Pneumonia

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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

Hospital-acquired pneumonia (HAP)

Ventilator-associated pneumonia (VAP)

Healthcare-associated pneumonia (HCAP)

Community acquired pneumonia

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

1. Lobar pneumonia
2. Bronchopneumonia
3. Interstitial pneumonia
4. Diffuse pneumonia
Lobes
bar Pneumonia Bronchopneumonia
Pneumonia

- Trachea
- Infected lung
- Bronch
- Lung

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 > 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°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

<table>
<thead>
<tr>
<th>Patient type</th>
<th>Etiology</th>
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<tbody>
<tr>
<td>Outpatient</td>
<td><em>Streptococcus pneumoniae</em>&lt;br&gt;<em>Mycoplasma pneumoniae</em>&lt;br&gt;<em>Haemophilus influenzae</em>&lt;br&gt;<em>Chlamydia pneumoniae</em>&lt;br&gt;Respiratory viruses&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inpatient (non-ICU)</td>
<td><em>S. pneumoniae</em>&lt;br&gt;<em>M. pneumoniae</em>&lt;br&gt;<em>C. pneumoniae</em>&lt;br&gt;<em>H. influenzae</em>&lt;br&gt;<em>Legionella</em> species&lt;br&gt;Aspiration&lt;br&gt;Respiratory viruses&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Inpatient (ICU)</td>
<td><em>S. pneumoniae</em>&lt;br&gt;<em>Staphylococcus aureus</em>&lt;br&gt;<em>Legionella</em> species&lt;br&gt;Gram-negative bacilli&lt;br&gt;<em>H. influenzae</em></td>
</tr>
</tbody>
</table>
• 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

Systemic:
- High fever
- Chills

Skin:
- Clamminess
- Blueness

Central:
- Headaches
- Loss of appetite
- Mood swings

Lungs:
- Cough with sputum or phlegm
- Shortness of breath
- Pleuritic chest pain
- Hemoptysis

Vascular:
- Low blood pressure

Heart:
- High heart rate

Gastric:
- Nausea
- Vomiting

Muscular:
- Fatigue
- Aches

Joints:
- Pain
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
  - Mycobactria
  - 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, Milliary TB
4. Lung abscess- S. Aureus, anaerobes
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
Aspiration pneumonia

Pneumocystis
Viral cause
CXR showing pneumonia
Before treatment

CT Scan showing lobar consolidation with air bronchogram

After 2 weeks of Treatment
AIR BRONCHOGRAM SIGN

LOBAR PNEUMONIA

CT air-bronchogram
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°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

Chest radiograph available

Yes

Lobar or patchy consolidation, loss of normal mediastinal, cardiac, or diaphragmatic silhouette, perihilar opacities or interstitial infiltrates, with other causes of the condition ruled out clinically

Absent

Consider alternative diagnoses

Present

Calculate CRB-65 score

>1

Check oxygen saturation using pulse oximetry

Yes

SaO₂ ≤92% (age ≤50 years) or ≤90% (age >50 years)

Admit to healthcare facility

No

≤1

Manage on outpatient basis
Chest radiograph

Send samples for urea, electrolytes, full blood counts, arterial blood gases, blood cultures, sputum Gram’s stain and cultures

Administer first antibiotic dose

Decide on ICU/non-ICU admission (ATS criteria, Table 6)

If admitted to ICU, obtain liver function tests, creatinine, Legionella urinary antigen assay
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 ≥7 mmol/L
- Respiratory rate ≥30/min
- Low blood pressure (diastolic blood pressure ≤60 mm Hg or systolic blood pressure ≤90 mm Hg)
- Age ≥65 years
## Criteria for ICU admission

<table>
<thead>
<tr>
<th>Major criteria</th>
<th>Minor criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Invasive mechanical ventilation</td>
<td>1. Respiratory rate $\geq$ 30 breaths/min</td>
</tr>
<tr>
<td>2. Septic shock with need for vasopressors</td>
<td>2. PaO2/FIO2 ratio $&lt;$ 250</td>
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<td></td>
<td>3. Multilobar radiographic involvement</td>
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<td></td>
<td>4. Confusion or disorientation</td>
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<td></td>
<td>5. Uremia (BUN level $&gt;$ 20 mg/dL)</td>
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<td></td>
<td>6. Leukopenia (WBC count $&lt;$ 4000 cells/dL)</td>
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<tr>
<td></td>
<td>7. Thrombocytopenia (platelet count $&lt;$ 100,000 cells/dL)</td>
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<tr>
<td></td>
<td>8. Hypothermia (core temperature $&lt;$ 36°C)</td>
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<td>9. Hypotension requiring aggressive fluid resuscitation</td>
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</tbody>
</table>
**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.
Outpatient treatment

Pathogen directed treatment
- Amoxicillin
- Amoxicillin + clavulanic acid
- Macrolide
- Doxycycline
- Fluoroquinolone

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

Emperic treatment
- Amoxicillin
- Amoxicillin + clavulanic acid
- Macrolide
- Doxycycline
- Fluoroquinolone

Single or combination therapy can be given
Inpatient management

Pathogen directed treatment/ Emperic

- Amoxycillin + clavulanic acid + Macrolide
- 3rd 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 virusesa
ICU management

- **Pathogen directed treatment**
  - Amoxycillin + clavulanic acid + Macrolide
  - 3rd & 4th 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 ≤37.8° C
- Heart rate ≤100 beats/minute
- Systolic blood pressure ≥90 mm Hg
- Respiratory rate ≤24 breaths/minute
- Oxyhemoglobin saturation ≥90% or PO2 ≥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

- Nasogastric tube
- Endotracheal tube
- Nasopharynx and oropharynx
- Larynx
- Endotracheal tube cuff
- Esophagus
- Lower esophageal sphincter
- Stomach
- Hands of medical personnel or patient
- Fecal-oral contamination
- Anus
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**

<table>
<thead>
<tr>
<th>Criteria</th>
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<tbody>
<tr>
<td>Fever &gt;38°C or &gt;100.4°F</td>
</tr>
<tr>
<td>Leukopenia (&lt;4000 WBC/μL) or leukocytosis (≥12,000 WBC/μL)</td>
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<td>Altered mental status with no other recognized cause in the elderly</td>
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<tr>
<td>New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements</td>
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<tr>
<td>Worsening gas exchange (e.g. desaturations, increased oxygen requirements, or increased ventilator demand)</td>
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<tr>
<td>New onset or worsening cough, or dyspnea, or tachypnea</td>
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<tr>
<td>Rales or bronchial breath sounds</td>
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</table>
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 >>>>>

Chest radiographic opacities (new, progressive or persistent infiltrate or cavitation) AND at least TWO of the following: fever >38°C or >100.4 F; leukocytosis (≥12000 WBC/µL) or leukopenia (<4000 WBC/µL); altered mental status with no other recognized cause in the elderly; new onset purulent sputum or change in sputum character; worsening gas exchange; new onset or worsening cough or dyspnea or tachypnea; rales or bronchial breathing)

Criteria fulfilled

Send sputum or blind tracheal aspirate sample for semi-quantitative culture (may use bronchoscopic sampling and/or quantitative cultures if facilities available)

Start empiric antibiotics
Modify as per culture results

Criteria not fulfilled

Consider noninfective etiology
Reevaluate periodically

Criteria still not fulfilled

Pneumonia unlikely
Clinical reassessment after 72 hours

Patient not improving

Patient improving

Culture positive
- De-escalate antibiotic
- Short course therapy (8 days)
- 10-14 days for *Ps. aeruginosa*, *Acinetobacter* spp., MRSA

Culture negative
- If CPIS <6: stop therapy
- If CPIS ≥6: short course therapy (8 days)

Culture positive
- Change antibiotic as per culture report
- Organism sensitive: drug dosing (PK/PD), new infection, complication (lung abscess, empyema), non-infective cause (PTE, CHF, ARDS)

Culture negative
- Repeat microbiological workup including fungal cultures
- Search for other source of sepsis
- Suspect non-infective cause of worsening
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
### Antibiotics used in HAP/VAP

<table>
<thead>
<tr>
<th>Category</th>
<th>Drug</th>
<th>Dosage</th>
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<tbody>
<tr>
<td><strong>β-lactam/β-lactamase inhibitors</strong></td>
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<tr>
<td>Piperacillin–tazobactam</td>
<td>4.5 g IV four to six times a day (4-h infusion)</td>
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<tr>
<td>Cefoperazone–sulbactam</td>
<td>2–3 g IV two to three times a day (3-h infusion)</td>
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<tr>
<td>Ticarcillin–clavulanate</td>
<td>3.1 g IV three to four times a day (3-h infusion)</td>
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<tr>
<td><strong>Carbapenems</strong></td>
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<tr>
<td>Meropenem</td>
<td>1 g IV thrice daily (3-h infusion)</td>
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<tr>
<td>Imipenem</td>
<td>0.5–1 g IV four times a day (2-h infusion)</td>
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<tr>
<td><strong>Antipseudomonal cephalosporins</strong></td>
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<tr>
<td>Cefepime</td>
<td>2 g IV two to three times a day (3-h infusion)</td>
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<tr>
<td>Cefpirome</td>
<td>2 g IV two to three times a day (3-h infusion)</td>
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<tr>
<td><strong>Antipseudomonal quinolones</strong></td>
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<tr>
<td>Ciprofloxacin</td>
<td>400 mg IV thrice daily over 30 min</td>
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<tr>
<td>Levofloxacin</td>
<td>750 mg IV daily over 30 min</td>
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<tr>
<td><strong>Antipseudomonal aminoglycosides</strong></td>
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<tr>
<td>Amikacin</td>
<td>20 mg/kg IV daily over 30 min</td>
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<td>Netilmicin</td>
<td>7 mg/kg IV daily over 30 min</td>
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<tr>
<td>Tobramycin</td>
<td>7 mg/kg IV daily over 30 min</td>
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<tr>
<td><strong>Anti-MRSA drugs</strong></td>
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<tr>
<td>Vancomycin</td>
<td>500 mg IV four times a day (4-h infusion)</td>
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<tr>
<td>Teicoplanin</td>
<td>12 mg/kg loading dose followed by 6–12 mg/kg daily (4-h infusion)</td>
<td></td>
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<tr>
<td>Linezolid</td>
<td>600 mg twice daily over 30 min</td>
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<tr>
<td><strong>Polymyxins</strong></td>
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<tr>
<td>Colistin</td>
<td>6–9 MU/day in divided doses</td>
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<tr>
<td>Polymyxin B</td>
<td>15,000–25,000 U/kg/day IV twice daily</td>
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</table>
• 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.
The following strategies are recommended in prevention of VAP:

- Oral cavity decontamination with 2% chlorhexidine (1A)[412-415]
- Hand hygiene preferably using alcohol-based hand rubs or soap and water (1A)[416]
- Use of sedation and weaning protocols (1A)[419,420]
- Use of NIV to avoid intubation, where feasible (1A)[264,421]
- Subglottic secretion drainage (2A)[422,423]
- Heat moisture exchangers in place of heated humidifiers (2A)[424-428]
- Closed suction systems (2A)[429-431]
- Use of orotracheal intubation as opposed to nasotracheal intubation (2A)[432,433]
- Proper and timely disposal of condensates (3A)[434,435]
- Maintaining tracheal cuff pressures <25 cm H₂O (2A)[436]
- Wipe stethoscopes with alcohol rubs (2A)[437]
- 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)

The following strategies are not recommended in prevention of VAP:

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