Chapter 16
Prevention of Lower Respiratory Tract Infections

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Key points

- Healthcare–associated pneumonia causes significant patient morbidity and mortality and increased utilisation of costly health care resources; prevention is therefore vital.
- Prevention measures include hand hygiene, use of gloves when handling respiratory secretions, daily assessment of readiness to wean from a ventilator, elevation of the bed head (unless contraindicated), use of orotracheal intubation, regular oral care with an antiseptic solution, and proper use, cleaning, and disinfection of respiratory equipment.

Introduction[1-4]

The cough reflex, together with a healthy respiratory mucosa, antimicrobial secretions, and immunity mechanisms, effectively prevent microorganisms from reaching the lower respiratory tract (LRT). As a result, in the healthy individual the LRT is sterile.

Factors that predispose to infection include alteration in level of consciousness, aspiration, endotracheal tubes, respiratory therapy devices, enteral feeding, severe underlying illness, extremes of age, malnutrition, immunosuppression, mechanical obstruction, viral infection, cigarette smoke, and alcohol intake. The LRT may become contaminated by aspiration of secretions, colonisation of the aerodigestive tract, or use of contaminated equipment/medication.

Pneumonia accounts for 11% - 15% of healthcare–associated infections (HAI) and for 25% of infections acquired in an intensive care unit (ICU). It has the highest mortality among HAIs; prevention is therefore vital. Postoperative pneumonia is a common complication of surgery, often because the patient fails to cough or breathe deeply because of pain. In these patients infections are usually caused by common respiratory pathogens.
Ventilator–associated pneumonia (VAP) is a more serious condition seen in mechanically ventilated patients in ICUs. It occurs in 8-28% of patients undergoing mechanical ventilation. In these patients, mechanical or chemical injury to the ciliated epithelium impairs the normal removal of mucus and microorganisms from the lower airway. In addition, reduction of gastric pH by H2 blocking agents is associated with colonisation of the upper gastrointestinal tract and oropharynx by aerobic Gram-negative bacilli derived from the patient's own bowel. These microorganisms may then pass to the LRT and cause infection.

These patients have usually had prolonged hospitalisation and antibiotics (sometimes several courses). Because of this, the microorganisms involved are often multidrug-resistant. Microorganisms may also be introduced into the respiratory tract via contaminated equipment or staff hands. Risk factors for healthcare-associated pneumonia can be related to the condition of the patient and/or the therapy received. (See Table 16.1)

Table 16.1. Risk factors for healthcare-associated pneumonia

Condition of patient	Severely ill, e.g., septic shock Age (elderly and neonates) Surgical operation (chest/abdomen) Major injuries Chronic obstructive lung disease Existing cardiopulmonary disease Cerebrovascular accidents Coma Heavy smoker
Therapy	Sedation General anaesthesia Tracheal intubation Tracheostomy Prolonged mechanical ventilation Enteral feeding Broad spectrum antibiotic therapy H2 blockers Immunosuppressive and cytotoxic drugs

Definitions and Diagnosis[5]

Healthcare-associated pneumonia is a LRT infection that appears during hospitalisation in a patient who was not incubating the infection at admission. It is diagnosed by the following:

- rales or bronchial breath sounds;
- fever;
- purulent sputum, cough, dyspnea, or tachypnea;
- relevant radiologic changes; and
- preferably, microbiological diagnosis from bronchial lavage, transtracheal aspirate, or protected brush culture.

Infection prevention and control (IPC) professionals must distinguish between clinical and surveillance definitions. For surveillance purposes, most IPC practitioners use the pneumonia definition published by the U.S. Centers for Disease Control and Prevention's National Healthcare Safety Network (NHSN) - see http://www.cdc.gov/nhsn/PDFs/pscManual/6pscVAPcurrent.pdf

There are three pneumonia categories:

PNU1 - X-ray changes and clinical signs and symptoms are present; pneumonia with specific laboratory findings

PNU2 - X-ray changes, clinical signs and symptoms are present as well as microbiological laboratory results from bronchoalveolar lavage, protected specimen brushing, blood culture, pleural fluid, or histopathologic exam; or

PNU3 - pneumonia in immuncompromised patients.

Etiological Agents[6-8]

Healthcare-associated pneumonia is divided into early- and late-onset disease. Early-onset pneumonia occurs within four days of admission and is usually caused by *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis*, or methicillin-sensitive *Staphylococcus aureus* (MSSA). It may occur in ICUs or after surgery, particularly in patients with existing pulmonary disease.

Late-onset healthcare-associated pneumonia occurs more than 4 days after admission and is usually caused by Gram-negative bacilli, e.g., *Pseudomonas aeruginosa*, *Acinetobacter*, or *Enterobacter* spp, or methicillin-resistant *Staphylococcus aureus* (MRSA). Many late-onset VAPs are caused by microorganisms that are resistant to multiple antibiotics.

Viruses (e.g., influenza, respiratory syncytial, or other respiratory viruses) may also cause early- and late-onset pneumonia. They easily spread in health care environments and can cause severe pneumonia in immunocompromised patients and young children. Fungi, e.g., *Candida* spp. and rarely *Aspergillus* spp., typically cause late-onset pneumonia. *Legionella* infection may be acquired from the air conditioning system or from water supplies, particularly by immunocompromised patients. *Aspergillus* and *Legionella* infections do not spread from person to person.

Pneumocystis carinii causes pneumonia in immunosuppressed patients, particularly those with acquired immune deficiency syndrome. Opportunistic pulmonary diseases caused by mycobacteria, including *Mycobacterium tuberculosis*, can cause pneumonia and can be spread by airborne transmission.

A NHSN survey of causes of VAP in the United States identified the following isolates: *Staphylococcus aureus* (24.4%), *Pseudomonas aeruginosa* (16.3%), *Enterobacter* spp. (8.4%), *Acinetobacter baumanii* (8.4%), *Klebsiella pneumoniae* (7.5%), *Escherichia coli* (4.6%), *Candida* spp. (2.7%), *Klebsiella oxytoca* (2.2%), coagulase-negative *Staphylococcus* (1.3%), unspecified (23.1%).

A European Centre for Disease Prevention and Control (ECDC) survey involving 12 countries in 2008 found ICU-acquired pneumonia was associated with: *Pseudomonas aeruginosa* (18.2%), *Staphylococcus aureus* (16.3%), *Escherichia coli* (9.3%), *Klebsiella* spp. (8.1%), *Candida* spp. (7.9%), *Enterobacter* spp. (7.1%), *Acinetobacter* spp. 3.7%), *Haemophilus* spp. (3.7%), *Stenotrophomonas* spp. (3.5%), *Enterococcus* spp. (3.2%), *Serratia* spp. (2.8), *Proteus* spp. (2.7%), coagulase-negative *Staphylococcus* (2.4%), *Streptococcus* spp. (2.4%), and *Citrobacter* spp. (1.8%).

Etiological agents of early- and late-onset pneumonia and VAP are summarised in Table 16.2.

Prevention[1-4, 9-11]

The core recommendations for prevention of healthcare-associated pneumonia are designed to avoid the three commonest mechanisms by which pneumonia develops: 1) aspiration, 2) contamination of the aerodigestive tract, and 3) contaminated equipment.

Basic measures for prevention of postoperative pneumonia include:

- Treat lung disease prior to surgery.
- Elevate the head of the bed, if not contraindicated.
- Avoid unnecessary suctioning of airways.
- Provide regular oral cavity care.
- Encourage deep breathing and coughing before and after operation.
- Provide appropriate pain therapy to avoid failing to cough or breathe deeply because of pain.
- Use non-sedative pain therapy.
- Use percussion and postural drainage to stimulate coughing.
- Encourage early mobilisation.

Table 16.2. Etiological agents of early- and late-onset and ventilator-associated pneumonia

Early-onset pneumonia	Late-onset pneumonia	VAP United States	VAP Europe
Streptococcus pneumoniae	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	*Pseudomonas aeruginosa*
Haemophilus influenzae	*Acinetobacter* spp.	*Pseudomonas aeruginosa*	*Staphylococcus aureus*
Moraxella catarrhalis	*Enterobacter* spp.	*Enterobacter* spp.	*Escherichia coli*
Methicillin-sensitive *Staphylocoocus aureus*	Methicillin-resistant *Staphylococcus aureus*	*Acinetobacter baumanii*	*Klebsiella* spp.
Influenza	Multidrug - resistant organisms	*Klebsiella pneumoniae*	*Candida* spp.
Respiratory syncytial or other respiratory viruses	*Candida* spp.	*Escherichia coli*	*Enterobacter* spp.
	Aspergillus spp.	*Candida* spp.	*Acinetobacter* spp.
		Klebsiella oxytoca	*Haemophilus* spp.
		Coagulase-negative *Staphylococcus*	*Stenotrophomonas* spp.

Basic measures for prevention of VAP include:

- Use hand hygiene before and after contact with patient, respiratory secretions, or objects contaminated with respiratory secretions, whether or not gloves are worn.
- Use single use or reprocessed gloves when handling respiratory secretions.
- Use sterile disposable or reprocessed gloves and sterile suction catheter for tracheal aspiration and tracheostomy care.
- Perform daily assessments of readiness to wean.
- Minimise the duration of ventilation and use noninvasive ventilation whenever possible.
- Elevate the head of the bed, if not contraindicated.

- Avoid gastric over-distension.
- Avoid unplanned extubation and reintubation.
- Use orotracheal intubation preferably vs. nasotracheal intubation.
- Avoid H2 blocking agents and proton pump inhibitors for patients who are not at risk for developing stress ulcer or stress gastritis.
- Perform regular oral care with an antiseptic solution.
- Use sterile water to rinse reusable respiratory equipment.
- Remove condensate from respiratory circuits. Keep the circuit closed during condensate removal.
- Change the ventilator circuit only when visibly soiled or malfunctioning.
- Store and disinfect respiratory therapy equipment properly. (See Table 16.3).
- Perform surveillance for VAP in units known or suspected to be at high risk for VAP.
- Perform direct observation of compliance with VAP-specific process measures (hand hygiene, bed position, daily assessment of readiness to wean, and regular oral care)
- Educate healthcare personnel who care for patients undergoing ventilation about VAP local epidemiology, risk factors, and patient outcomes.
- Establish antibiotic regimens in accordance with the local situation.

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Table 16.3. Prevention of ventilator-associated pneumonia

General measures	
1.	Thoroughly clean all respiratory equipment to be sterilised or disinfected.
2.	Whenever possible, use steam sterilisation or high-level disinfection by pasteurisation for reprocessing semi-critical equipment or devices (items that come into direct or indirect contact with mucous membranes of the lower respiratory tract). Use low-temperature sterilisation methods for equipment or devices that are heat or moisture sensitive. Take care not to contaminate the disinfected items during rinsing, drying, or packaging.
3.	Use sterile water to rinse reusable semi-critical respiratory equipment and devices after chemical disinfection. If this is not feasible, rinse the device with filtered water (0.2 μm filter) or tap water, and then rinse with isopropyl alcohol and dry with forced air or in a drying cabinet.
Mechanical ventilators	
1.	Do not routinely sterilise or disinfect the internal machinery of mechanical ventilators.
Breathing circuits, humidifiers, and heat-moisture exchangers	
1.	Do not routinely change the breathing circuit (ventilator tubing, exhalation valve, and attached humidifier) used by an individual patient. Change the circuit only when it is visible soiled or mechanically malfunctioning.
2.	Periodically drain and discard any condensate that collects in the tubing of a mechanical ventilator, taking precautions not to allow condensate to drain toward the patient.
3.	Wear gloves to perform the above procedures or when handling fluid.
4.	Decontaminate hands with soap and water (if hands are visibly soiled) or with an alcohol-based hand rub, after performing a procedure or handling fluid.
5.	Use sterile (not distilled, non-sterile) water to fill bubbling humidifiers.
6.	Change a heat-moisture exchanger when it malfunctions mechanically or becomes visibly soiled. Do not change it routinely at less than 48 hours.

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Further Reading

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