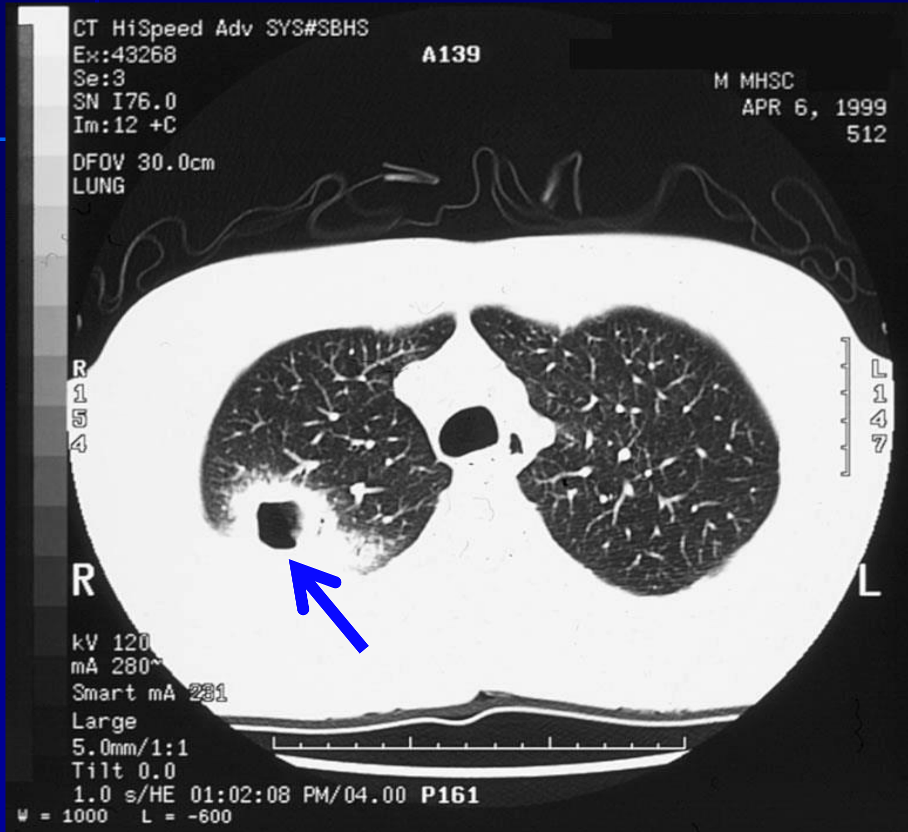
There is a **lung abscess** which has developed secondary to aspiration.
There is also extensive consolidation around the abscess.



Complicated staphylococcal pneumonia associated with hyperimmunoglobulin E syndrome (Job's syndrome) in a 5-year old girl.

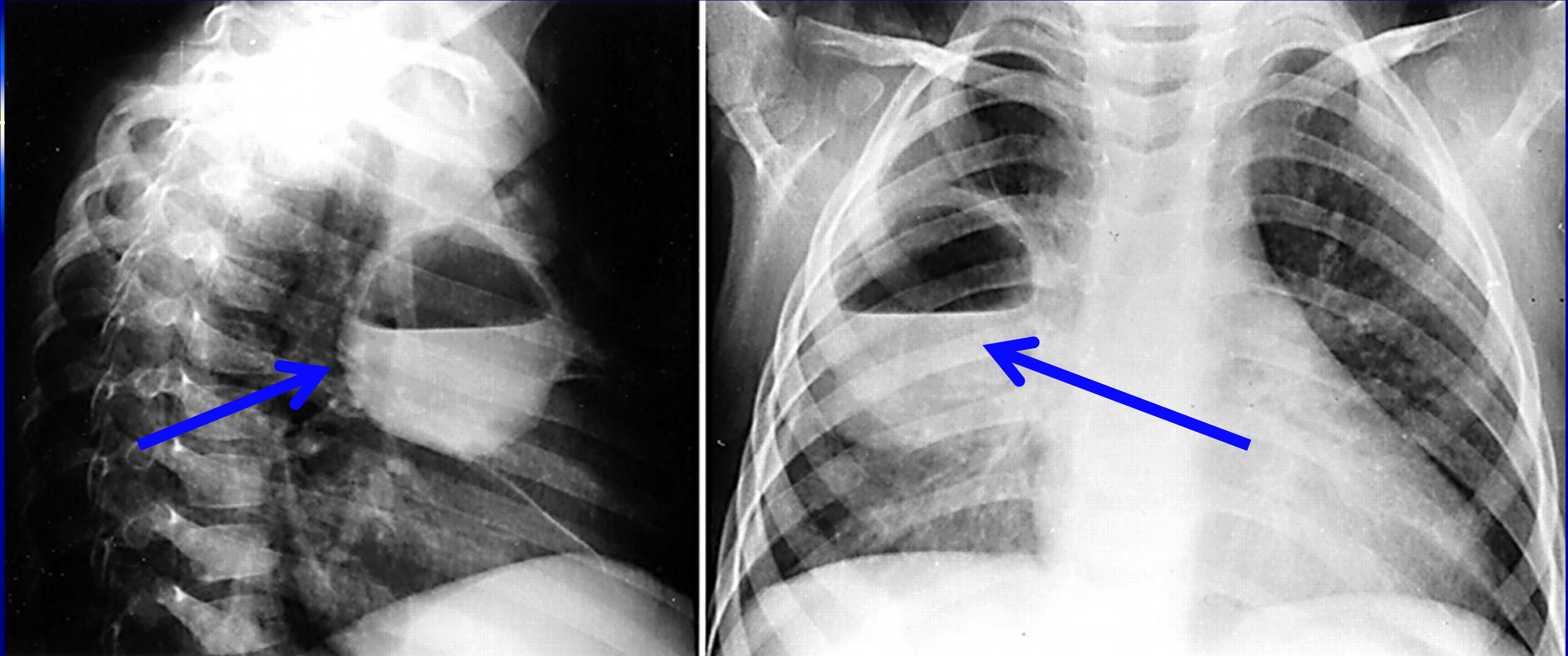
a) Chest radiograph and b) CT scan show **bilateral pneumatoceles** with thin walls (white arrows) on the right and with air-fluid level on the left (white arrow). c) Follow-up CT scan obtained 4 years after the initial CT scan shows a **fungus ball or mycetoma within the pneumatocele** (white arrow) on the left. Diagnosis was confirmed at post-mortem examination.

Pulmonary complication of pneumonia



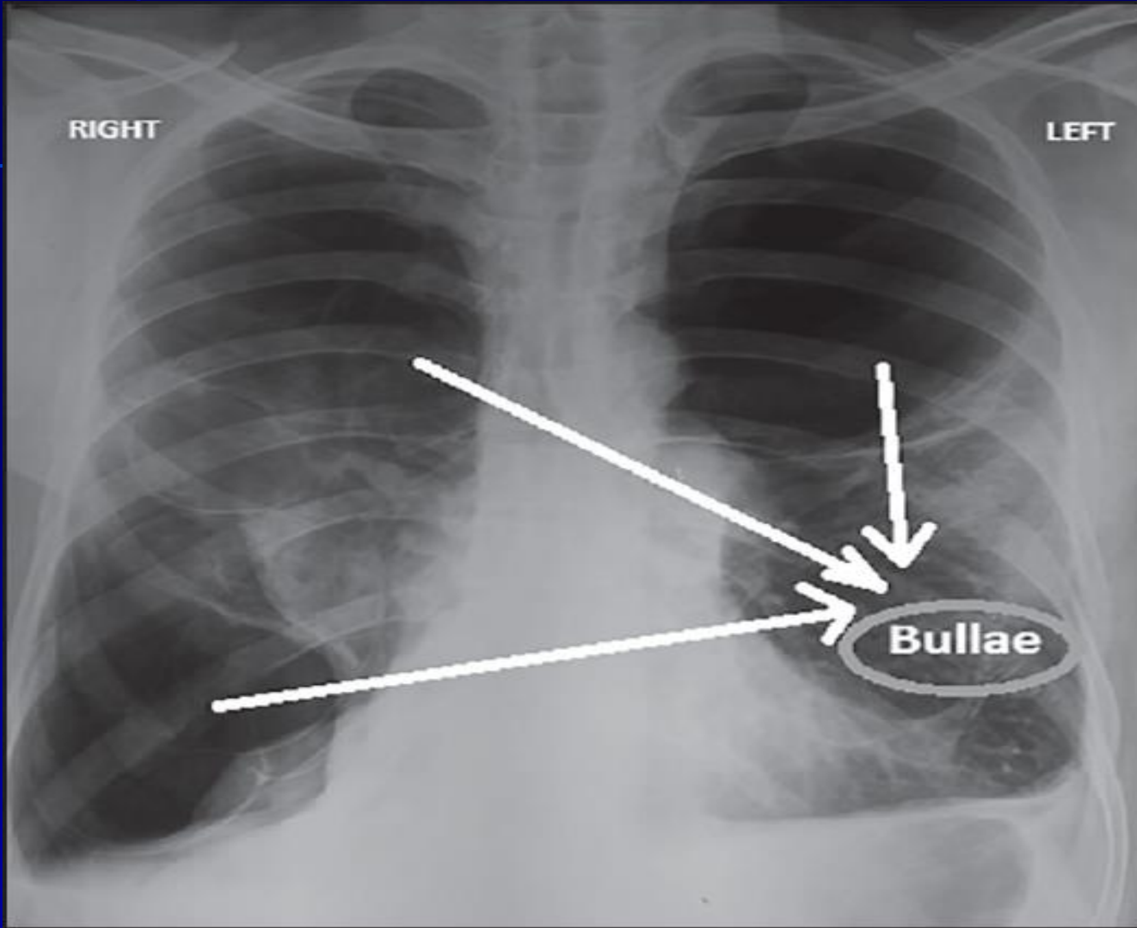
CT scan shows a thin-walled **cavity of lung abscess** with surrounding consolidation

Pulmonary complication of pneumonia



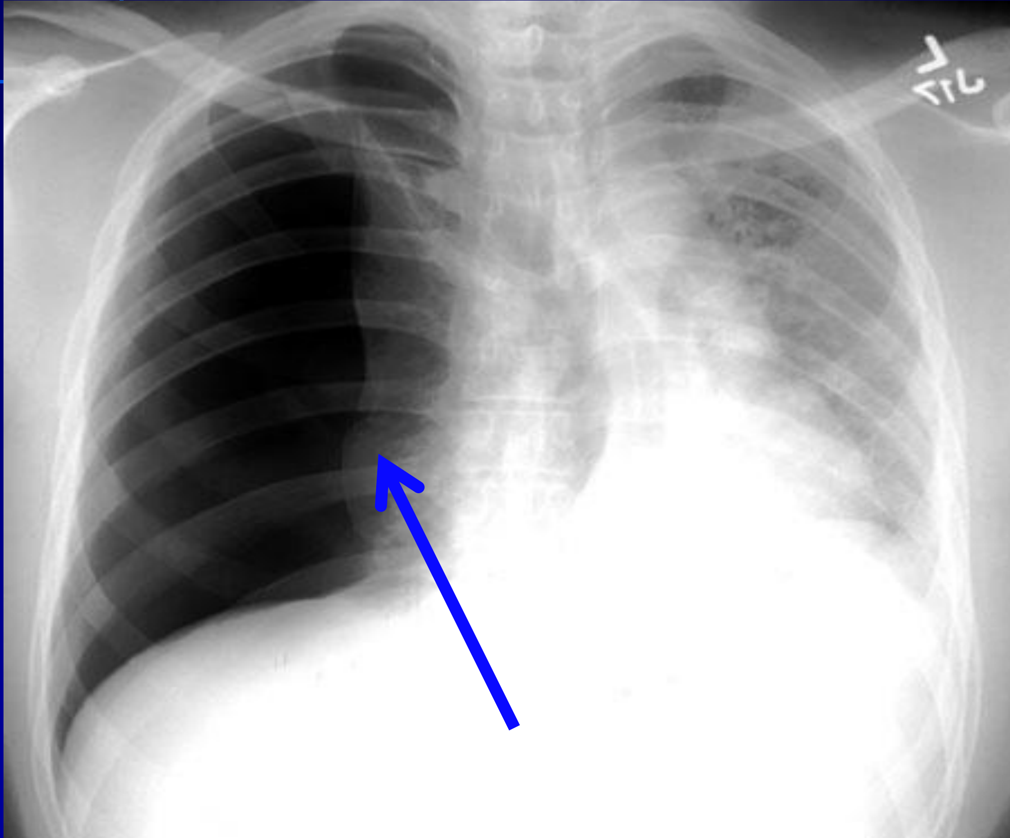
Anteroposterior and lateral chest X- ray showing air **fluid level into the cavity (abscess).**

Pulmonary complication of pneumonia



Chest X-ray showing bullae in right upper and lower lobe and giant bullae in left upper lobe

Pulmonary complication of pneumonia



The film shows a **right sided tension pneumothorax** with right sided lucency and leftward mediastinal shift.

Treatment

- Most cases of pneumonia can be treated at home. However babies, children with severe pneumonia may need to be admitted to hospital for treatment.

- Pneumonia is usually treated with antibiotics, even if viral pneumonia is suspected as there may be a degree of bacterial infection as well.

- The type of antibiotic used and the way it is given will be determined by the severity and cause of the pneumonia.

Treatment

If able to be treated at home, treatment usually includes:

- ✓ Antibiotics - given by mouth as tablets or liquid
- ✓ Pain relieving medications
- ✓ Paracetamol or Ibuprofen to reduce fever
- ✓ Rest.

Antitussives are NOT indicated

Treatment

If treatment in hospital is required, treatment usually includes:

- ✓ Antibiotics given intravenously (via a drip into a vein)
- ✓ Oxygen therapy - to ensure the body gets the oxygen it needs
- ✓ Intravenous fluids - to correct dehydration or if the person is too unwell to eat or drink
- ✓ Physiotherapy - to help clear the sputum from the lungs.

Hospitalization

Most children can be treated as outpatients

Admit if:

- Toxic appearance;
- Respiratory compromise, including marked tachypnea (>60 breaths/min in infant and
- > 40-50 breaths/min in older children);
- Hypoxemia (SpO2 < 92-94% in room air);
- Dehydration or inability to maintain oral hydration or tolerate oral medications.

Hospitalization

Admit if:

- Young age – < 6 months of age;
- Underlying diseases:
  - - cardiac disease
  - - renal disease
  - - hematological disease
- Inability of family to provide care at home;
- Failure of outpatient therapy

Treatment

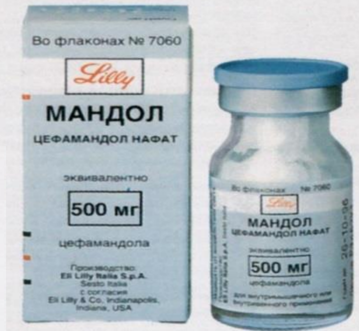
Initial priorities in children with pneumonia include the identification and treatment of respiratory distress, hypoxemia, and hypercarpnia.

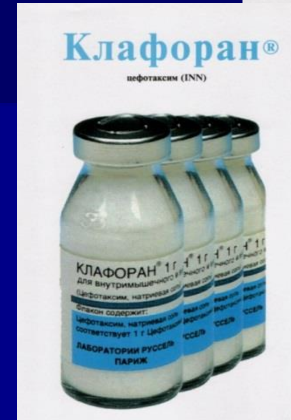
Grunting, flaring, severe tachypnea, and retractions should prompt immediate respiratory support. Children who are in severe respiratory distress should undergo tracheal intubation if they are unable to maintain oxygenation or have decreasing levels of consciousness.

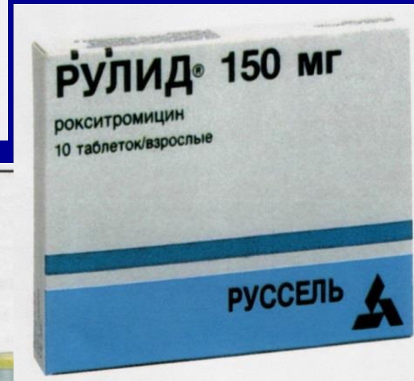
Antibiotic therapy

- I – beta-lactam:
  - Penicillin;
  - Cephalosporin;
  - Carbopenem;

- Aminoglycoside
- Macrolide
- Linkozamide – linkomycin, clindomycin
- Vancomycin







Treatment in hospital

- **Bacterial**

- 1 month
  - Ampicillin (75–100 mg/kg/day)
  - Gentamicin (5 mg/kg/day)

- >> 1 - 3 months
  - Cefuroxime (75–150 mg/kg/day) or
  - Amoxiclav (20/5 mg/kg/day – 60/15 mg/kg/day)

Treatment

Supportive for atypical pneumonia

- **Chlamydia and mycoplasma** should be treated with

Erythromycin 40–50 mg/kg/day usually orally.

Azithromycin 10 mg/kg/day

Clarithromycin 15-30 mg/kg/day

- If **pneumocystis carinii** pneumonia is suspected

Co-trimoxazole 18–27 mg/kg/day IV should be prescribed.

Treatment

Patients are treated as an outpatient:

- Children < 5 yr:

  high dose **amoxicillin (80-90 mg/kg/d)** for 7-10 d

- Children > 5 yr:

  increased prevalence of M. pneumoniae and C. pneumoniae - **MACROLIDE** is reasonable choice

- Older children with signs most consistent with S. pneumoniae infection (lobar infiltrate, increased WBC or inflammatory markers) - **AMOXICILLIN** may be used;

Treatment
Patients requiring admission:

- **IV AMPICILLIN 150-200 mg/kg/d**
- May used 2-nd or 3-rd generation **cephalosporins**;
- Consider combining beta-lactam and macrolide;

Treatment
Children with more severe disease:

Consider other organisms including

Methicillin-resistant S. aureus (MRSA)

- **Vancomycin;**
- **3-rd generation cephalosporin, plus Clindamycin;**

Treatment

Age	Start	Alternative
6 mo.-6 yr	**Ampicillin 100 mg/kg/day** or **amoxiklav 20-40 mg/kg** (Amoxicillin/clavulanate)	**Cefuroxime (Zinacef)** **Cefotaxime (Claforan)** **Clarithromycin** **Azithromycin**

Treatment

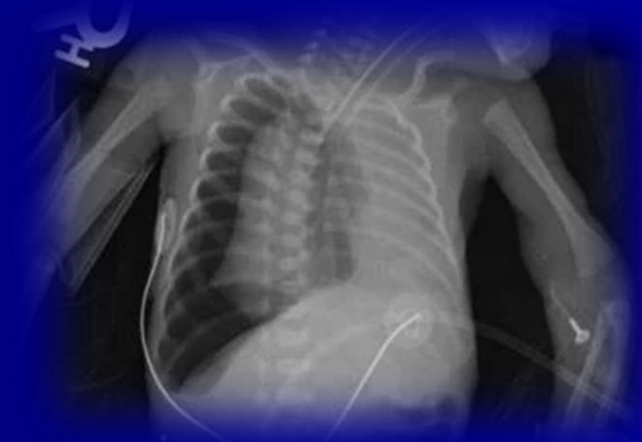
Age	Start
6 mo.-6 yr Complicated	**Ceftazidime 150 mg/kg/day or** **Cefotaxime or ceftriaxone** **+ netilmicin (Netromycin)** **(6-7.5 mg/kg)** **(amikacinum 15 mg/kg)**

Treatment

Age	Start
6 mo – 6 yr atypical	- Azithromycin 10 mg/kg or Clarithromycin 15-30 mg/kg/day
6 mo – 6yr atypical complicated	Rovamycine 1 500 000 IU per 10 kg

Pneumothorax
Treatment & Management

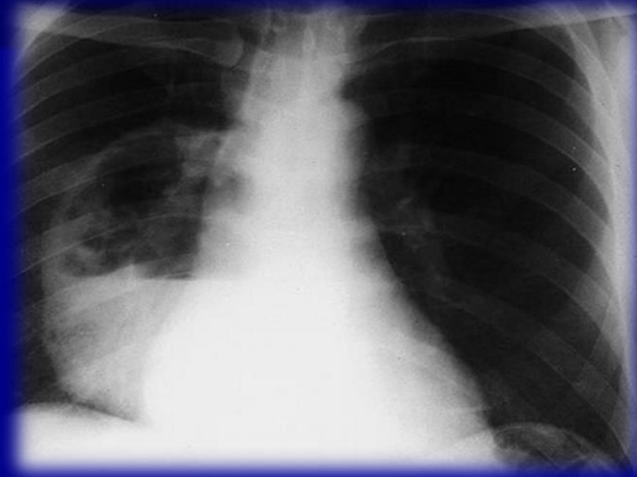
Large or significantly symptomatic pneumothoraces require chest tube placement and surgical intervention.



A tension pneumothorax requires immediate decompression with needle thoracostomy.

Empyema and Abscess Pneumonia Treatment & Management

Lung abscesses typically respond well to antibiotic therapy, but when that therapy is unsuccessful, the consulting clinician might consider percutaneous catheter drainage or endoscopic surgical resection of the involved area of the lung.



Complicated parapneumonic effusions or empyemas require drainage in addition to medical therapy to ensure a good prognosis.

Prevention

- avoiding infectious contacts (difficult for many families who use daycare facilities)

- vaccination is the primary mode of prevention.

Introduction of the conjugated HIB vaccine, conjugated and unconjugated polysaccharide vaccines for S pneumoniae, influenza vaccine

Summary

- Pneumonia is a common infection in children;
- Pneumonia is the commonest cause of mortality;
- Fast breathing in a child with cough or difficulty breathing is highly sensitive and specific for diagnosis;
- Tachypnea is the most useful physical sign.
- Most children can be treated as outpatients; therapy should be guided by probable etiology and severity of disease.

Thank You
For Your Attention