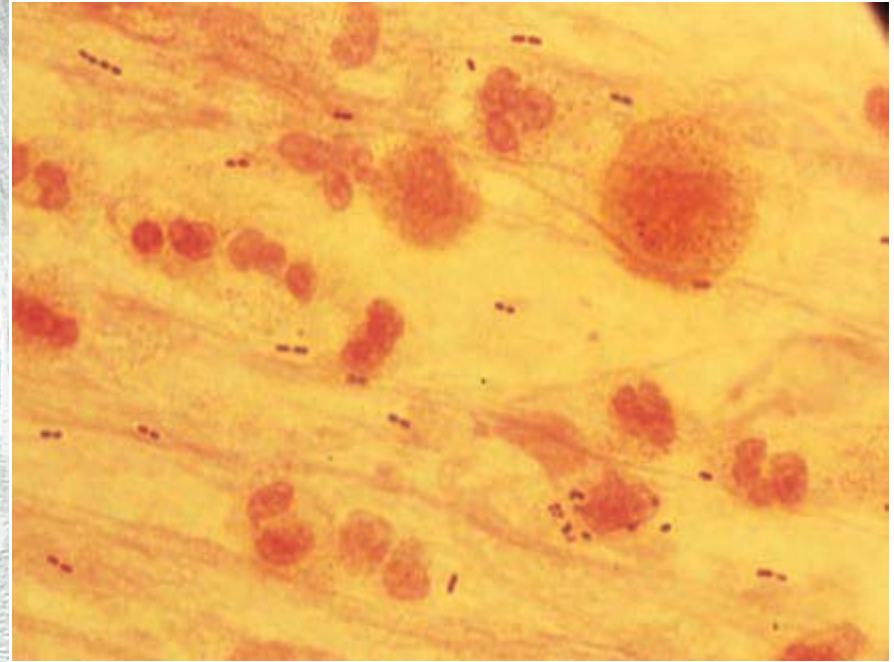
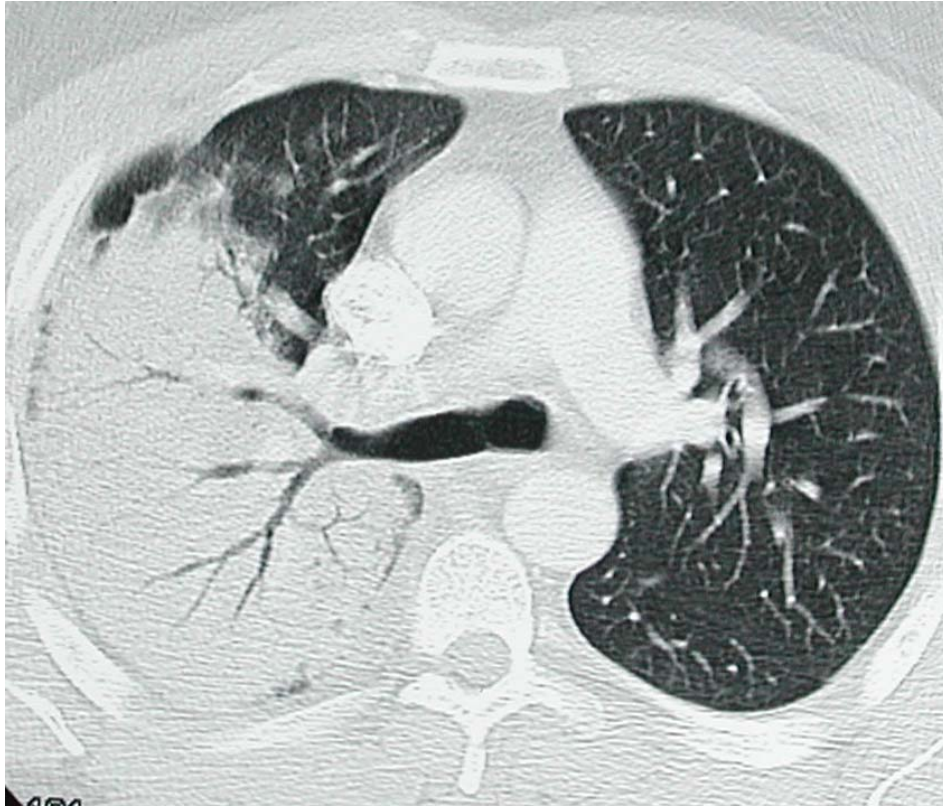


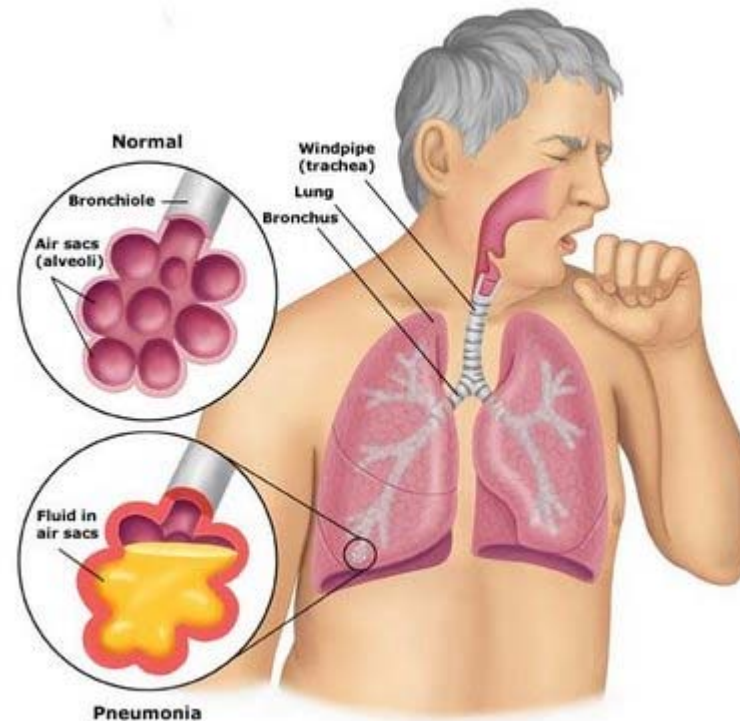
# Pneumonia



Dr Deepak Aggarwal  
Dept. Of Pulmonary Medicine

# What is pneumonia?

- **Lung parenchyma/ alveolar** (air-filled sacs of the lung responsible for absorbing oxygen from the atmosphere)  
**inflammation and (abnormal) alveolar filling with fluid.**



# Pneumonia

**Nosocomial pneumonia**

**Community acquired pneumonia**

**Hospital-acquired pneumonia (HAP)**

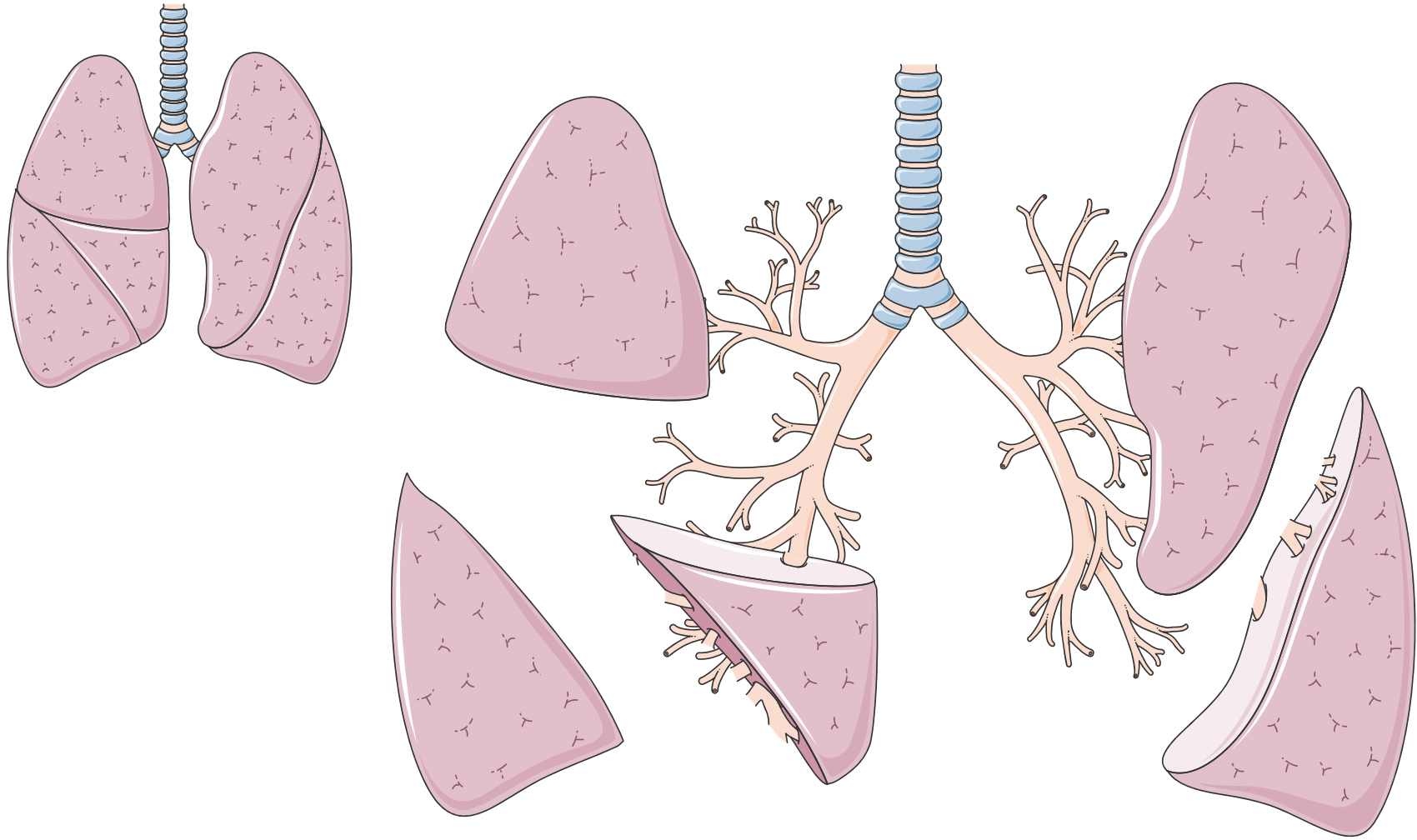
**Ventilator-associated pneumonia (VAP)**

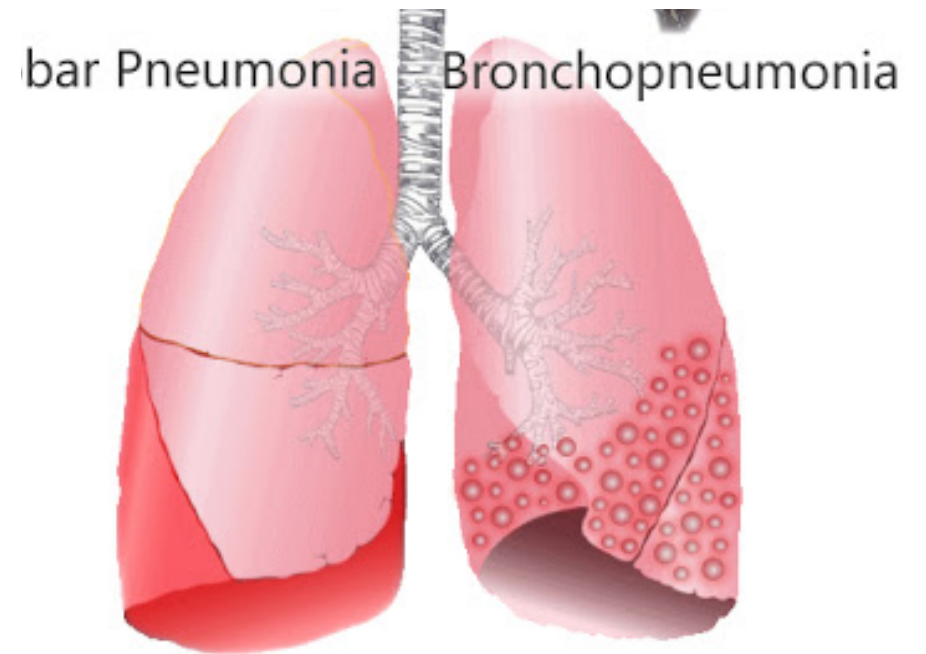
**Healthcare-associated pneumonia (HCAP)**

1. Bacterial
2. Viral
3. Fungal
4. Parasitic
5. eosinophilic

1. Lobar pneumonia
2. Bronchopneumonia
3. Interstitial pneumonia
4. Diffuse pneumonia

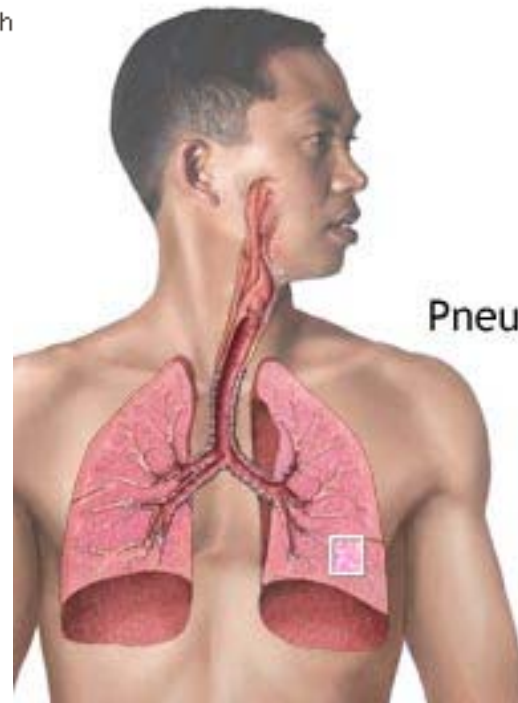
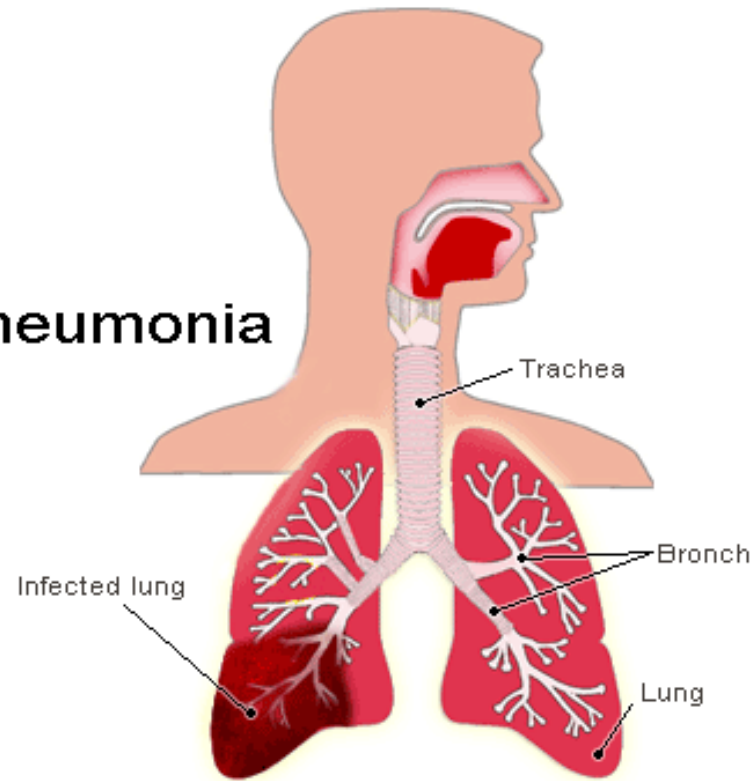
# Lobes







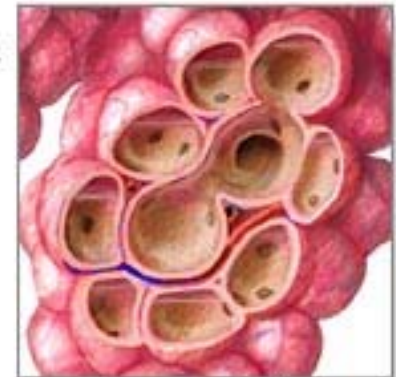
# Pneumonia



Normal alveoli



Pneumonia



# Community acquired pneumonia

- **Definition:**
  - ... an acute infection of the pulmonary parenchyma that is associated with at least some symptoms of acute infection, accompanied by the presence of an acute infiltrate on a chest radiograph, or auscultatory findings consistent with pneumonia, in a patient not hospitalized or residing in a long term care facility for  $\geq 14$  days before onset of symptoms.

# Community acquired pneumonia

- CAP can be defined both on clinical and radiographic findings.

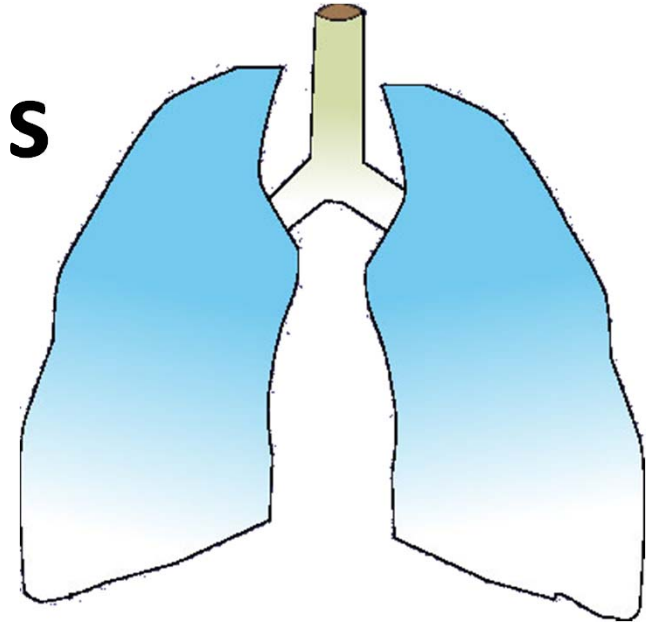
In the absence of chest radiograph, CAP is defined as:

- (a) symptoms of an acute lower respiratory tract illness (cough with or without expectoration, shortness of breath, pleuritic chest pain) for less than 1 week; and
- (b) at least one systemic feature (temperature  $>37.7^{\circ}\text{C}$ , chills, and rigors, and/or severe malaise); and
- (c) new focal chest signs on examination (bronchial breath sounds and/or crackles); with
- (d) no other explanation for the illness



- When a chest radiograph is available, CAP is defined as: symptoms and signs as above with new radiographic shadowing for which there is no other explanation (not due to pulmonary edema or infarction).

# Pathogenesis



- Inhalation
  - Aspiration
  - Hematogenous
- 
- **Primary inhalation:** when organisms bypass normal respiratory defense mechanisms or when the Pt inhales aerobic GN organisms that colonize the upper respiratory tract or respiratory support equipment

# Pathogenesis

- **Aspiration:** occurs when the Pt aspirates colonized upper respiratory tract secretions
- **Hematogenous:** originate from a distant source and reach the lungs via the blood stream.

# Risk factors

1. **Viral infections** (damage cilia and produce serous exudates)
2. **Age** (elderly- defect in swallowing, ↓ immunity)
3. **Alcoholism** (depress coughing and epiglottis function)
4. **Smoking** (damage epithelial cells and impair cilia functions)
5. **Asthma/COPD**
6. **Immunosuppression** (AIDS, transplant pt, cancer chemo)

# Risk factors

**7. Dementia**

**8. Diabetes Mellitus-** defective neutrophil function,  
↓ CMI

**9. Renal Failure-** ↓ humoral response, ↓ leukocyte  
chemotaxis, complement depletion

**10. Chronic lung diseases**

**11. Cold Weather** (dry mucous membrane and  
person to person spread)- common in winter

**12. Heart Disease-** Impaired lymphatics & alv  
macrophage function, edema promotes bacterial  
growth

# **Risk Factors in Patients Requiring Hospitalization**

- older, unemployed, unmarried**
- common cold in the previous year**
- asthma, COPD; steroid or bronchodilator use**
- Chronic disease**
- amount of smoking**
- alcohol NOT related to increased risk**

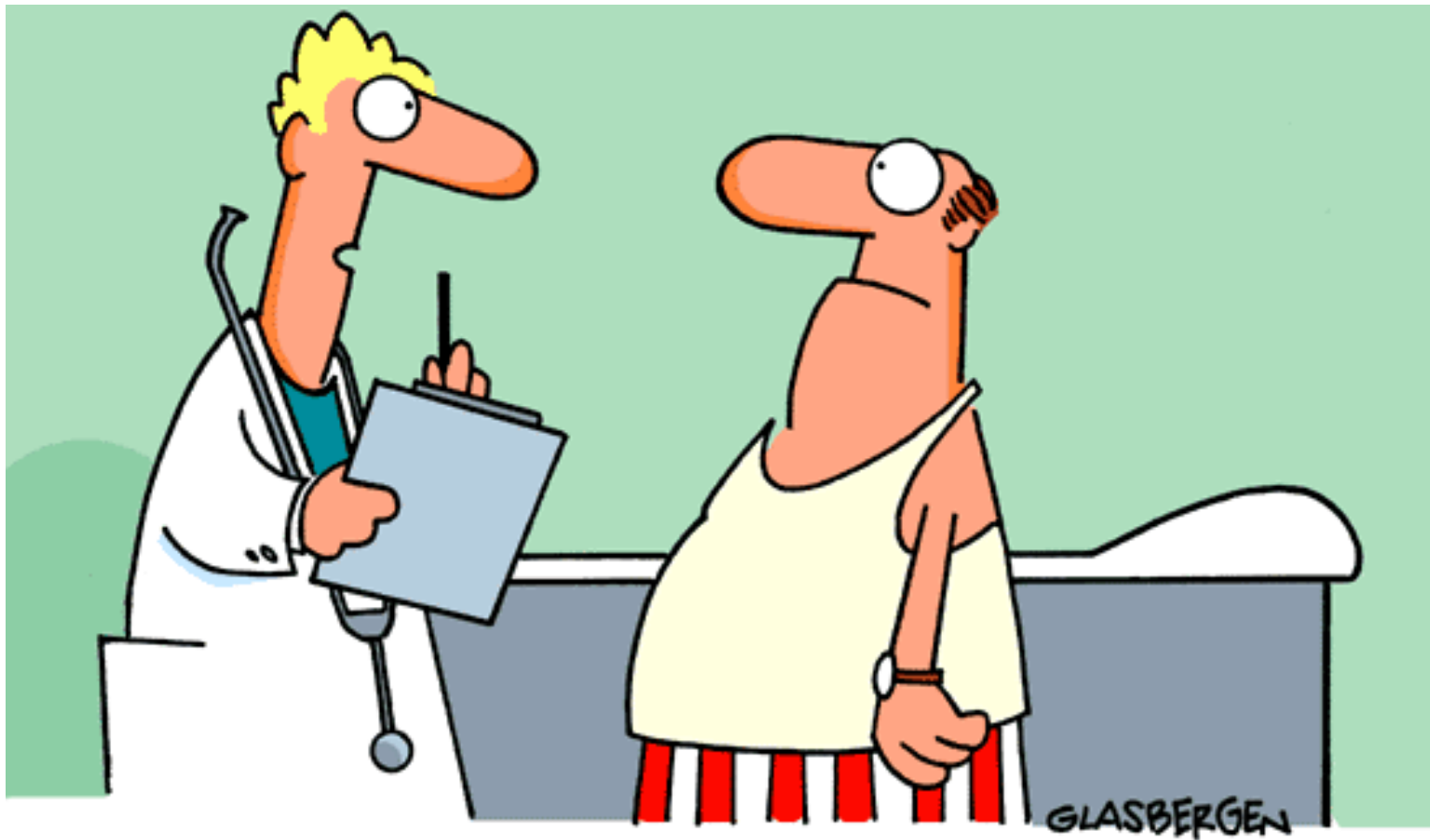


# Bacterial causes

| Patient type        | Etiology  |
|---------------------|---|
| Outpatient          | <i>Streptococcus pneumoniae</i><br><i>Mycoplasma pneumoniae</i><br><i>Haemophilus influenzae</i><br><i>Chlamydophila pneumoniae</i><br>Respiratory viruses <sup>a</sup>     |
| Inpatient (non-ICU) | <i>S. pneumoniae</i><br><i>M. pneumoniae</i><br><i>C. pneumoniae</i><br><i>H. influenzae</i><br><i>Legionella</i> species<br>Aspiration<br>Respiratory viruses <sup>a</sup> |
| Inpatient (ICU)     | <i>S. pneumoniae</i><br><i>Staphylococcus aureus</i><br><i>Legionella</i> species<br>Gram-negative bacilli<br><i>H. influenzae</i>  |

- *Streptococcus pneumoniae* (20% to 60% of CAP cases)
- *Haemophilus influenzae* (3% to 10% of CAP cases)
- *L. pneumophila* (1% to 5% of adult pneumonias) (2% to 8% of CAP cases)
- *Klebsiella, Pseudomonas, Escherichia coli, Staphylococcus aureus* (3% to 5% of CAP cases)
- **Atypical organisms such as *M. pneumoniae*, *C. pneumoniae*, and *L. pneumophila* implicated in up to 40% of cases of CAP**
- Pneumococcal infection responsible for 50% to 75% of CAPs. Influenza infection is one of the important predisposing factors to *S. pneumoniae* and *S. aureus pneumonia*;
- *gram-negative organisms cause .80% of nosocomial pneumonias*

# Symptoms and Signs



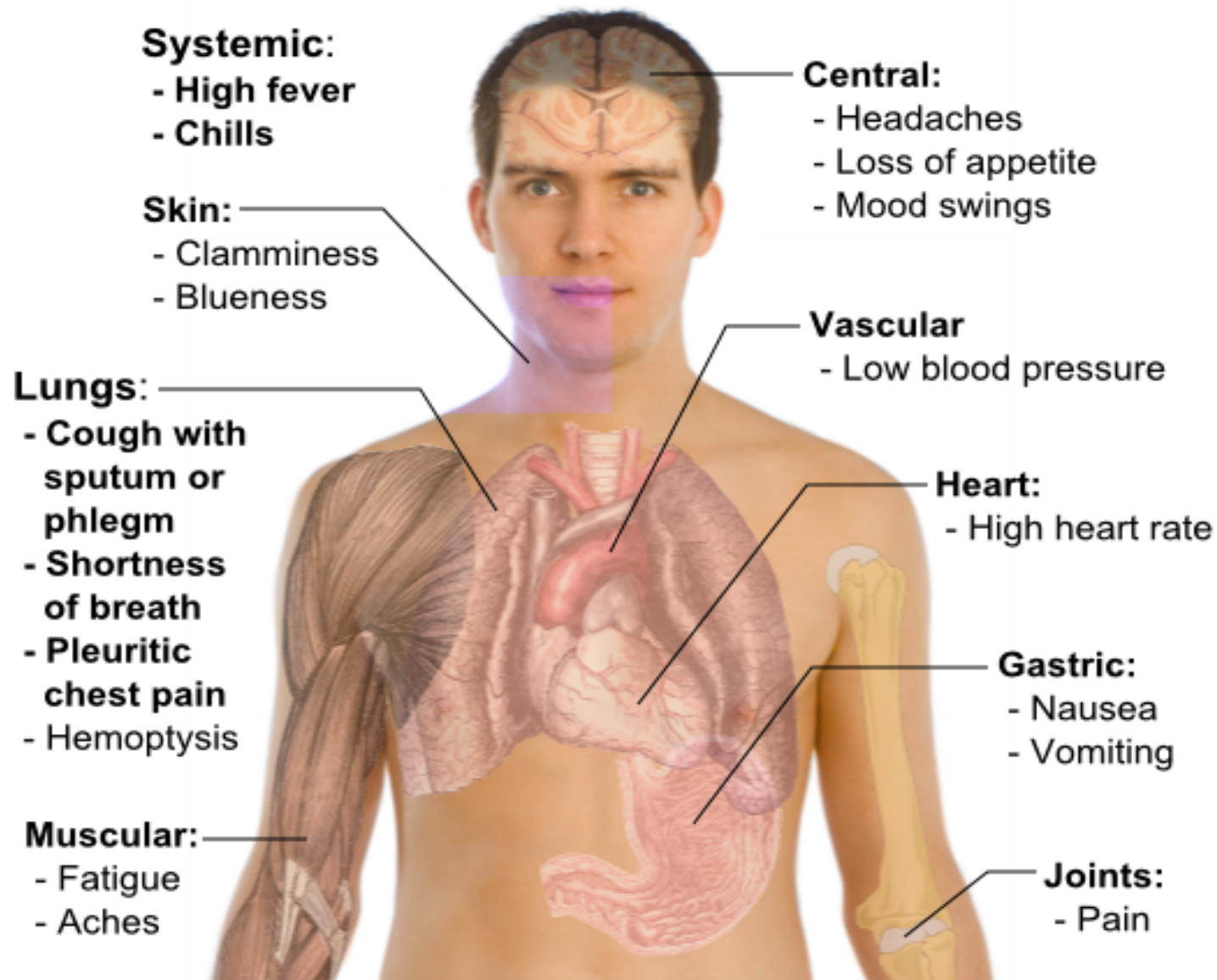
# Typical pneumonia:

## Clinical presentation

- Usual bacteria
  - Sudden/subacute onset
  - Fever with chills, rigors
  - Productive cough, Mucopurulent sputum
  - Tachypnea and tachycardia
  - breathlessness
  - Pleuritic chest pain
  - Breath sound: crackles and rales
  - CXR: air-bronchogram, consolidation

Main symptoms of infectious

# Pneumonia



# Atypical pneumonia:

## Clinical presentation

### Atypical

- Gradual onset
- Afebrile
- Dry cough
- Breath sound: Rales
- Uni/bilateral patchy, infiltrates
- WBC: usual normal or slight high
- Sore throat, myalgia, fatigue, diarrhea
- Common etiology
  - *Mycoplasma pneumoniae*
  - *Chlamydia pneumoniae*
  - *Legionella pneumophilla*
  - *Mycobacteria*
  - Virus, Others



# Differential diagnosis

- Pulmonary edema
- Pulmonary infarction
- Acute respiratory distress syndrome
- Pulmonary hemorrhage
- Lung cancer or metastatic cancer
- Atelectasis
- Radiation pneumonitis
- Drug reactions involving the lung
- Extrinsic allergic alveolitis
- Pulmonary vasculitis
- Pulmonary eosinophilia
- Bronchiolitis obliterans and organizing pneumonia

# DIAGNOSIS

# Laboratory Tests:

## **Routine blood investigations**

**CBC with differential**  
**BUN/Cr, electrolytes**  
**Glucose, liver enzymes**  
**Blood culture**

## **Imaging studies**

**X-Ray chest P/A & lateral view**  
**Compute tomography**

## **Microbiological tests**

**Sputum Gram stain**  
**Sputum for culture**  
**Sputum for Ziehl Neelsen stain**  
**Sputum cytology**

## **Serological test**

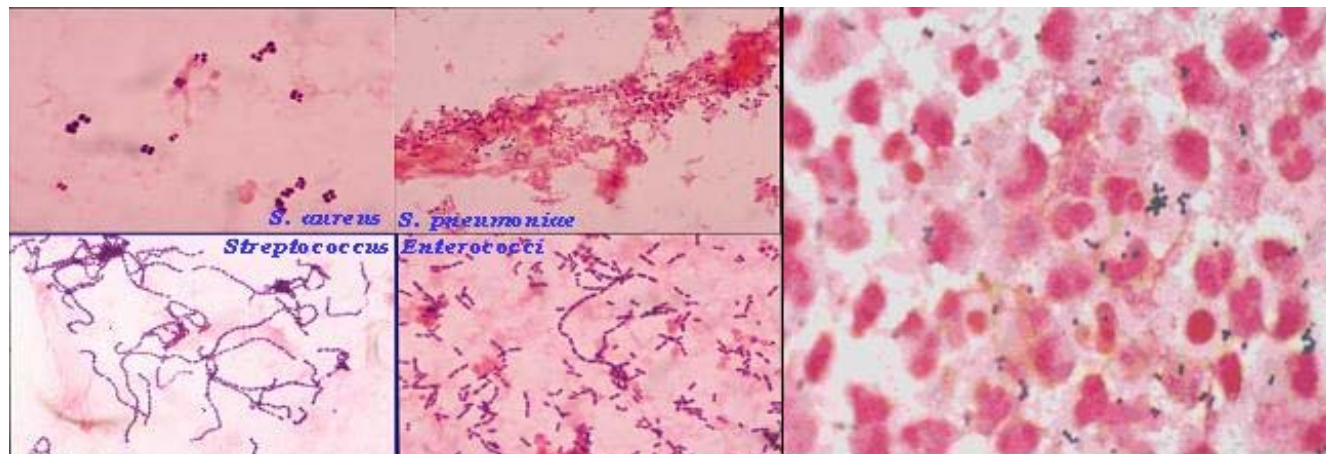
**Pneumococcal antigen test**  
**Legionella antigen**

## **Pulse oximetry**

**Arterial oxygen saturation**

## Sputum gram stain and culture

- The yield of sputum cultures varies from 34 to 86%.
- An initial sputum Gram stain and culture (or an invasive respiratory sample as appropriate) should be obtained in all **hospitalized patients** with CAP
- **Sputum quality should be ensured**
  - *PMN's > 25/LPF*
  - *Few epithelial cells < 10/LPF*
  - *Single predominant organism*



# Chest radiography

*Postero-anterior and lateral view- important*

- Establish the diagnosis
- Delineate the extent of consolidation
- Indicate the presence of underlying disorders
- Identify complications (pleural effusion, multilobar disease, lung abscess)
- To prognosticate the disease

*(chest radiography performed early in the course of the disease could be negative)*

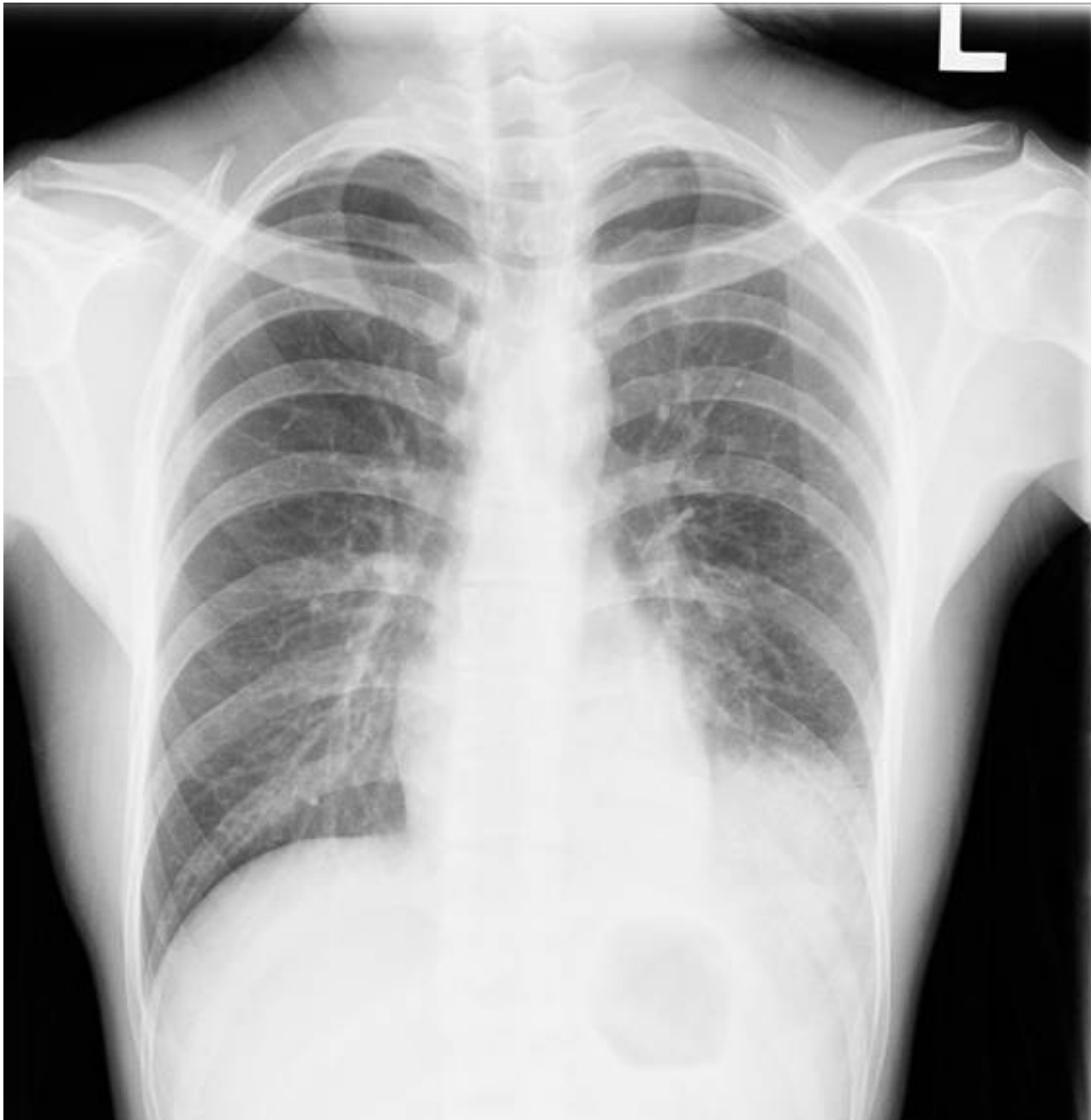
# Chest X Ray (mostly five patterns)

1. **Lobar-** S. Pneumoniae
2. **Patchy pattern-** Virus Atypicals, Mycoplasma, Chlamydia, Legionella
3. **Interstitial-** Influenza, CMV, PCP, Millitary TB
4. **Lung abscess-** S. Aureus, anerobes
5. **Nodular-** Fungal infection (Histoplasmosis, Coccidiomycosis, cryptococosis)

**‘Bulging fissure’ sign** of Klebsiella Pneumoniae

Pleural effusion - Streptococcus, anaerobes, Kleb

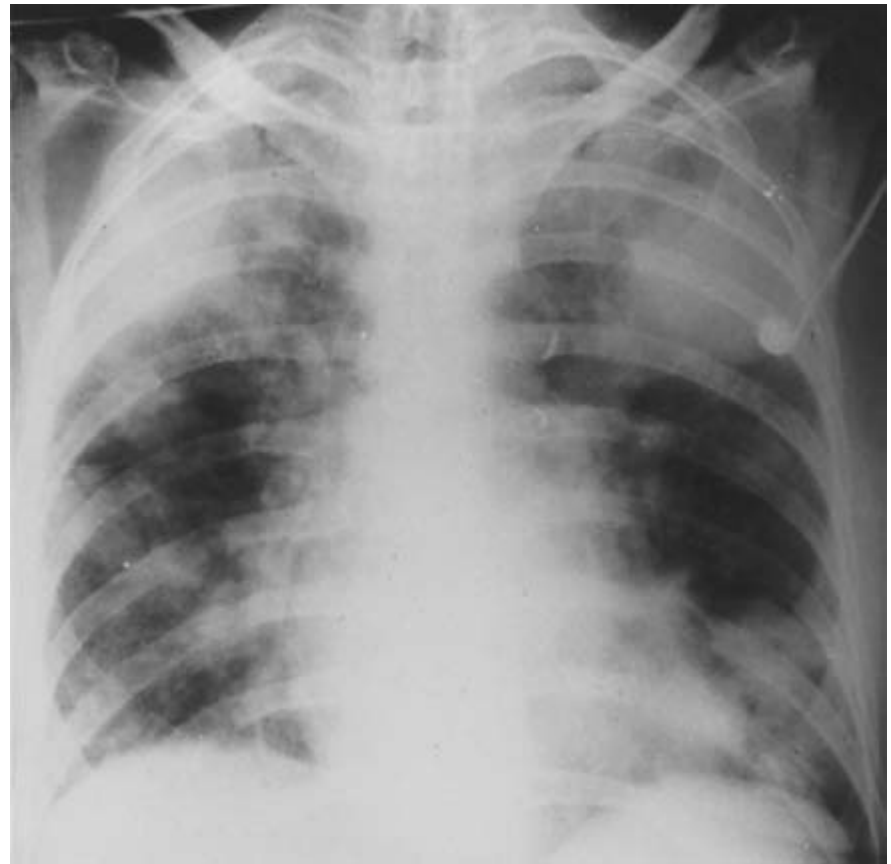




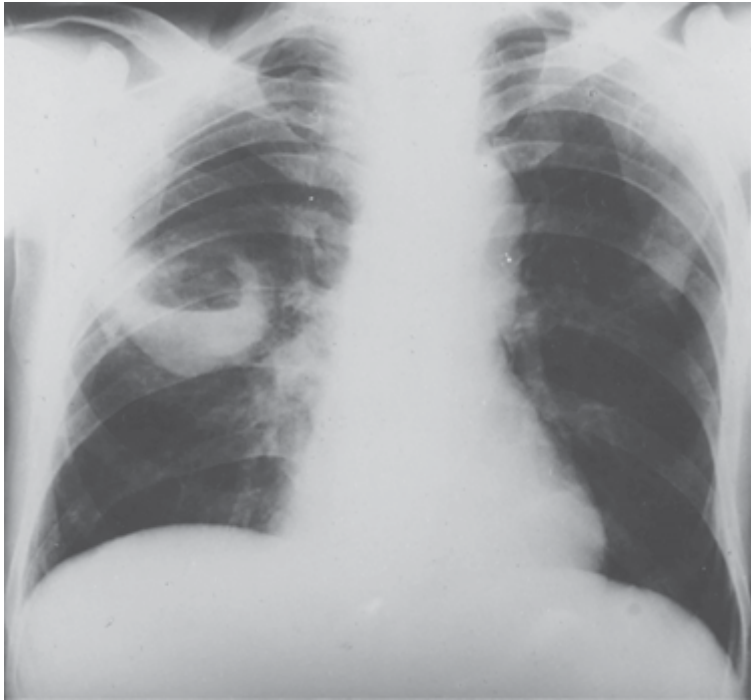
- 32 Y/O male
- Cough for 1 wk
- Fever for 2 days
- Crepts over LLL



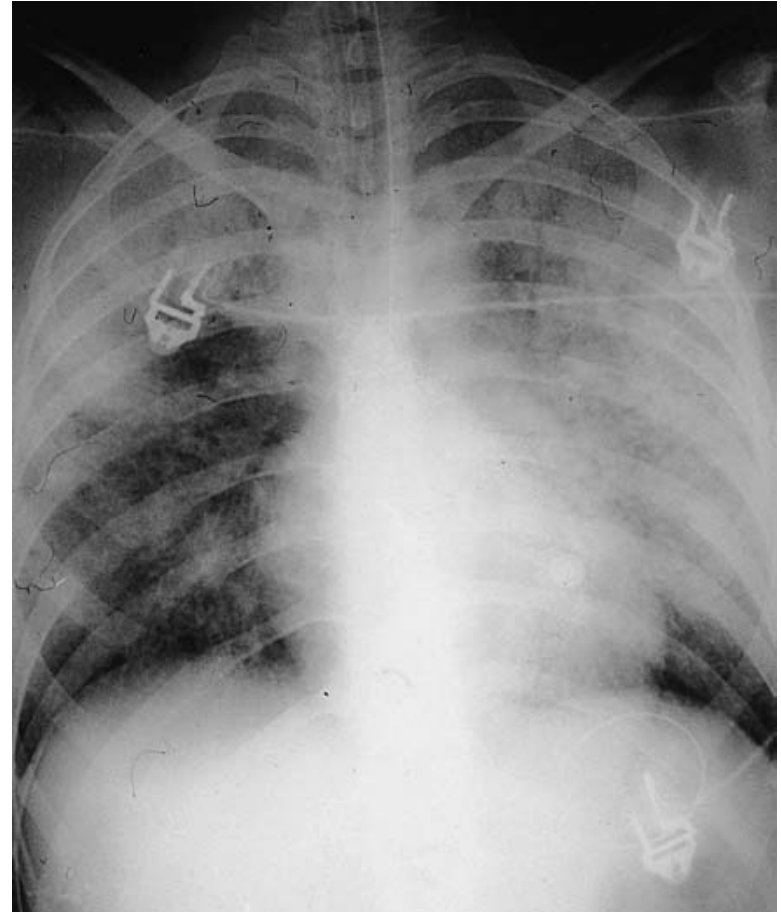
**Mycoplasma**



**Pseudomonas**

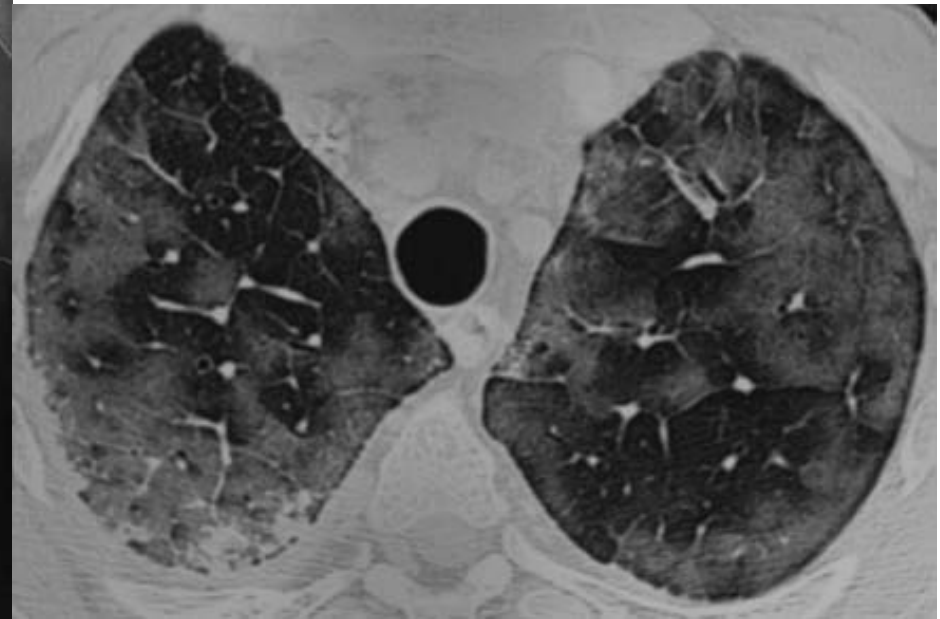
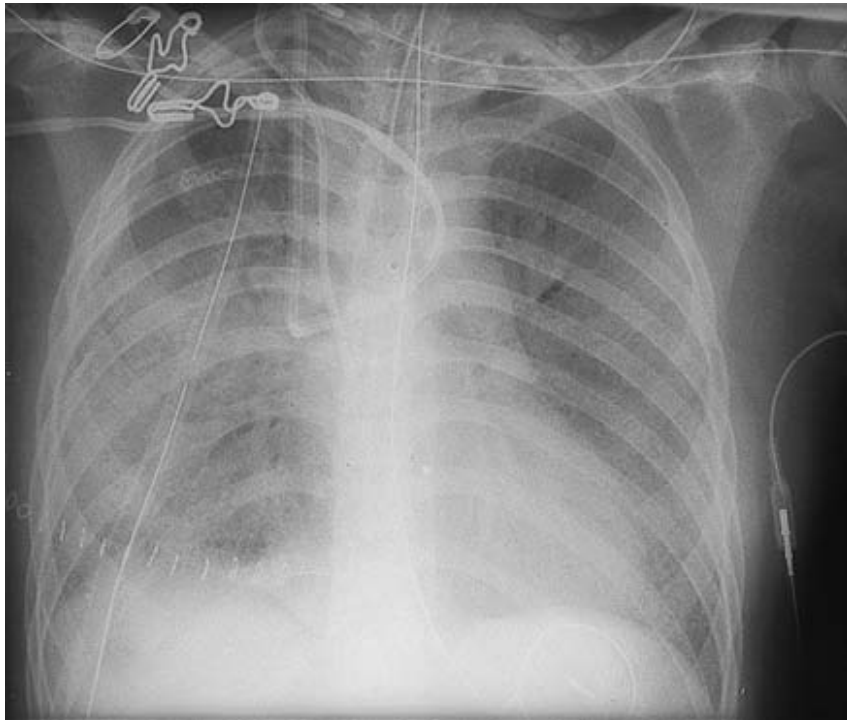


**Aspiration pneumonia**



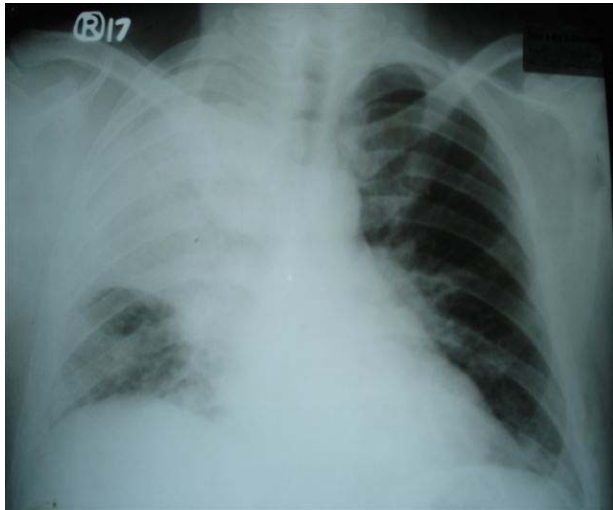
**Pneumocystis**

# Viral cause

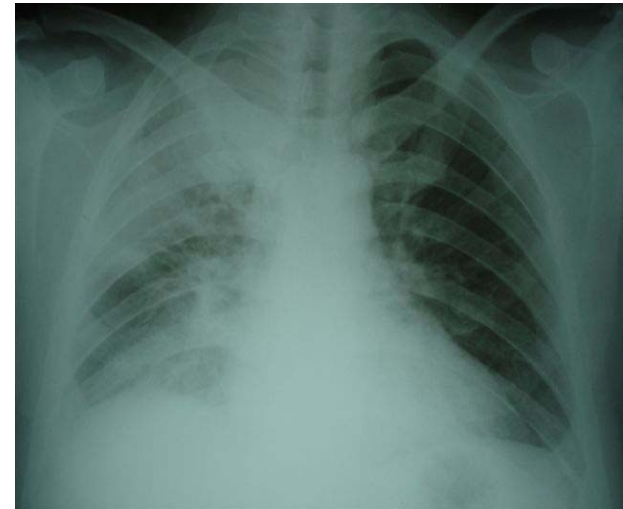


# CXR showing pneumonia

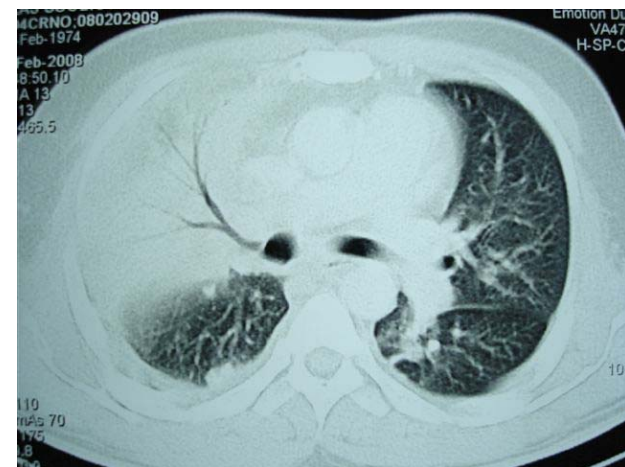
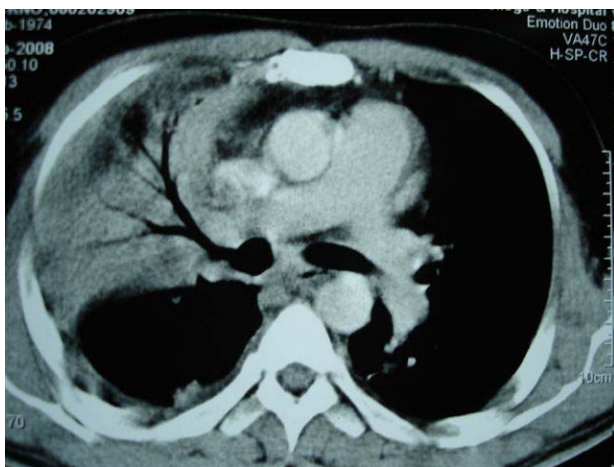




Before treatment



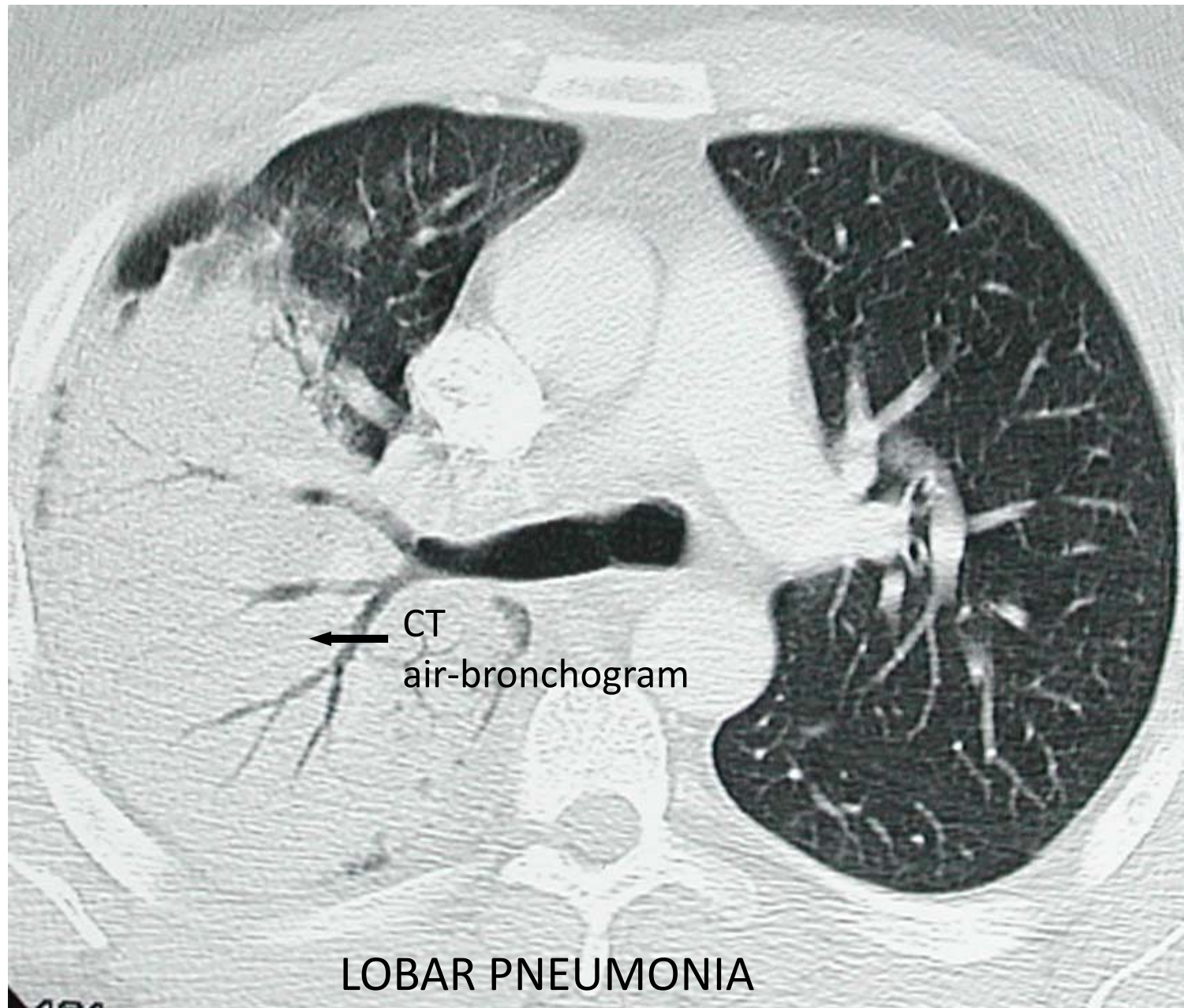
After 2 weeks of Treatment



CT Scan showing lobar consolidation with air bronchogram



## AIR BRONCHOGRAM SIGN



# Clinical Diagnosis

- ***Suggestive signs and symptoms***
- ***CXR or other imaging technique***
- ***Microbiologic testing***

**TREATMENT**

## Why do we need to treat

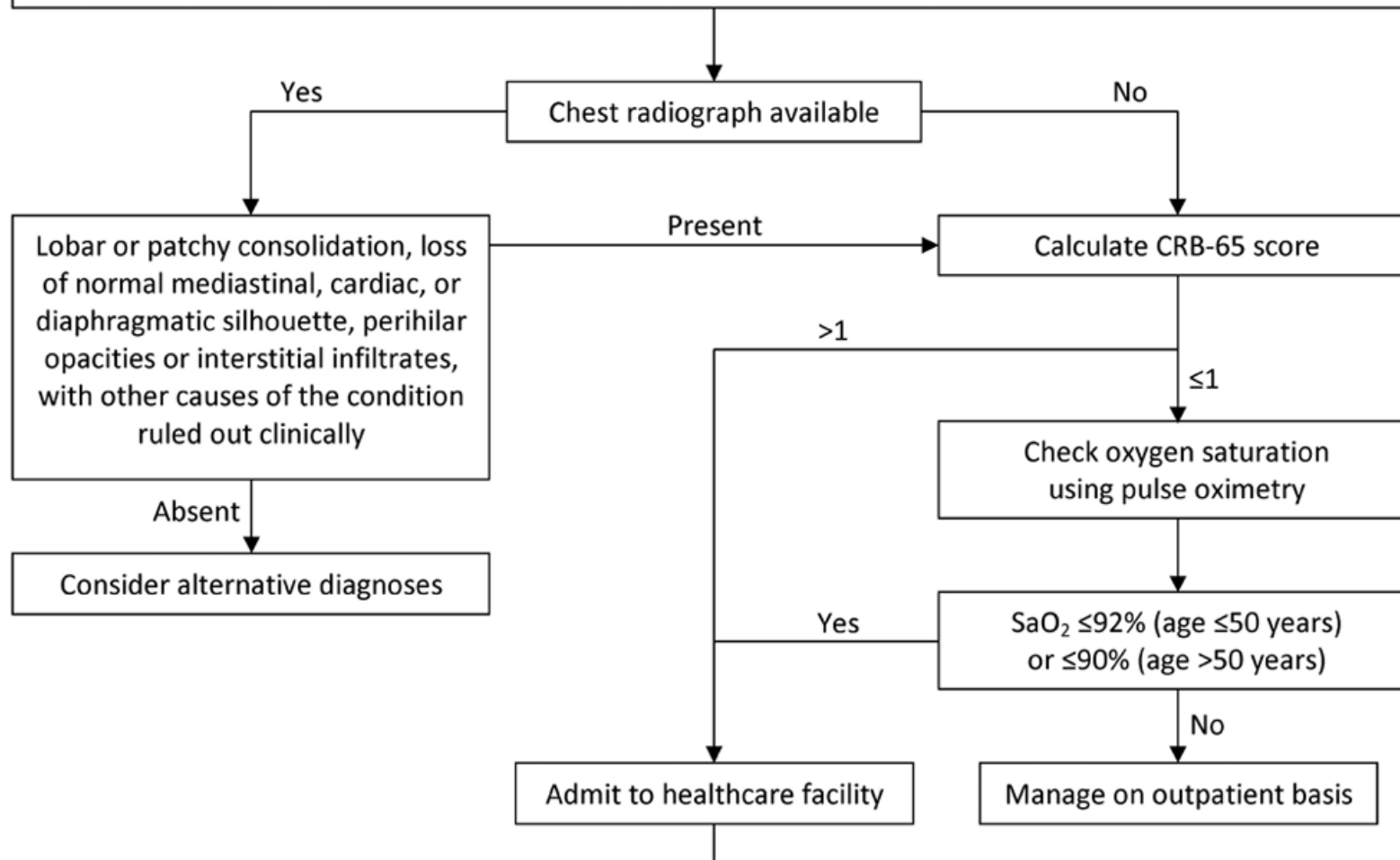
- Its potentially fatal
- Eradicate the causative organism from the site and reverse the inflammatory process
- Prevent complications
- Prevent mortality

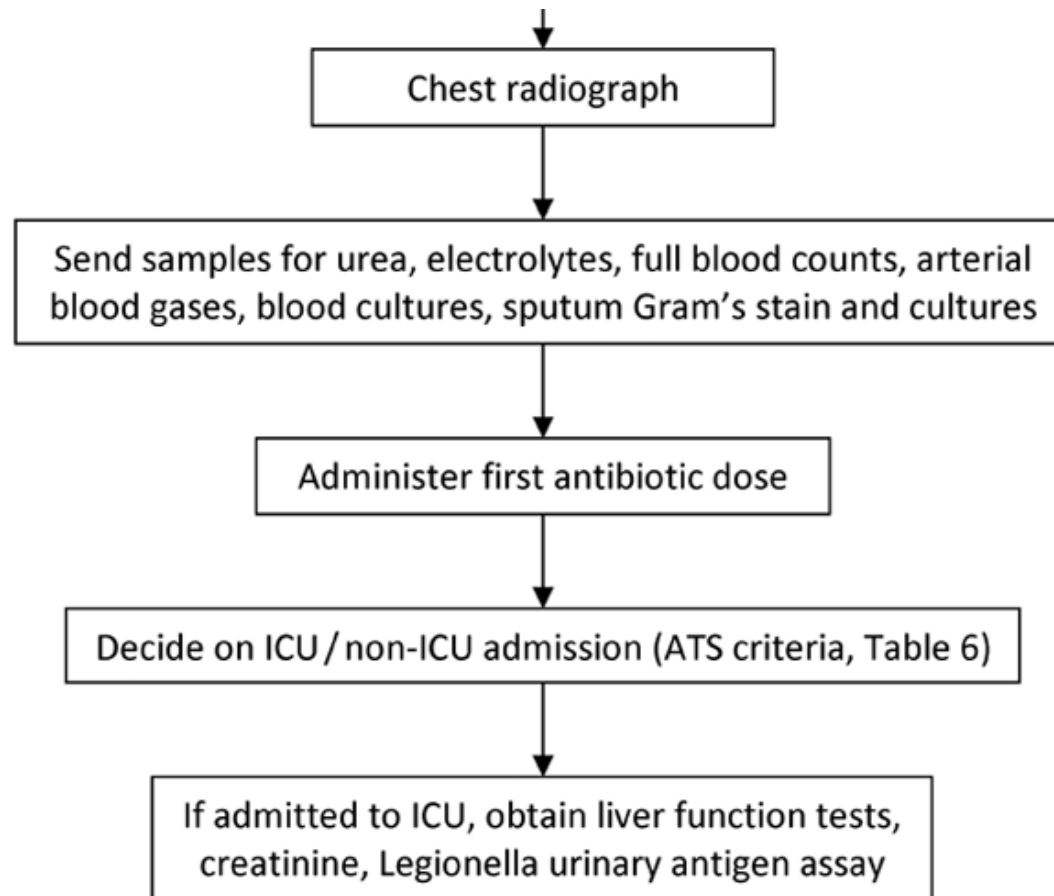
# Principles of management

- *Prompt initiation of antibiotic therapy*
- *Pathogen directed antimicrobial therapy whenever possible*
- *Rational use of microbiology laboratory*
- *Decision to hospitalize based on prognostic criteria*

# How to proceed >>>>>>

- Cough with or without expectoration, shortness of breath, pleuritic chest pain for less than one week WITH
- At least one systemic feature (temperature  $>37.7^{\circ}\text{C}$ , chills and rigors, and/or severe malaise) AND
- New focal chest signs on examination (bronchial breath sounds and/or crackles) WITH
- No other explanation for the illness





# Management options

- **Outpatient**
- **Inpatient**
- **ICU management**



## **Factors for consideration**

- Risk of death from the pneumonia,
- Disease severity
- Presence of comorbid conditions,
- Need for advanced diagnostics,
- Inability to take oral medications
- Lack of social support

# Criteria for risk stratification (CURB-65)

- Confusion
- Urea  $\geq 7$  mmol/L
- Respiratory rate  $\geq 30$ /min
- Low blood pressure (diastolic blood pressure  $\leq 60$  mm Hg or systolic blood pressure  $\leq 90$  mm Hg)
- Age  $\geq 65$  years

# Criteria for ICU admission

| Major criteria  | Minor criteria   |
|---|--|
| <ol style="list-style-type: none"><li>1. Invasive mechanical ventilation</li><li>2. Septic shock with need for vasopressors</li></ol> | <ol style="list-style-type: none"><li>1. Respiratory rate <math>\geq 30</math> breaths/min</li><li>2. <math>\text{PaO}_2/\text{FIO}_2</math> ratio <math>&lt; 250</math></li><li>3. Multilobar radiographic involvement</li><li>4. Confusion or disorientation</li><li>5. Uremia (BUN level <math>&gt; 20</math> mg/dL)</li><li>6. Leukopenia (WBC count <math>&lt; 4000</math> cells/dL)</li><li>7. Thrombocytopenia (platelet count <math>&lt; 100,000</math> cells/dL)</li><li>8. Hypothermia (core temperature <math>&lt; 36^\circ\text{C}</math>)</li><li>9. Hypotension requiring aggressive fluid resuscitation</li></ol> |

**Scoring System** for Determining Risk of Complications in Patients with Community-Acquired Pneumonia

**score < 50: Outpatient treatment**  
**scores > 90: hospitalization**

*Proper management of patients with scores of 70–90 requires careful application of clinical judgment.*

| Patient Characteristic  | Points Assigned  |
|---|------------------|
| <b>DEMOGRAPHIC FACTORS</b>                                    |                  |
| Males   | Age (in yr)      |
| Females   | Age (in yr) – 10 |
| Nursing home residents  | Age (in yr) +10  |
| <b>COMORBID ILLNESSES</b>                                     |                  |
| Neoplastic disease  | +30              |
| Liver disease   | +20              |
| Congestive heart failure                                      | +10              |
| Cerebrovascular disease                                       | +10              |
| Renal disease   | +10              |
| <b>PHYSICAL EXAMINATION FINDINGS</b>                          |                  |
| Altered mental status   | +20              |
| Respiratory rate 30/min or more                               | +20              |
| Systolic blood pressure < 90 mm Hg                            | +20              |
| Temperature < 35°C or ≥40°C                                   | +15              |
| Pulse 125/min or more   | +10              |
| <b>LABORATORY FINDINGS</b>                                    |                  |
| pH < 7.35   | +30              |
| BUN > 10.7 mmol/L   | +20              |
| Sodium < 130 mEq/L  | +20              |
| Glucose > 13.9 mmol/L   | +10              |
| Hematocrit < 30%  | +10              |
| PO <sub>2</sub> < 60 mm Hg or O <sub>2</sub> saturation < 90% | +10              |
| Pleural effusion  | +10              |

# Outpatient treatment

## Pathogen directed treatment

Amoxycillin  
Amoxycillin + clavulanic acid  
Macrolide  
Doxycycline  
Fluoroquinolone

- *Streptococcus pneumoniae*
- *Mycoplasma pneumoniae*
- *Haemophilus influenzae*
- *Chlamydomphila pneumoniae*
- Respiratory viruses

## Emperic treatment

Amoxycillin  
Amoxycillin + clavulanic acid  
Macrolide  
Doxycycline  
Fluoroquinolone

Single or combination  
therapy can be given

# Inpatient management

## Pathogen directed treatment/ Empiric

- Amoxycillin + clavulanic acid + Macrolide
- 3<sup>rd</sup> generation cephalosporins
- Fluoroquinolone

### Important:

1. *Injectable drugs are used initially*
2. *Combinations of drugs are preferred*
3. *In elderly, diabetics, alcoholism, those with structural lung disease, cephalosporins are preferred*

- *S. pneumoniae*
- *M. pneumoniae*
- *C. pneumoniae*
- *H. influenzae*
- *Legionella species*
- Aspiration
- Respiratory viruses

# ICU management

## ➤ Pathogen directed treatment

- Amoxycillin + clavulanic acid + Macrolide
- 3<sup>rd</sup> & 4<sup>th</sup> generation cephalosporins
- Fluoroquinolone
- Aminoglycosides
- Carbapenems
- Vancomycin/Teicoplanin
- Metronidazole/clindamycin

- *S. pneumoniae*
- *Staphylococcus aureus*
- *Legionella species*
- Gram-negative bacilli
- *H. influenzae*

**Note:** Wait for 48-72 hrs for the drugs to act and before labelling treatment failure

# Criteria for clinical stability

- Temperature  $\leq 37.8^{\circ}\text{C}$
- Heart rate  $\leq 100$  beats/minute
- Systolic blood pressure  $\geq 90$  mm Hg
- Respiratory rate  $\leq 24$  breaths/minute
- Oxyhemoglobin saturation  $\geq 90\%$  or  $\text{PO}_2 \geq 60$  mm Hg on preadmission level of oxygen supplementation

*4 out of 5 criteria need to be fulfilled in stability criteria*



- Generally 7-10 days of antibiotics are sufficient
- Once the stability criteria are met, patient can be switched to oral antibiotics ( same group)

# **Hospital acquired pneumonia**

# Definition

- *HAP is an inflammatory condition of the lung parenchyma, caused by infectious agents, neither present nor incubating at the time of hospital admission. It is defined as pneumonia developing 48 h after admission to the hospital.*
- Divided into **ICU HAP** or **non-ICU HAP** depending upon whether this infection is acquired in the intensive care unit (ICU) or in other clinical areas (e.g. wards)

# **“Nosocomial” Pneumonia**

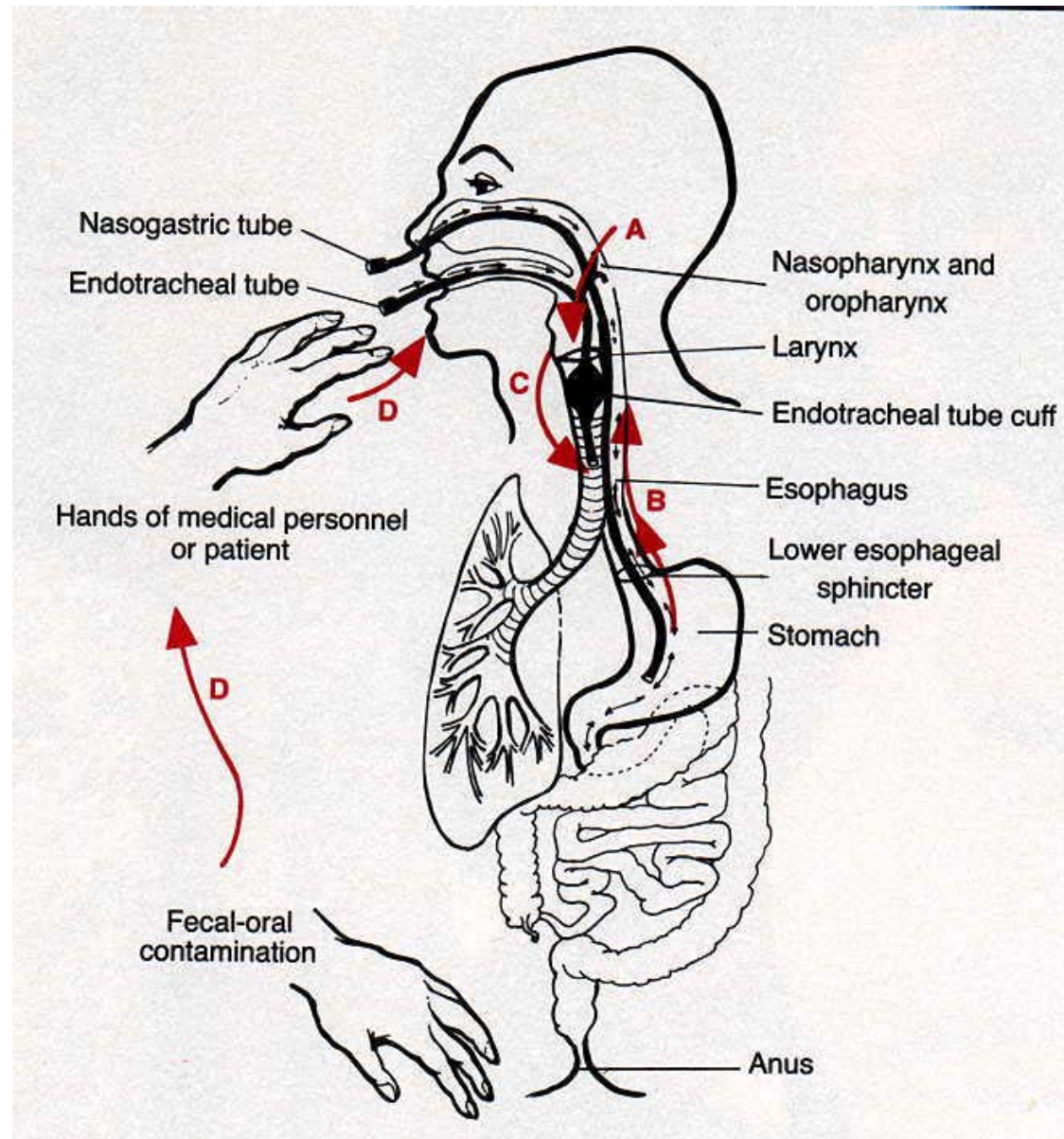
- **Hospital-acquired pneumonia (HAP)**
  - Occurs 48 hours or more after admission, which was not incubating at the time of admission
- **Ventilator-associated pneumonia (VAP)**
  - Arises more than 48-72 hours after endotracheal intubation
- **Healthcare-associated pneumonia (HCAP)**
  - Patients who were hospitalized in an acute care hospital for two or more days within 90 days of the infection; resided in a nursing home; received recent IV, chemotherapy, or wound care within the past 30 days of the current infection; or attended a hospital or hemodialysis clinic

- **Early-onset HAP** (and VAP) is defined as pneumonia occurring within the **first 4 days** of hospitalization (or endotracheal intubation).
- It usually carries a better prognosis and is more likely to be caused by antibiotic-sensitive bacteria.
- **Late-onset HAP and VAP** (**day 5 or thereafter**) are more likely to be caused by MDR pathogens, and are associated with higher morbidity and mortality.

# Burden of disease

- HAP is the second most common nosocomial infection
- HAP accounts for up to 25% of all ICU infections and more than 50% of the entire antibiotic prescriptions.
- The crude mortality rate for HAP may be as high as 30–70%
- The risk of HAP/VAP is the highest early in the course of hospital stay

# ROUTE OF INFECTION



# Organism profile in India

## Aerobic Gram-negative bacilli (most common)

- *P. aeruginosa*
- *E. coli*
- *K. pneumoniae*
- *Acinetobacter species*.
- *Staph. aureus* (more common in diabetes, head trauma and in ICU admitted patients)
- 

**HAP/VAP can be clinically defined using modified CDC criteria**



# Modified CDC criteria for diagnosis of HAP/ VAP

**Chest radiographic opacities (new, progressive, or persistent infiltrate or cavitation) and at least two of the following**

Fever  $>38^{\circ}\text{C}$  or  $>100.4^{\circ}\text{F}$

Leukopenia ( $<4000$  WBC/ $\mu\text{L}$ ) or leukocytosis ( $\geq 12,000$  WBC/ $\mu\text{L}$ )

Altered mental status with no other recognized cause in the elderly

New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements

Worsening gas exchange (e.g. desaturations, increased oxygen requirements, or increased ventilator demand)

New onset or worsening cough, or dyspnea, or tachypnea

Rales or bronchial breath sounds

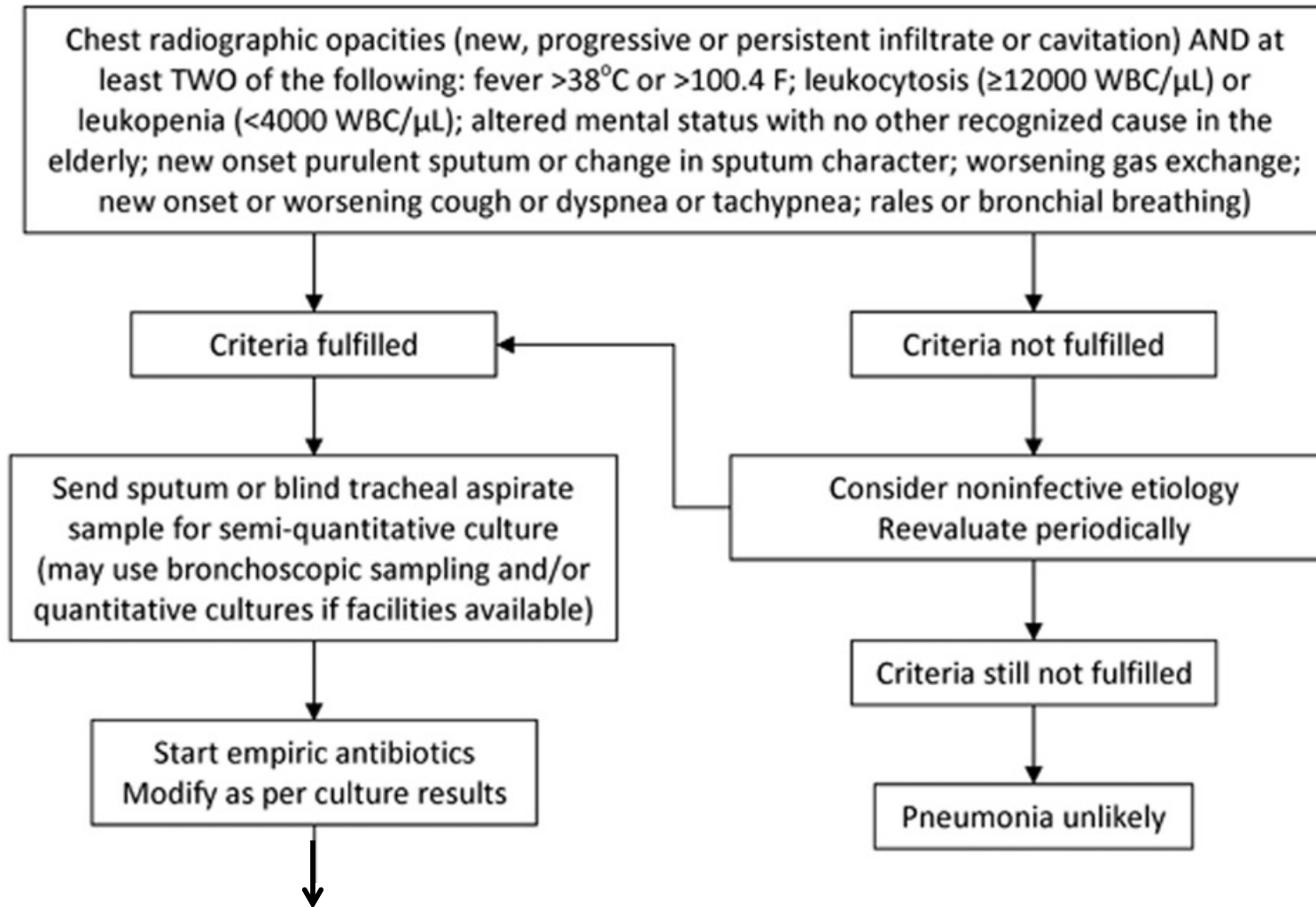
# Differential diagnosis

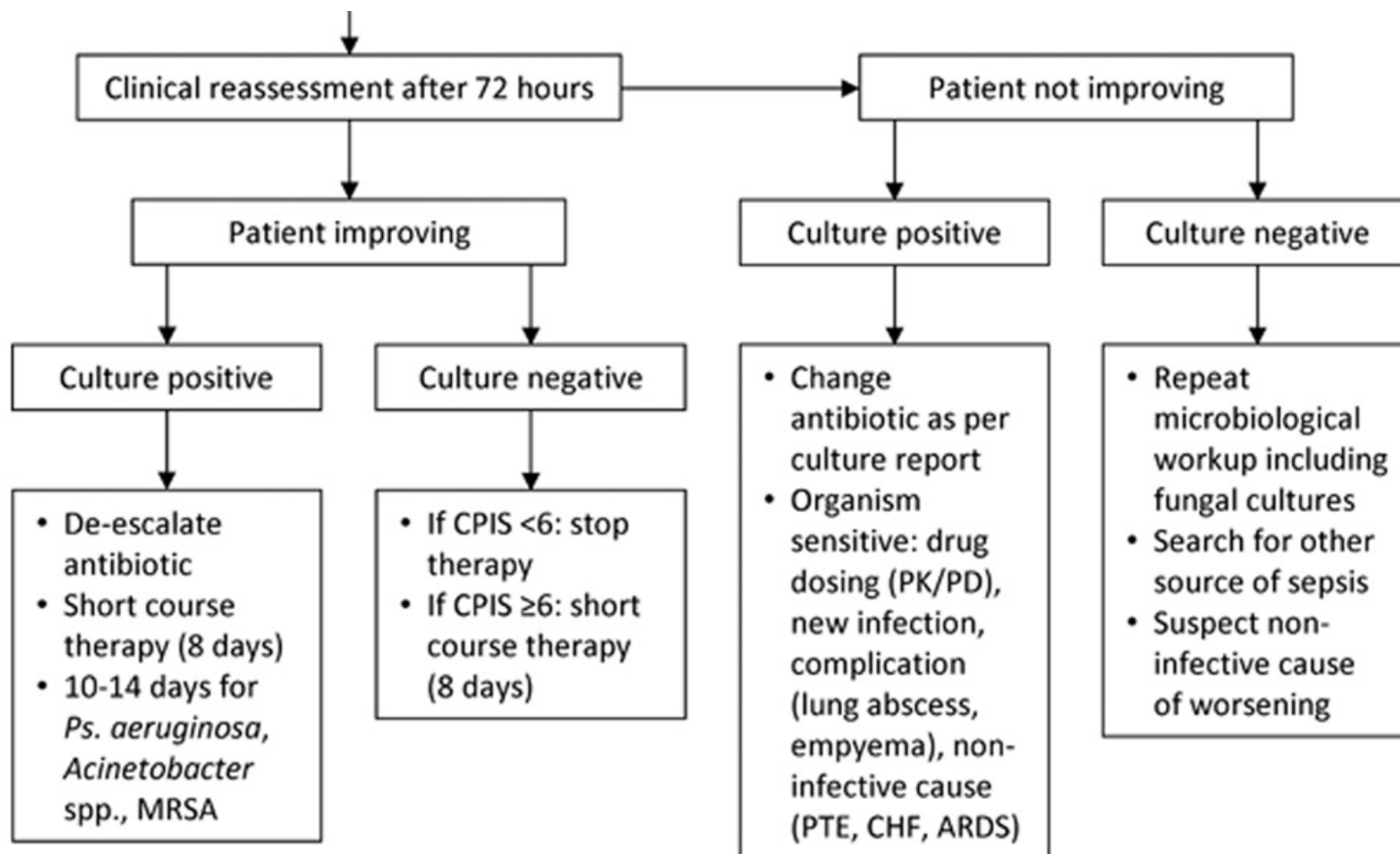
- ARDS
- Congestive heart failure
- Pulmonary embolism
- Fluid overload
- Pulmonary haemorrhage

- One or more lower respiratory tract samples and blood should be sent for cultures prior to institution of antibiotics
- Good-quality sputum microbiology
- CT scan should not be routinely obtained for diagnosing HAP/VAP
- Appropriate management should not be delayed in clinically unstable patients for the purpose of performing diagnostic sampling.

- Quantitative and or semi-quantitative cultures using various sampling techniques like ETA, bronchoscopic or non-bronchoscopic BAL and PSB are equally useful for establishing the diagnosis of HAP/VAP

# How to proceed >>>>>





# Basic principles

- Start antibiotics as early as possible
- The exact choice of antibiotic to be started is based on local availability, antibiotic resistance patterns, preferred routes of delivery, other complicating factors, and cost.
- The initial combination therapy should be converted to appropriate monotherapy once culture reports are available
- The strategy for de-escalation of antibiotics is strongly recommended

---

### $\beta$ -lactam/ $\beta$ -lactamase inhibitors

|                         |   |
|-------------------------|---|
| Piperacillin–tazobactam | 4.5 g IV four to six times a day (4-h infusion)   |
| Cefoperazone–sulbactam  | 2–3 g IV two to three times a day (3-h infusion)  |
| Ticarcillin–clavulanate | 3.1 g IV three to four times a day (3-h infusion) |

### Carbapenems

|           |  |
|-----------|--|
| Meropenem | 1 g IV thrice daily (3-h infusion)         |
| Imipenem  | 0.5–1 g IV four times a day (2-h infusion) |

### Antipseudomonal cephalosporins

|           |  |
|-----------|--|
| Cefepime  | 2 g IV two to three times a day (3-h infusion) |
| Cefpirome | 2 g IV two to three times a day (3-h infusion) |

### Antipseudomonal quinolones

|               |                                    |
|---------------|------------------------------------|
| Ciprofloxacin | 400 mg IV thrice daily over 30 min |
| Levofloxacin  | 750 mg IV daily over 30 min        |

### Antipseudomonal aminoglycosides

|            |                               |
|------------|-------------------------------|
| Amikacin   | 20 mg/kg IV daily over 30 min |
| Netilmicin | 7 mg/kg IV daily over 30 min  |
| Tobramycin | 7 mg/kg IV daily over 30 min  |

### Anti-MRSA drugs

|             |   |
|-------------|---|
| Vancomycin  | 500 mg IV four times a day (4-h infusion)                         |
| Teicoplanin | 12 mg/kg loading dose followed by 6–12 mg/kg daily (4-h infusion) |
| Linezolid   | 600 mg twice daily over 30 min                                    |

### Polymyxins

|             |                                       |
|-------------|---------------------------------------|
| Colistin    | 6–9 MU/day in divided doses           |
| Polymyxin B | 15,000–25,000 U/kg/day IV twice daily |

**Antibiotics  
used in  
HAP/VAP**



- Among patients with suspected VAP in whom an alternate cause for pulmonary infiltrates is identified, it is recommended that antibiotics should be stopped (1A).
- If cultures are sent after initiation of antibiotics and there is clinical improvement with subsequent cultures being sterile, antibiotics should be continued for 7 days followed by assessment.
- Empiric antifungal therapy (on day 3) should not be used as a routine in all patients if cultures are sterile and there is clinical worsening

- In patients with VAP due to *Pseudomonas*, *Acinetobacter*, and MRSA, a longer duration (14 days) of antibiotic course is recommended. Assessment of CPIS on day 7 may identify the patients in whom therapy could be stopped early.
- In other patients with VAP who are clinically improving, a 7-day course of antibiotics is recommended.

# Preventive strategies for VAP

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## The following strategies are recommended in prevention of VAP:

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- Oral cavity decontamination with 2% chlorhexidine (1A)<sup>[412-415]</sup>
- Hand hygiene preferably using alcohol-based hand rubs or soap and water (1A)<sup>[416]</sup>
- Use of sedation and weaning protocols (1A)<sup>[419,420]</sup>
- Use of NIV to avoid intubation, where feasible (1A)<sup>[264,421]</sup>
- Subglottic secretion drainage (2A)<sup>[422,423]</sup>
- Heat moisture exchangers in place of heated humidifiers (2A)<sup>[424-428]</sup>
- Closed suction systems (2A)<sup>[429-431]</sup>
- Use of orotracheal intubation as opposed to nasotracheal intubation (2A)<sup>[432,433]</sup>
- Proper and timely disposal of condensates (3A)<sup>[434,435]</sup>
- Maintaining tracheal cuff pressures <25 cm H<sub>2</sub>O (2A)<sup>[436]</sup>
- Wipe stethoscopes with alcohol rubs (2A)<sup>[437]</sup>
- Regular postural mobilization to prevent stasis of secretions (2A)
- Use of only normal saline for suctioning (3A)
- Proper sterilization of nebulizer and other chambers (2A)
- Head end elevation to 30°–45° (2A)

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## The following strategies are not recommended in prevention of VAP:

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- Antibiotics for prevention of VAP (2A)
- Selective digestive tract decontamination (2A)<sup>[438]</sup>
- Routine ventilator circuit changes (2A)<sup>[439,440]</sup>

**Thank you**