Guidelines for Prevention of Nosocomial Pneumonia

Summary

This document updates and replaces CDC's previously published "Guideline for Prevention of Nosocomial Pneumonia 1983;11:230-44). This revised guideline is designed to reduce the incidence of nosocomial pneumonia and is intended for use in hospitals; the information may not be applicable in long-term-care facilities because of the unique characteristics of such facilities. Sections on the prevention of respiratory-therapy devices, prevention of cross-contamination, and prevention of viral lower respiratory tract infections have been updated. New sections on Legionnaires disease and pneumonia caused by Aspergillus sp. have been included. Lower respiratory tract infections caused by Mycobacterium tuberculosis is not addressed in this document; CDC published such recommendations in 1992. The guideline is the first of a series of CDC guidelines being revised by HICPAC and NCID.

Pneumonia is the second most common nosocomial infection in the United States and is associated with substantial morbidity and mortality. Pneumonia occurs in patients who have severe underlying disease, immunosuppression, depressed immune function, or aspiration of bacteria colonizing the oropharynx or upper gastrointestinal tract. This increase the risk for nosocomial bacterial pneumonia. Pneumonias caused by Legionella sp., Aspergillus sp., and influenza virus (H1N1) are examples of nosocomial bacterial pneumonia. Pneumonias caused by Legionella sp., Aspergillus sp., and influenza virus (H1N1) are examples of nosocomial bacterial pneumonia.

New measures being investigated involve reducing oropharyngeal and gastric colonization by pathogenic microorganisms. Part I, "An Overview of the Prevention of Nosocomial Pneumonia, 1994," provides the background information for the recommendations in Part II, "Recommendations for Prevention of Nosocomial Pneumonia."

Part I. An Overview of the Prevention of Nosocomial Pneumonia, 1994

INTRODUCTION

This document updates and replaces CDC's previously published "Guideline for Prevention of Nosocomial Pneumonia 1983;11:230-44). This revised guideline is designed to reduce the incidence of nosocomial pneumonia and is intended for use in hospitals; the information may not be applicable in long-term-care facilities because of the unique characteristics of such facilities.

This revised guideline addresses common problems encountered by infection-control practitioners regarding the prevention of nosocomial pneumonia in mechanically ventilated and/or critically ill patients, care of respiratory-therapy devices, prevention of respiratory syncytial virus (RSV) and influenza infections, and prevention of bacterial pneumonia caused by Mycobacterium tuberculosis. The guideline is the first of a series of CDC guidelines being revised by HICPAC and NCID.

This guideline can be an important resource for educating health-care workers (HCWs) regarding prevention and control of nosocomial infections in U.S. hospitals. HCWs should give high priority to continuing infection-control educational programs.
BACKGROUND

Pneumonia is the second most common nosocomial infection in the United States and is associated with substantial morbidity and mortality in persons greater than 65 years of age; persons who have severe underlying disease, immunosuppression, depression of cell-mediated immunity, or are receiving mechanical ventilation.

Most bacterial nosocomial pneumonias occur by aspiration of bacteria colonizing the oropharynx or upper gastrointestinal tract. Given that most respiratory defenses, they greatly increase the risk for nosocomial bacterial pneumonia. Pneumonias caused by Legionella sp., Aspergillus, and other fungi infection usually occurs after viral inoculation of the conjunctivae or nasal mucosa by contaminated hands.

Traditional preventive measures for nosocomial pneumonia include decreasing aspiration by the patient, preventing colonization by pathogenic microorganisms.

BACTERIAL PNEUMONIA

I. Etiologic Agents

The reported distribution of etiologic agents that cause nosocomial pneumonia differs between hospitals because clinicians differ in their ability to identify and treat respiratory infections effectively. Aerobic bacteria have been the most frequently isolated pathogens (2-6,9,11-13). During 1986-1989, aerobic bacteria colonized the oropharynx or upper gastrointestinal tract, and these bacteria were reported, probably because aerobic and anaerobic cultures were not performed routinely in the reporting hospitals. Nosocomial bacterial pneumonias are frequently polymicrobial (4,7,9,11,12,15-19), and gram-negative bacilli (especially methicillin-resistant S. aureus) (5,7,10,15,20,21) and other gram-positive cocci, including Streptococcus pneumoniae, have been isolated from mechanically ventilated patients who had pneumonia that occurred within 48-96 hours of mechanical ventilation, reported a predominance of anaerobes (4).

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II. Diagnosis

Nosocomial bacterial pneumonia has been difficult to diagnose (7,8,16,23-32). Frequently, the criteria for diagnosis have included evidence of a new or progressive pulmonary infiltrate, a suggestive Gram stain, and positive cultures of sputum, with cultures of sputum or tracheal specimens may be sensitive for bacterial pathogens, they are highly nonspecific (42); conversely, cultures of blood or pleural fluid have very low sensitivity (8,18,19,43).

Because of these problems, a group of investigators recently formulated consensus recommendations for standard pneumonias (44-46). These methods involve bronchoscopic techniques such as quantitative culture of protected-specimen brushings (PSB) (5,7-9,11,14,15). In another published report, 20% of pathogens recovered from cultures of PSB, blood, pleural fluid, and other procedures have been polymicrobial; however, 54% of specimens did not yield any microorganism, probably because the patients from whom nosocomial pneumonia was diagnosed by using clinical criteria; S. aureus accounted for 16%, and H. influenzae was isolated from mechanically ventilated patients who had pneumonia that occurred within 48-96 hours of mechanical ventilation, reported a predominance of anaerobes (4).

Epidemiology

Results of the NNIS indicate that pneumonias (diagnosed on the basis of the CDC surveillance definition of nosocomial pneumonia) are the most common type of nosocomial infection after those of the urinary tract (2,61). In 1984, the overall incidence of low discharges per 1000 patient-days; pneumonia occurred in 6.7% of discharges per 1000 patient-days; pneumonia occurred in 11.7% of discharges in nonteaching hospitals to 7.7 in university-affiliated hospitals, probably related to the lower use of antibiotics in the former.
Nosocomial bacterial pneumonia often has been identified as a postoperative infection (62,63). In the Study of the Effi-
nosocomial bacterial pneumonia occurred in patients who had had a surgical operation; the risk was 38 times greater f
body sites (63). More recent epidemiologic studies, including NNIS studies, have identified other subsets of patients at
70 years of age; persons who have endotracheal intubation and/or mechanically assisted ventilation, a depressed level
persons who have previously had an episode of a large-volume aspiration. Other risk factors include 24-hour ventilato-
cimetidine (either with or without antacid), administration of antimicrobials, presence of a nasogastric tube, severe tran

The NNIS has stratified the incidence density of nosocomial pneumonia by patients' use of mechanical ventilation and
pneumonia cases per 1,000 ventilator-days ranged from 4.7 cases in pediatric ICUs to 34.4 cases in burn ICUs (66). In
ranged from zero cases in pediatric and respiratory ICUs to 3.2 cases in trauma ICUs.

Nosocomial pneumonia has been associated with high fatality rates. Crude mortality rates of 20%-50% and attributabl
pneumonia reflected 60% of all deaths resulting from nosocomial infections (17,35,74-80). Patients receiving mecha-
support; however, other factors (e.g., the patient's underlying disease{s} and organ failure) are stronger predictors of d

Analyses of pneumonia-associated morbidity have indicated that pneumonia could prolong hospitalization by 4-9 days
hospitalization is $1.2 billion per year (83). Nosocomial pneumonia is a major infection-control problem because of its

IV. Pathogenesis

Bacteria can invade the lower respiratory tract by aspiration of oropharyngeal organisms, inhalation of aerosols contain
addition, bacterial translocation from the gastrointestinal tract has been hypothesized recently as a mechanism for infect
community-acquired pneumonia.

In radioisotope-tracer studies, 45% of healthy adults were found to aspirate during sleep (84). Persons who swallow ab
mechanically assisted ventilation, or gastrointestinal tract instrumentation or diseases) or who have just undergone sur

The high incidence of gram-negative bacillary pneumonia in hospitalized patients might result from factors that promo
into the lower respiratory tract (33,88-91). Although aerobic gram-negative bacilli are recovered infrequently or are fo
substantially increases in comatose patients, in patients treated with antimicrobial agents, and in patients who have hy

disease, or nasogastric or endotracheal tubes in place (33,91,93,94).

Oropharyngeal or tracheobronchial colonization by gram-negative bacilli begins with the adherence of the microorgan
associated with the bacteria (e.g., presence of pili, cilia, capsule, or production of elastase or mucinase), host cell (e.g.,
respiratory secretions) (89,90,95,98-107). Although the exact interactions between these factors have not been fully el
negative bacilli to host cells (98,100,108). Conversely, certain conditions (e.g., malnutrition, severe illness, or postope

The stomach also might be an important reservoir of organisms that cause nosocomial pneumonia (34,110-114). The α
and on prophylactic or therapeutic interventions (22,111,115-118). In healthy persons, few bacteria entering the stoma
pH increases from the normal levels to greater than or equal to 4, microorganisms are able to multiply to high concent
have achlorhydria (119), ileus, or upper gastrointestinal disease; and in patients receiving enteral feeding, antacids, or 1
and the presence of bile) may contribute to gastric colonization in patients who have impaired intestinal motility; these

Bacteria also can enter the lower respiratory tract of hospitalized patients through inhalation of aerosols generated prin
related to the use of respiratory-therapy equipment have been associated with contaminated nebulizers, which are hum
spinning disk, or the Venturi mechanism (126,129,130). When the fluid in the reservoir of a nebulizer becomes contam
deposited deep in the patient's lower respiratory tract (126,130,131). Contaminated aerosol inhalation is particularly ha
lower respiratory tract. In contrast to nebulizers, bubble-through or wick humidifiers primarily increase the water-vap
generate aerosol droplets, they do so in quantities that may not be clinically important (127,132); wick humidifiers do

Bacterial pneumonia has resulted, in rare instances, from hematogenous spread of infection to the lung from another i
mechanism, translocation of viable bacteria from the lumen of the gastrointestinal tract through epithelial mucosa to th
Translocation is postulated to occur in patients with immunosuppression, cancer, or burns (133); however, data are ins

V. Risk Factors and Control Measures

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm
Several large studies have examined the potential risk factors for nosocomially acquired bacterial pneumonia (Table 2) can be grouped into the following general categories:

a. host factors (e.g., extremes of age and severe underlying conditions, including immunosuppression); b) factors of antimicrobials, admission to an ICU, underlying chronic lung disease, or coma; c) conditions favoring aspiration conditions requiring prolonged use of mechanical ventilatory support with potential exposure to contaminated re that impede adequate pulmonary toilet (e.g., undergoing surgical procedures that involve the head, neck, thorax,

A. Oropharyngeal, Tracheal, and Gastric Colonization

The association between colonization of the oropharynx (88,137), trachea (138), or stomach (110,111,117,123) could eradicate common gram-negative pathogens from the upper respiratory tract (138), superinfection occurs interference (with alpha-hemolytic streptococci) has been used successfully by some investigators to prevent the method for general usage has not been evaluated.

In many studies, the administration of antacids and H-2 blockers for prevention of stress bleeding in critically ill overgrowth (34,112,113, 118,122,123,145-147). Sucralfate, a cytoprotective agent that has little effect on gastric antacids and H-2 blockers (148-150). The results of clinical trials comparing the risk for pneumonia in patients r (112,118,147,148,151-153). In most randomized trials, ICU patients receiving mechanically assisted ventilation could differ between 1 of 69 treated with antacids, and 21% of 68 treated with an H-2 blocker (147). Conversely, a meta-analysis of dat indicate a strong association between nosocomial pneumonia and drugs that increase gastric pH. Additional stud are being conducted to compare the efficacy of sucralfate and ranitidine.

Selective decontamination of the digestive tract (SDD) is another strategy designed to prevent bacterial coloniza aimed at preventing oropharyngeal and gastric colonization with aerobic gram-negative bacilli and Candida sp. administered nonabsorbable antibiotic agents, such as polymyxin and an aminoglycoside (either tobramycin, ger either amphotericin B or nystatin. The local antimicrobial preparation is applied as a paste to the oropharynx anc a systemic (intravenous) antimicrobial (e.g., cefotaxime or trimethoprim) is administered to the patient.

Although most studies (155-158,160-167,169,170,175-177), including two meta-analyses (171,178), have demo been difficult to assess because they have differed in design and study population and many have had short follo criteria; bronchoscopy with BAL or PSB was used in only a few studies (159,162,173,175-177,179).

Two recently published reports of large, double-blind, placebo- controlled trials demonstrated no benefit from S gram-negative bacillary pneumonia decreased significantly after SDD, but this decrease was not accompanied by between patients randomly assigned to SDD or placebo treatment conditions; however, both patient groups also

Although an earlier meta-analysis indicated a trend toward decreased mortality in patients administered SDD (1: mortality, as well as the high cost of using SDD to prevent nosocomial pneumonia or death resulting from nosoc nine patients) would have to be administered SDD; to prevent one death, 23 patients {range: 13-39 patients}) (1 positive bacteria and other antibiotic-resistant nosocomial pathogens are public health concerns (156,158, 159,1 nosocomial pneumonia in ICU patients. SDD may be ultimately useful for specific subsets of ICU patients, such

A new approach advocated to prevent oropharyngeal colonization in patients receiving enteral nutrition is to red of bacteria from the stomach has been confirmed in patients given acidified enteral feeding, the effect on the inc

B. Aspiration of Oropharyngeal and Gastric Flora

Clinically important aspiration usually occurs in patients who a) have a depressed level of consciousness; b) hav or orostrachal), tracheostomal, or enteral (nasogastric or orogastric) tube in place; and/or d) are receiving enteral colonazation, cause reflux of gastric contents, or allow bacterial migration via the tube from the stomach to the u enteral solution during preparation (189-191) and elevated gastric pH (70,192,193) may lead to gastric colonizat
increased intragastric volume and pressure (70,117,183).

Although prevention of pneumonia in such patients may be difficult, methods that make regurgitation less likely withholding enteral feeding if the residual volume in the stomach is large or if bowel sounds are not heard upon been obtained by a) administering enteral nutrition intermittently in small boluses rather than continuously (70,1 stomach (e.g., in the jejunum) (199,200).

C. Mechanically Assisted Ventilation and Endotracheal Intubation

Patients receiving continuous, mechanically assisted ventilation have 6-21 times the risk for acquiring nosocomial indicated that the risk for developing ventilator-associated pneumonia increased by 1% per day (5). This increase endotracheal tube into the trachea during intubation, as well as to depressed host defenses secondary to the patient tube over time and form a glycocalyx (i.e., a biofilm) that protects the bacteria from the action of antimicrobial agents dislodged by ventilation flow, tube manipulation, or suctioning and subsequently embolize into the lower respiratory tract and using aseptic techniques to reduce cross-contamination to patients from contaminated respiratory therapy equipment pneumonia in patients receiving mechanically assisted ventilation.

The risk for pneumonia also is increased by the direct access of bacteria to the lower respiratory tract, which often occurs above the cuff to enter the trachea (206). In one study, the occurrence of nosocomial pneumonia was delayed after drainage (i.e., by suctioning) of secretions in the space above the endotracheal tube cuff and below the glottis (207).

D. Cross-Colonization Via Hands of HCWs

Pathogens that cause nosocomial pneumonia (e.g., gram-negative bacilli and S. aureus) are ubiquitous in hospital patients frequently occurs via an attending HCW's hands that have become contaminated or transiently colonized. Endotracheal tubes or ventilator circuit increase the opportunity for cross-contamination (215,216). The risk for pneumonia when appropriate (65) and by eliminating pathogens from the hands of HCWs (65,215,217-219).

In theory, adequate handwashing is an effective way of removing transient bacteria from the hands (218,219); however, it is not effective (223). For this reason, the routine use of gloves has been advocated to help prevent cross-contamination (224,225). Incidence of nosocomial RSV infection (226) and other infections acquired in ICUs (227). However, nosocomial pneumonia can be delayed for as long as 2-3 days after having contact with one patient and before providing care to another (229,230). In addition, gloved hands of the HCW may persistently be contaminated or colonized by microorganisms and serve as a reservoir for cross-contamination (217). This is especially a concern when patients have active respiratory infections because of the high concentration of infectious microorganisms (218,220).

E. Contamination of Devices Used on the Respiratory Tract

Devices used on the respiratory tract for respiratory therapy (e.g., nebulizers), diagnostic examination (e.g., bronchoscopy) for infectious microorganisms (65,232-236). Routes of transmission might be from device to patient (127,129,240). The same patient via hand or device (233,246-248). Contaminated reservoirs of aerosol-producing devices (e.g., nebulizers) increase the risk for pneumonia by increasing the risk of aspiration and subsequent infection (129,130,242). Gram-negative bacilli (e.g., Pseudomonas sp., Xanthomonas sp., Flavobacterium sp.) and increase the risk for pneumonia in patients using such devices.

Proper cleaning and sterilization of reusable equipment are important components of a program to minimize the risk for nosocomial pneumonia (240,242,254-259). Many devices or parts of devices used on the respiratory tract have been categorized as semicritical devices because they come into direct or indirect contact with mucous membranes but do not ordinarily penetrate normally sterile tissues (260). Thus, if sterilization cannot be subjected to high-level disinfection by pasteurization at 75 C for 30 minutes (262-265) by use of liquid sterilants/disinfectants and approved for use on medical instruments by the Food and Drug Administration (225,266). If a respiratory device needs rinsing to remove a residual liquid chemical sterilant/disinfectant after chemical disinfection (249,250,269-272). In some hospitals, a tap-water rinse followed by complete drying is achieved after a tap-water rinse, the risk for nosocomial pneumonia associated with the use of HCWs after washing, and air drying also reduces contamination of gastrointestinal endoscopes (274-276). However, nebulizers, bronchoscopes) are difficult to dry, and the degree of dryness of a device is difficult to assess (274-276).
1. Mechanical Ventilators, Breathing Circuits, Humidifiers, Heat-Moisture Exchangers, and In-Line Nebulizers

a. Mechanical ventilators. The internal machinery of mechanical ventilators used for respiratory therapy, routine sterilization or high-level disinfection of the internal machinery is considered unnecessary. Filters interposed between the machinery and the main breathing machine by the patient; however, these filters also might alter the functional specifications of the breathing circuits. The expiratory-phase tubing of the mechanical-ventilator circuit may help prevent cross-contamination preventing nosocomial pneumonia needs further evaluation.

b. Breathing circuits, humidifiers, and heat-moisture exchangers. In the United States, most hospitals use (132,283) or no aerosols, respectively, for humidification. Thus, these devices probably do not pose a risk of infection that reduce or eliminate bacterial pathogens (283,284). Sterile water, however, is heated to temperatures that reduce or eliminate bacterial pathogens (283,284). Microorganisms, such as Legionella sp., that are more heat-resistant than other bacteria (252,271).

The potential risk for pneumonia in patients using mechanical ventilators that have heated bubble-thet the ventilator circuit as a result of the difference in the temperatures of the inspiratory-phase gas and condensate can rapidly become contaminated, usually with bacteria that originate in the patient's oropharynx within 2 hours, and 80% within 24 hours, after initiation of mechanical ventilation (286). Spillage of procedures in which the tubing is moved (e.g., for suctioning, adjusting the ventilator setting, or feeding) may cause the tubing to become contaminated, and many hospitals, HCWs are trained to prevent such spillage and to drain the fluid periodically. Microliter of HCWs handling the fluid, especially if the HCW neglects washing hands after handling the tubing.

The role of ventilator-tubing changes in preventing pneumonia in patients using mechanical ventilators with humidifiers have indicated that neither the rate of bacterial contamination was changed every 24 hours rather than every 8 or 16 hours (287). A later study indicated the increase in contamination of the inspiratory-phase gas or tubing of the ventilator circuits (288). In another study, when the circuits were changed every 48 hours rather than every 24 hours (288). More recent reports suggest that the risk of contamination increased even further when the circuits were changed every 48 hours (11 {31%} of 35 patients) (289).

These findings indicate that the recommended daily change in ventilator circuits may be extended to savings for U.S. hospitals by reducing the number of circuits used and the amount of personnel time left unchanged on a patient has not been determined.

Condensate formation in the inspiratory-phase tubing of a ventilator breathing circuit can be decreased by using a heat-moisture exchanger (HME) or a hygroscopic agent that results from the elevation of the gas temperature (290). Condensate formation can be eliminated by using a heat-moisture exchanger (HME) or a hygroscopic agent that results from the elevation of the gas temperature (290). Until additional information regarding the role of ventilator-tubing changes in preventing pneumonia in patients using mechanical ventilators with humidifiers have indicated that neither the rate of bacterial contamination of the tubing was changed every 24 hours rather than every 8 or 16 hours (287). A later study indicated the increase in contamination of the inspiratory-phase gas or tubing of the ventilator circuits (288). In another study, when the circuits were changed every 48 hours rather than every 24 hours (288). More recent reports suggest that the risk of contamination increased even further when the circuits were changed every 48 hours (11 {31%} of 35 patients) (289).

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c. Small-volume ("in-line") medication nebulizers. Small-volume medication nebulizers that are insert devices become contaminated by condensate in the inspiratory tubing of the breathing circuit, they endotracheal tube and bypasses many of the normal host defenses against infection (286).

2. Large-Volume Nebulizers. Nebulizers with large-volume (greater than 500 cc) reservoirs, including those room-air humidifiers, pose the greatest risk for pneumonia to patients, probably because of the large amounts of HCWs, unsterile humidification fluid, or inadequate sterilization or disinfection between uses (12 sufficient large numbers within 24 hours to pose a risk for infection in patients who receive inhalation therapy eliminate vegetative bacteria from their reservoirs and make them safe for patient use (260). However, unl
evidence of clinical benefits from their use in hospitals is lacking, and the potential cost of daily sterilizati

3. Hand-Held Small-Volume Medication Nebulizers. Small-volume medication nebulizers used to administ
nebulizers have been associated with nosocomial pneumonia, including Legionnaires disease, resulting fr
c water used for rinsing and filling the reservoir (258).

4. Suction Catheters, Resuscitation Bags, Oxygen Analyzers, and Ventilator Spirometers. Tracheal suction c
ether systems are used in U.S. hospitals: the open single-use catheter system and the closed multi-use c
results of these studies suggest that the risk for catheter contamination or pneumonia does not differ betw
ether system is used (305-307). Although advantages of cost and decreased environmental contaminatin
compare the advantages and disadvantages of both systems (310).

Reusable resuscitation bags are particularly difficult to clean and dry between uses; microorganisms in sec
the patient on whom the bag is used; in addition, contaminating microorganisms might be transmitted fro
have been associated with outbreaks of gram-negative respiratory tract colonization and pneumonia result
require either sterilization or high-level disinfection between uses on different patients. Education of phys
these devices is essential.

5. Anesthesia Equipment. The contributory role of anesthesia equipment in outbreaks of nosocomial pneum
results of these studies suggest that the risk for catheter contamination or pneumonia does not differ betw
ether system is used (305-307). Although advantages of cost and decreased environmental contaminatin
compare the advantages and disadvantages of both systems (310).

a. Anesthesia machine. The internal components of anesthesia machines, which include the gas source
b. Breathing system or patient circuit. The breathing system or patient circuit (including the tracheal tu
become contaminated with microorganisms that might originate from the patient's oropharynx or tra
disinfection or sterilization) of the components of the breathing system have been published (317,31
membranes (e.g., face mask or tracheal tube) or become readily contaminated with the patient's resp
and subjected to high-level disinfection or sterilization between patients. The other parts of the brea
schedule of reprocessing has not been firmly determined (319), are changed, cleaned, and sterilized
and/or the manufacturers' instructions.

Using high-efficiency bacterial filters at various positions in the patient circuit (e.g., at the y-piece o
shown to decrease contamination of the circuit (321-323). However, the use of bacterial filters to pr
analysis (324-326).


a. Internal parts of pulmonary function testing apparatus. The internal parts of pulmonary function test
gas (327). However, because of concern about possible carry-over of bacterial aerosols from an infe
that remove exhaled bacteria) between the patient and the testing equipment has been advocated (24
nosocomial pneumonia (330).

b. Tubing, rebreathing valves, and mouthpieces. Tubing, connectors, rebreathing valves, and mouthpie
apparatus. Thus, these items should be cleaned and subjected to high-level disinfection or sterilizatio

F. Thoracoabdominal Surgical Procedures

Certain patients are at high risk for developing postoperative pulmonary complications, including pneumonia. T
obstructive pulmonary disease (331-334). Abnormal results from pulmonary function tests (especially decreased
intubation, or protein depletion that can cause respiratory-muscle weakness are also risk factors (62,68,136). Pat
swallowing and respiratory clearance mechanisms as a result of instrumentation of the respiratory tract, anesthe
abdominal surgery usually have diaphragmatic dysfunction that results in decreased functional residual capacity
Interventions aimed at reducing the postoperative patient's risk for pneumonia have been developed (339). These include continuous positive airway pressure by face mask (339-349). Studies evaluating the relative efficacy of these maneuvers assessed, patient populations studied, and study design (339,341,342,348-350). Nevertheless, many studies have shown advantageous maneuvers, especially in patients who had preoperative pulmonary dysfunction (342,343,345,346). Immediate postoperative period decreases the incidence of pulmonary complications after surgery. Several meth patient-controlled) administration of analgesia and regional (e.g., epidural) analgesia (351-358).

**G. Other Prophylactic Measures**

1. **Vaccination of Patients.** Although pneumococci are not a major cause of nosocomial pneumonia, these organisms can cause bacteremia (359-361). The following factors place patients at high risk for complications from pneumococcal disease, diabetes mellitus, alcoholism, cirrhosis, cerebrospinal fluid leaks, immunosuppression, functional status, and age (362,363). Because two thirds or more of patients who are hospitalized with pneumococcal illness, offering pneumococcal vaccine in hospitals (e.g., at the time of patient discharge).

2. **Prophylaxis with Systemic Antimicrobial Agents.** The systemic administration of antimicrobials is common but may not completely prevent pneumonia in patients who are ventilated, are postoperative, and/or are critically ill (365-367). However, the efficacy of this practice is questionable (74,91,366-371).

3. **Use of "Kinetic Beds" or Continuous Lateral Rotational Therapy (CLRT) for Immobilized Patients.** Use of kinetic beds or continuous lateral rotation (CLRT) for immobilized patients is hypothesized to improve drainage of secretions within the lungs and lower airways, increased tidal ventilation, and to prevent aspiration pneumonia. The hypothesized benefits are improved drainage of secretions within the lungs and lower airways, increased tidal ventilation, and to prevent aspiration pneumonia. However, the efficacy of CLRT in preventing pneumonia needs further evaluation because studies have yielded conflicting results. Studies have lacked adequate randomization, had no clear definition of pneumonia, did not distinguish confounding factors (e.g., mechanical ventilation, endotracheal intubation, nasogastric intubation, and enteral feeding), and have had small sample sizes.

**LEGIONNAIRES DISEASE**

**I. Epidemiology**

Legionnaires disease is a multisystem illness, with pneumonia, caused by Legionella sp. (382). Since the etiologic agent was identified, thus enabling researchers to study the epidemiology of epidemic legionellosis. In contrast, the etiologic agent has not been defined. However, when one case is identified, the presence of additional cases should be suspected. Of 196 cases that occurred during 22 nosocomial outbreaks (defined as two or more cases occurring at a hospital during a 6-month outbreak, and another 13% occurred in hospitals in which other sporadic cases, but no outbreaks, were identified identified.

In North America, the overall proportion of nosocomial pneumonias caused by Legionella sp. has not been determined (384-386). Because diagnostic tests for Legionella sp. infection are not performed routinely on all patients who have pneumonia, the incidence of Legionnaires disease in the United States has not been determined. Legionella sp. are commonly found in various natural and man-made aquatic environments (387,388) and may be found in condensers, heated potable-water-distribution systems within hospitals, and locally produced distilled water can and water chemistry. Habitat for growth of legionellae in man-made water environments include temperatures of 25-42 °C (391-395), st that are capable of supporting intracellular growth of legionellae (397,398).

A person's risk for acquiring legionellosis after exposure to contaminated water depends on a number of factors, especially immune status, underlying illnesses, and later stages of acquired immunodeficiency syndrome (AIDS) also are probably at increased risk for legionellosis. Chronic lung disease, or nonhematologic malignancy; those who smoke cigarettes; and the elderly are at increased risk for legioniellae disease. Underlying disease and advanced age are risk factors not only for acquiring Legionnaires disease but also for death.
through 1989, immunosuppression, advanced age, end-stage renal disease, cancer, and nosocomial acquisition of underlying disease in hospitalized patients.

II. Diagnosis

The clinical spectrum of disease caused by Legionella sp. is broad and ranges from asymptomatic infection to radiographically from pneumonia caused by other agents (407,408), and evidence of infection with other respiratory tract specimen (419,420).

The diagnosis of legionellosis may be confirmed by any one of the following: culture isolation of Legionella from secretions or tissue by immunofluorescent microscopy, or, for legionellosis caused by Legionella pneumophila observation of a four-fold rise in L. pneumophila serogroup-1 antibody titer to greater than or equal to 1:128 in IFA test (412,413). A single elevated antibody titer does not confirm a case of Legionnaires disease because IF tests is 100% sensitive, the diagnosis of legionellosis is not excluded even if one or more of the tests are negative.

Because the above tests complement each other, performing each test when Legionnaires disease is suspected in tests is 100% sensitive, the diagnosis of legionellosis is not excluded even if one or more of the tests are negative.

Modes of Transmission

Inhalation of aerosols of water contaminated with Legionella sp. might be the primary mechanism by which these organisms are infected, through exposure to contaminated aerosols generated by cooling towers, showers, faucets, respiratory tract colonizers was proposed as the mode of transmission to certain patients (42:5).

IV. Definition of Nosocomial Legionnaires Disease

The incubation period for Legionnaires disease is usually 2-10 days (431); thus, for the purposes of this document and patient who has been hospitalized continuously for greater than or equal to 10 days before the onset of illness is considered to occur 2-9 days after hospital admission is a possible case of the disease.

V. Prevention and Control Measures

A. Prevention of Legionnaires Disease in Hospitals with No Identified Cases (Primary Prevention)

Prevention strategies in health-care facilities in which no cases of nosocomial legionellosis have been identified facility, the resources available for implementing prevention strategies, and state and local regulations.

At least two strategies are practiced with regard to the most appropriate and cost-effective means of preventing illness have been detected. However, a study comparing the cost-benefit ratios of these strategies has not been conducted.

The first approach is based on periodic, routine culturing of water samples from the hospital's potable water system. If samples obtained are culture-positive for Legionella sp., the hospital's potable water system is decontaminated (433,434). This approach is based on the presence or concentration of Legionella sp. in the potable water system, and, conversely, if Legionella sp. are cultured from the water, cases of nosocomial legionellosis have occurred.

The main argument against this approach is that, in the absence of cases, the relationship between the results of routine culturing of water samples obtained are culture-positive for Legionella sp., and 26% were colonized at greater than 30% of sites sampled; however, cases of which active surveillance for legionellosis and environmental culturing for Legionella sp. were done, no cases of nosocomial legionellosis have occurred. It is that routinely culturing a single water system and by fluctuations in the concentration of Legionella sp. at the same site (439,440). In addition, other than the presence or concentration of organisms; these factors include the degree to which contaminated water systems of buildings (436), often without being associated with known cases of disease (271,38 colonized with Legionella sp., and 26% were colonized at greater than 30% of sites sampled; however, cases of which active surveillance for legionellosis and environmental culturing for Legionella sp. were done, no cases of nosocomial legionellosis have occurred.

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm
host, the susceptibility of the host, and the virulence properties of the contaminating strain (441-443). Thus, data
forming units detected in samples from the hospital environment. By routinely culturing water samples, many h
identified. Because of this problem, routine monitoring of water from the hospital's potable water system and fre
The second approach to preventing and controlling nosocomial legionellosis involves a) maintaining a high inde
who have nosocomial pneumonia and who are at high risk for developing the disease and dying from the infecti
of one case of definite or two cases of possible nosocomial Legionnaires disease, and c) routinely maintaining c
Measures used in hospitals in which cases of nosocomial legionellosis have been identified include either a) rout
chlorination of heated water to achieve 1-2 mg/L of free residual chlorine at the tap, especially in areas where in
benefit ratio of such measures in hospitals in which no cases of legionellosis have been identified needs addition
B. Prevention of Legionnaires Disease in Hospitals with Identified Cases (Secondary Prevention)

The indications for a full-scale environmental investigation to search for and subsequently decontaminate identit
probably differ depending on the hospital. In hospitals in which as few as one to three nosocomial cases are iden
frequently identified numerous additional cases (403,422,425,447). This finding suggests the need for a low thr
legionellosis. However, when developing a strategy for responding to such an identification, infection-control pe
Legionella sp. infection at their particular hospital.

An epidemiologic investigation conducted to determine the source of Legionella sp. involves several important s
should be initiated to identify all recent or ongoing cases of legionellosis. Third, potential risk factors for infectio
should be identified by creating a line listing of cases, analyzing the collected information (by time, place, and p
lected from environmental sources implicated by the epidemiologic investigation and from other potential so
environmental samples should be conducted (427,450-452). This last step can be crucial in supporting epidemio:

In some hospitals in which the heated-water system was identified as the source of the organism, the system was
outlet of the hot-water system for at least 5 minutes with water at greater than or equal to 65 C) and hyperchlorir
mg/L of free residual chlorine) (449, 454-456). After either of these procedures, most hospitals either a) maintai
water to achieve 1-2 mg/L of free residual chlorine at the tap, especially in areas where in
However, additional data are needed regarding the efficacy of these methods before they can be considered stan
previously (463).

Additional preventive measures have been used to protect severely immunocompromised patients. At one hosp
sterile water was used for drinking or flushing nasogastric tubes (429). In another hospital, a combined approac
hyperchlorination of the water supply to the bone-marrow transplant unit was used to decrease the incidence of I

The decision to search for hospital environmental sources of Legionella sp. and the choice of procedures to use t
hospital. Furthermore, decision makers should consider a) the high cost of an environmental investigation and ol
b) the differential risk, based on host factors, for acquiring nosocomial legionellosis and of having severe and fa

ASPERGILLOSIS

I. Epidemiology

Aspergillus sp. are ubiquitous fungi that commonly occur in soil, water, and decaying vegetation. Aspergillus sp.
hospital renovation and construction, horizontal surfaces, food, and ornamental plants (466).

Aspergillus fumigatus and Aspergillus flavus are the most frequently isolated Aspergillus sp. in patients who ha
increasingly as a cause of severe illness and mortality in highly immunocompromised patients (e.g., patients un
hematologic and other malignant neoplasms) (468-472).

The most important nosocomial infection caused by Aspergillus sp. is pneumonia (473,474). Hospital outbreaks
bone-marrow transplant units (473-480). Although invasive aspergillosis has been reported in recipients of solid these patients has been lower than in recipients of bone-marrow transplants, probably because granulocytopenia transplant recipients, has decreased with the introduction of cyclosporine (483,486). The efficacy of infection- in preventing aspergillosis in solid-organ transplant recipients has not been well evaluated (483,484,486,487). In fungal infections (488).

The reported attributable mortality from invasive pulmonary aspergillosis has differed depending on the patient | transplants and patients who have aplastic anemia, compared with rates of 13%-80% in leukemic patients (489-4

II. Pathogenesis

In contrast to most bacterial pneumonias, the primary route of acquiring Aspergillus sp. infection is by inhalation results from invasion of local lung tissue (467,474,492). Subsequently, the fungus might disseminate via the blo colonzation with Aspergillus sp., as an intermediate step before invasive pulmonary disease, has been proposed Aspergillus sp. has predisposed patients, especially those with preexisting lung disease (e.g., chronic obstruc

Diagnosis

Diagnosing pneumonia caused by Aspergillus sp. is often difficult without performing invasive procedures. Although l most reliable technique (501). Histopathologic demonstration of tissue invasion by fungal hyphae has been required in may indicate colonization (502). However, when Aspergillus sp. is grown from the sputum of a febrile, granulocytopenic aspergillosis (495,503). Routine blood cultures are remarkably insensitive for detecting Aspergillus sp. (504), and syst infection (505-507). Antigen-based serologic assays are being developed in an attempt to allow for the rapid and speci been determined (508,509).

IV. Risk Factors and Control Measures

The primary risk factor for invasive aspergillosis is severe and prolonged granulocytopenia, both disease- and therapy- granulocytopenia, they probably constitute the population at highest risk for developing invasive aspergillosis (490,51: than 1,000 polymorphonuclears/µL) is associated with the type of graft they receive. Although both autologous and all transplant procedure, acute or chronic graft-versus-host disease also could develop in allogeneic-transplant recipients. (which often includes high doses of corticosteroids, cyclosporine, and other immunosuppressive agents) might result in infection in bone-marrow-transplant recipients, infection-control personnel should consider exposures of the patient to discharge, patients (especially allogeneic-transplant recipients) might continue to manifest severe granulocytopenia and address the problem of invasive aspergillosis in bone-marrow-transplant recipients, various studies are in progress to e b) eliminating or suppressing respiratory fungal colonization of the upper respiratory tract. These methods include, res amphotericin B or oral or systemic antifungal drug prophylaxis (466,512-515). For solid-organ transplant recipients, ri transplant recipients, risk factors for invasive infection with Aspergillus sp. included preoperative and postoperative re

The presence of aspergilli in the hospital environment is the most important extrinsic risk factor for opportunistic inv renovation activities in and around hospitals markedly increase the airborne Aspergillus sp. spore counts in such hosp immunosuppressed patients also has been associated with other hospital environmental reservoirs. Such reservoirs incl A single case of nosocomial Aspergillus sp. pneumonia is often difficult to link to a specific environmental exposure. I retrospective review of microbiologic, histopathologic, and postmortem records; notification of clinicians caring for hi When additional cases are detected, the likelihood is increased that a hospital environmental source of Aspergillus sp. construction activities and/or fungal contamination of hospital air-handling systems as major sources for outbreaks (47 endonuclease profiling, which is now available for A. fumigatus (526)) may substantially aid in identifying the source Outbreaks of invasive aspergillosis reinforce the importance of maintaining an environment as free as possible of Asp services in many large hospitals -- particularly bone-marrow transplant services -- have installed "protected environme vigilance during hospital construction and routine maintenance of hospital air- filtration and ventilation systems to pre

Although the exact configuration and specifications of the protected environments might differ between hospitals, sucl
incoming air by using central or point-of-use high-efficiency particulate air (HEPA) filters that are capable of removing
from intake on one side of the room, across the patient, and out through the exhaust on the opposite side of the room;
room-air changes (range: 15 to greater than 400 per hour), although air-change rates at the higher levels might pose prn
environment is a room with laminar airflow. Such an environment consists of a bank of HEPA filters along an entire w
velocity (90 plus or minus 20 feet/minute), forcing the air to move in a laminar, or at least unidirectional, pattern (535)
air changes per hour) are achieved (473,527). The net effects are essentially sterile air in the room, minimal air turbule

The laminar-airflow system is effective in decreasing or eliminating the risk for nosocomial aspergillosis in high-risk t
alternative systems with lower air-change rates (i.e., 10-15 air changes per hour) have been used in some hospitals (52)
airflow rooms in eliminating Aspergillus sp. spores and preventing nosocomial aspergillosis are limited. One hospital t
that cases of nosocomial aspergillosis had occurred in patients housed in these rooms, although this rate was low (i.e.,
cultured from the room air, suggesting that the patients were probably exposed to fungal spores when they were allow

Copper-8-quinolinololate was used on environmental surfaces contaminated with Aspergillus sp. to control one reported
constructed hospital to help decrease the environmental spore burden (530); however, its general applicability has not l

VIRAL PNEUMONIAS

Viruses can be an important and often unappreciated cause of nosocomial pneumonia (538-540). In one prospective st
infections (539). Although the early diagnosis and treatment of viral pneumonia infections have been possible in recen
sometimes fatal viral pneumonia (538,545-552). These data and reports of well-documented outbreaks involving noso
instituted.

Nosocomial respiratory viral infections a) usually follow community outbreaks that occur during a particular period ev
persons (547,548,554,562-564), and d) have exogenous sources. A number of viruses -- including adenoviruses, influe
cause nosocomial pneumonia (548,555,556,565-571,572); however, adenoviruses, influenza viruses, parainfluenza vir
(573).

Influenza and RSV infections contribute substantially to the morbidity and mortality associated with viral pneumonia,
section concerning viral pneumonias focuses on the principles of, and approaches to, the control of these two types of i
viral pathogens were published previously (224).

RSV INFECTION

I. Epidemiology

RSV infection is most common during infancy and early childhood, but it can also occur in adults (562,565,574, l
life-threatening pneumonia and bronchiolitis have occurred in immunocompromised patients, the elderly, and ch

Recent surveillance of 10 U.S. hospital laboratories in which cultures for RSV are performed suggests that com
months and are associated with an increased number of hospitalizations and deaths among infants and young ch
time of hospital admission are often reservoirs for RSV (553,555).

II. Diagnosis

The clinical characteristics of RSV infection, especially in neonates, are often indistinguishable from those of ot
standard for diagnosis. Rapid antigen-detection kits that use direct immunofluorescence or enzyme-linked immu
infected patients depends on the sensitivity and specificity of the test. The reported sensitivity and specificity of (579-582). In general, once laboratory-confirmed cases of RSV infection are identified in a hospital, a presumpt
may be acceptable for infection-control purposes.

Modes of Transmission

RSV is present in large numbers in the respiratory secretions of symptomatic persons infected with the virus, and it ca
RSV-contaminated hands or fomites (553,583,584). The portal of entry is usually the conjunctiva or the nasal mucosa

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm 5/3/2009
or nose (553,583-585). Hands can become contaminated by handling either the respiratory secretions of infected perso

In nosocomial RSV outbreaks for which the viral isolates were typed, more than one strain of RSV often was identified
and visitors. Because infected infants shed large amounts of virus in their respiratory secretions and can easily contami infected after exposure in the community (588) or in the hospital and subsequently transmit infection to patients, other

IV. Control Measures

Different combinations of control measures, ranging from the simple to the complex, have been effective in varying dc have shared two common elements: implementation of contact-isolation precautions and compliance with these preca
most nosocomial RSV infections; however, studies have indicated that such compliance among HCWs is poor (221,22

The wearing of gloves and gowns has been associated with decreased incidence of nosocomial RSV (226). The wearin comply with handwashing and other precautions and deter them from touching their eyes or nose. However, the benef patient or with contaminated fomites and if hands are not washed adequately after glove removal (229). The wearing o has been successful in preventing infection (226). In addition, the use of eye-nose goggles rather than masks has prote

Additional measures may be indicated to control ongoing nosocomial transmission of RSV or to prevent transmission cardiac, pulmonary, or immune systems are compromised). The following additional control measures have been used with or without preadmission screening by rapid laboratory diagnostic tests; b) cohorting HCWs; c) excluding HCWs risk for severe or fatal RSV infection (e.g., infants); d) limiting visitors; and e) postponing admission of patients at hig

INFLUENZA

I. Epidemiology

Pneumonia that occurs in patients who have influenza can be caused by the influenza virus, a secondary bacteria person but is more common in infants and young children, in persons greater than 65 years of age, and in person underlying heart or lung disease) (575,601-603).

Influenza typically occurs on a seasonal basis during December-April; during this period, peak influenza activity community affected by an influenza epidemic; these outbreaks are often characterized by abrupt onset and rapid homes; however, hospital outbreaks in pediatric and chronic-care wards and in medical and neonatal intensive-c

Influenza is believed to be spread from person to person by a) direct inhalation of droplet nuclei or small-particl respiratory tract of a person during close contact with an infected person (613-616). The extent to which transmi contact is not the primary mode of transmission (617).

The most important reservoirs of influenza virus are infected persons. Although the period of greatest communic and for greater than or equal to 7 days afterward (556,604, 618).

II. Diagnosis

Influenza is clinically indistinguishable from other febrile respiratory illnesses; however, during outbreaks with have similar manifestations (619). Historically, diagnosis of influenza was made by virus isolation from nasopha similar to culture in sensitivity and specificity now enable early diagnosis and treatment of cases and provide a

Prevention and Control of Influenza

The most effective measure for reducing the impact of influenza is the vaccination of persons at high risk for complica persons 6 months-18 years of age who are receiving long-term aspirin therapy and persons who either a) are greater than the pulmonary or cardiovascular systems, diabetes mellitus, renal dysfunction, hemoglobinopathies, or immunosuppre also may be at high risk for complications resulting from influenza. When high vaccination rates are achieved in clothe 13 of 42Guidelines for Prevention of Nosocomial Pneumonia 5/3/2009http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm
When an institutional outbreak is caused by influenza type A, antiviral agents can be used both for treatment of ill persons and prophylaxis for high-risk persons after late vaccination; b) as prophylaxis for persons for whom vaccination is contraindicated; c) as short-term prophylaxis for all high-risk persons until protective levels of antibody in response to vaccination; d) as prophylaxis for unvaccinated HCWs who provide care to patients with influenza type A if they are administered to all or most patients when influenza type A illnesses begin in a facility; and e) as prophylaxis when vaccine strains do not closely match the epidemic strain.

Amantadine has been available in the United States for many years; rimantadine has been approved for use since 1993. Both amantadine and rimantadine (e.g., amantadine hydrochloride, are effective against influenza type A but not against influenza type B (543,632-634). These drugs can reduce the severity and duration of illness caused by influenza A virus if administered early in the course of the illness, and prophylaxis with these drugs can reduce the spread of influenza type A if they are administered to all or most patients when influenza type A illnesses begin in a facility. In addition, prophylaxis with rimantadine reduces the likelihood of developing resistance to amantadine.

Compared with rimantadine, amantadine has been associated with a higher incidence of adverse central nervous system changes and lightheadedness. These symptoms have been reported in 5%-10% of healthy young adults receiving 200 mg/day of amantadine. Dizziness and ataxia occur more frequently among persons in this age group than among younger persons (644). These symptoms are generally mild and transient, and they resolve prior to discontinuation of therapy. These drugs. Guidelines for the use of amantadine and rimantadine and considerations for the selection of these drugs are available in the CDC Guidelines for the Use of Antiviral Agents for Influenza (643,644).

The emergence of amantadine- and rimantadine-resistant strains of influenza A virus has been observed in persons who were treated with these drugs. This is particularly important if the contacts are unvaccinated. The drug package inserts for these drugs contain specific information on the use of prophylaxis and treatment, including the duration of treatment and prophylaxis and the indication for the use of these drugs.

The primary focus of efforts to prevent and control nosocomial influenza is the vaccination of high-risk patients and HCWs. Influenza vaccination of healthcare workers (HCWs) is an adjunct to vaccination in the prevention and control of nosocomial influenza. Influenza vaccine is recommended for HCWs, including those in acute care facilities, long-term care facilities, and emergency departments. The effectiveness of vaccination in preventing influenza among healthcare workers varies, but it is generally higher in healthcare workers who receive influenza vaccine than in those who do not receive influenza vaccine.

Measures other than vaccination and chemoprophylaxis have been recommended for controlling nosocomial influenza. These recommendations are presented in the following order based on the etiology of the infection: bacterial pneumonia (i.e., RSV and influenza infections). Each topic is subdivided according to the following general approaches:

1. Staff education and infection surveillance;
2. Interruption of transmission of microorganisms by eradicating infecting microorganisms from their epidemiologic niche;
3. Modifying host risk for infection.

As in previous CDC guidelines, each recommendation is categorized on the basis of existing scientific evidence, theoretical considerations, and expert opinion. The system of categorizing recommendations has been modified as follows:

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm
CATEGORY IA Strongly recommended for all hospitals and strongly supported by well-designed experimental or epidemiologic studies.

CATEGORY IB Strongly recommended for all hospitals and viewed as effective by experts in the field and a consensus of HICPAC. These recommendations are based on strong rationale and consensus regarding an unresolved issue.

CATEGORY II Suggested for implementation in many hospitals. These recommendations may be supported by suggestive clinical or epidemiologic studies, a strong theoretical rationale, or data from other sites.

NO RECOMMENDATION; Practices for which insufficient evidence or consensus regarding an unresolved issue exist.

BACTERIAL PNEUMONIA

I. Staff Education and Infection Surveillance

A. Staff education

Educate HCWs regarding nosocomial bacterial pneumonias and infection-control procedures used to prevent them.

B. Surveillance

1. Conduct surveillance of bacterial pneumonia among ICU patients at high risk for nosocomial bacterial pneumonias to determine trends and identify potential problems (6,34,35,62,63,662-664). Include data as rates (e.g., number of infected patients or infections per 100 ICU days or per 1,000 ventilator days).

2. Do not routinely perform surveillance cultures of patients or of equipment or devices used for respiratory care.

II. Interrupting Transmission of Microorganisms

A. Sterilization or disinfection and maintenance of equipment and devices

1. General measures

   a. Thoroughly clean all equipment and devices before sterilization or disinfection (266,267,670).

   b. Sterilize or use high-level disinfection for semicritical equipment or devices (i.e., items that come in contact with mucous membranes and intact skin but not with breaks in the skin). High-level disinfection can be achieved either by wet heat pasteurization at 76°C for 30 minutes or by use of high-level disinfectants approved by the Environmental Protection Agency and cleared for marketing for use on medical instruments by the Food and Drug Administration (260,262,264,267,671). Follow disinfection with appropriate rinsing, drying, and alcohol-based methods.

   c. (1) Use sterile (not distilled, nonsterile) water for rinsing reusable semicritical equipment and devices used on the respiratory tract after they have been sterilized or high-level disinfected.

   (2) No Recommendation for using tap water (as an alternative to sterile water) to rinse reusable semicritical equipment and devices used on the respiratory tract followed by drying with or without the use of alcohol (241,249,250,258,269,273,277). UNRESOLVED ISSUE.
d. Do not reprocess equipment or devices that are manufactured for a single use only, unless data change the structural integrity or function of the equipment or device (672,673). CATEGORY I

2. Mechanical ventilators, breathing circuits, humidifiers, and nebulizers

a. Mechanical ventilators

Do not routinely sterilize or disinfect the internal machinery of mechanical ventilators (126,127). CATEGORY IA

b. Ventilator circuits with humidifiers

(1) Do not routinely change more frequently than every 48 hours the breathing circuit, including tubing and exhalation valve, and the attached bubbling or wick humidifier (126,127). CATEGORY IA

(2) No Recommendation for the maximum length of time after which the breathing circuit and the attached bubbling or wick humidifier of a ventilator being sterilized is used (215,282,286). CATEGORY IB

(3) Sterilize reusable breathing circuits and bubbling or wick humidifiers or subject them to high-level disinfection between their uses on different patients (215,282,286). CATEGORY IB

(4) Periodically drain and discard any condensate that collects in the tubing of a mechanical ventilator, taking precautions not to allow condensate to enter the patient circuit (247,281). CATEGORY IA

(5) No Recommendation for placing a filter or trap at the distal end of the expiratory-phase tubing of the breathing circuit to collect condensate (247,281). CATEGORY IB

(6) Do not place bacterial filters between the humidifier reservoir and the inspiratory-phase tubing of the breathing circuit of a mechanical ventilator (215,282,286). CATEGORY IB

(7) Humidifier fluids

(a) Use sterile water to fill bubbling humidifiers (132, 241,249,250,286). CATEGORY II

(b) Use sterile, distilled, or tap water to fill wick humidifiers (249, 250,286). CATEGORY II

(c) No Recommendation for preferential use of a closed, continuous-feed humidification system. UNRESOLVED ISSUE

(c) Ventilator breathing circuits with hygroscopic condenser-humidifiers or heat-moisture exchangers

(1) No Recommendation for preferential use of hygroscopic
condenser-humidifier or heat-moisture exchanger rather than a heated humidifier to prevent n

(2) Change the hygroscopic condenser-humidifier or heat-
mooture exchanger according to the manufacturer's recommendation and/or when evidence o

(3) Do not routinely change the breathing circuit attached to
a hygroscopic condenser-humidifier or heat-moisture exchanger while it is being used on a pa

3. Wall humidifiers

a. Follow manufacturers' instructions for using and maintaining wall oxygen humidifiers unless
679). CATEGORY IB

b. Between uses on different patients, change the tubing, including any nasal prongs or mask, us

4. Small-volume medication nebulizers: "in-line" and hand-held nebulizers

a. (1) Between treatments on the same patient, disinfect, rinse
with sterile water, or air-dry small-volume medication nebulizers (242,258). CATEGORY IB

(2) No Recommendation for using tap water as an alternative
to sterile water when rinsing reusable small-volume medication nebulizers between treatment

b. Between uses on different patients, replace nebulizers with those that have undergone steriliz:
c. Use only sterile fluids for nebulization, and dispense these fluids aseptically (238,241,249,25

d. If multi-dose medication vials are used, handle, dispense, and store them according to manufa

5. Large-volume nebulizers and mist tents

a. Do not use large-volume room-air humidifiers that create aerosols (e.g., by Venturi principle, subjected to high-level disinfection at least daily and filled only with sterile water (239-241,2

b. Sterilize large-volume nebulizers that are used for inhalation therapy (e.g., for tracheostomiz
every 24 hours of use on the same patient (126,128,129). CATEGORY IB

c. (1) Use mist-tent nebulizers and reservoirs that have
undergone sterilization or high-level disinfection, and replace these items between uses on dif

(2) No Recommendation regarding the frequency of changing
mist-tent nebulizers and reservoirs while such devices are being used on one patient. UNRES

6. Other devices used in association with respiratory therapy

a. Between uses on different patients, sterilize or subject to high-level disinfection portable resp
CATEGORY IB

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm
5/3/2009
b. (1) Between uses on different patients, sterilize or subject to high-level disinfection reusable hand-powered resuscitation bags (e.g., Ambu bags) (255, 3 hydrophobic filters placed on the connection port of resuscitation bags. UNRESOLVED ISS

7. Anesthesia machines and breathing systems or patient circuits
   a. Do not routinely sterilize or disinfect the internal machinery of anesthesia equipment (316). C
   b. Clean and then sterilize or subject to high-level liquid chemical disinfection or pasteurization inspiratory and expiratory breathing tubing, y-piece, reservoir bag, humidifier, and humidifier reprocessing such components (260, 264, 267, 317, 685). CATEGORY IB
   c. No Recommendation for the frequency of routinely cleaning and disinfecting unidirectional v
   d. Follow published guidelines and/or manufacturers' instructions regarding in-use maintenance system or patient circuit of anesthesia equipment (317, 318). CATEGORY IB
   e. Periodically drain and discard any condensate that collects in the tubing of a breathing circuit procedure or handling the fluid, wash hands with soap and water or with a waterless handwas
   f. No Recommendation for placing a bacterial filter in the breathing system or patient circuit of

8. Pulmonary-function testing equipment
   a. Do not routinely sterilize or disinfect the internal machinery of pulmonary-function testing m:
   b. Sterilize or subject to high-level liquid-chemical disinfection or pasteurization reusable moutf manufacturers' instructions for their reprocessing (260, 261, 263-267). CATEGORY IB

B. Interrupting person-to-person transmission of bacteria

1. Handwashing

   Regardless of whether gloves are worn, wash hands after contact with mucous membranes, respirate worn, wash hands both before and after contact with a) a patient who has an endotracheal or tracheoc 212, 218, 219, 231, 689, 690). CATEGORY IA

2. Barrier precautions

   a. Wear gloves for handling respiratory secretions or objects contaminated with respiratory secr
   b. Change gloves and wash hands a) after contact with a patient; b) after handling respiratory se patient, object, or environmental surface; and c) between contacts with a contaminated body s CATEGORY IA
   c. Wear a gown if soiling with respiratory secretions from a patient is anticipated, and change th

3. Care of patients who have a tracheostomy

   a. Perform tracheostomy under sterile conditions. CATEGORY IB
   b. When changing a tracheostomy tube, use aseptic techniques and replace the tube with one tha
4. Suctioning of respiratory tract secretions
   a. No Recommendation for wearing sterile gloves rather than clean but nonsterile gloves when s
   b. If the open-suction system is employed, use a sterile single-use catheter. CATEGORY II
   c. Use only sterile fluid to remove secretions from the suction catheter if the catheter is to be us
   d. No Recommendation for preferential use of the multiuse closed-system suction catheter or th
   e. Change the entire length of suction-collection tubing between uses on different patients. CAT
   f. Change suction-collection canisters between uses on different patients except when used in sl

III. Modifying Host Risk for Infection

A. Precautions for preventing endogenous pneumonia

   Discontinue enteral-tube feeding and remove devices such as endotracheal, tracheostomy, and/or enteral (i are resolved (6,34,35,85-87,117,183,185,186, 202,692). CATEGORY IB

   1. Preventing aspiration associated with enteral feeding
      a. If the maneuver is not contraindicated, elevate at an angle of 30-45 the head of the bed of a pa
      and/or who has an enteral tube in place) (74,185). CATEGORY IB
      b. Routinely verify the appropriate placement of the feeding tube (693-695). CATEGORY IB
      c. Routinely assess the patient's intestinal motility (e.g., by auscultating for bowel sounds and m
      feeding to avoid regurgitation (692). CATEGORY IB
      d. No Recommendation for the preferential use of small-bore tubes for enteral feeding (694). U
      e. No Recommendation for administering enteral feeding continuously or intermittently (70,193
      f. No Recommendation for preferentially placing the feeding tubes (e.g., jejunal tubes) distal to

   2. Preventing aspiration associated with endotracheal intubation
      a. No Recommendation for using orotracheal rather than nasotracheal tube to prevent nosocomi:
      b. No Recommendation for routinely using an endotracheal tube with a dorsal lumen above the p
      patient's subglottic area (206). UNRESOLVED ISSUE
      c. Before deflating the cuff of an endotracheal tube in preparation for tube removal, or before m

   3. Preventing gastric colonization
      a. If stress-bleeding prophylaxis is needed for a patient receiving mechanically assisted ventilati
      CATEGORY II
      b. No Recommendation for selective decontamination of a critically ill, mechanically ventilated,
      bacillary (or Candida sp.) pneumonia (155-180). UNRESOLVED ISSUE
c. No Recommendation for routine acidification of gastric feedings to prevent nosocomial pneumonia.

B. Preventing postoperative pneumonia

1. Instruct preoperative patients, especially those at high risk for contracting pneumonia, regarding frequent postoperative period (346,348). Patients at high risk include those who will receive anesthesia -- especially those with substantial pulmonary dysfunction (e.g., patients who have chronic obstructive lung disease, a musculoskeletal abnormality, or significant respiratory disease). CATEGORY IB

2. Encourage postoperative patients to cough frequently, take deep breaths, move about the bed, and ambulate if possible. CATEGORY IB

3. Control pain that interferes with coughing and deep breathing during the immediate postoperative period with as little cough-suppressant effect as possible; b) providing appropriate support for abdominal and chest wall pain (e.g., epidural analgesia) (356-358). CATEGORY IB

4. Use an incentive spirometer or intermittent positive-pressure breathing equipment on patients at high risk for pneumonia. CATEGORY II

C. Other prophylactic procedures for pneumonia

1. Vaccination of patients

Vaccinate patients at high risk for complications of pneumococcal infections with pneumococcal polysaccharide vaccine, especially those who have chronic cardiovascular or pulmonary disease, diabetes mellitus, alcoholism, cirrhosis, or anatomic asplenia or HIV infection (362-364). CATEGORY IA

2. Antimicrobial prophylaxis

Do not routinely administer systemic antimicrobial agents to prevent nosocomial pneumonia (74,91). CATEGORY IB

3. Use of rotating "kinetic" beds or continuous lateral rotational therapy

No Recommendation for the routine use of kinetic beds or continuous lateral rotational therapy (i.e., prevention of nosocomial pneumonia in patients in the ICU, critically ill patients, or patients immobilized). CATEGORY II

PREVENTION AND CONTROL OF LEGIONNAIRES DISEASE

IV. Staff Education and Infection Surveillance

A. Staff education

Educate a) physicians to heighten their suspicion for cases of nosocomial Legionnaires disease and to use control, and engineering personnel) about measures to control nosocomial legionellosis (659-661). CATEGORY IB

B. Surveillance

1. Establish mechanism(s) to provide clinicians with appropriate laboratory tests for the diagnosis of Legionnaires disease.

2. Maintain a high index of suspicion for the diagnosis of nosocomial Legionnaires disease, especially in immunosuppressed patients (e.g., organ-transplant recipients, patients who have AIDS, and patients being treated with immunosuppressive agents). CATEGORY IB

3. Maintain a high index of suspicion for the diagnosis of Legionnaires disease in patients with a chronic underlying disease (e.g., diabetes mellitus, congestive heart failure, and chronic obstructive pulmonary disease). CATEGORY IB


V. Interrupting Transmission of Legionella sp.
A. Primary prevention (preventing nosocomial Legionnaires disease when no cases have been documented)

1. Nebulization and other devices
   a. (1) Use sterile (not distilled, nonsterile) water for rinsing nebulization devices and other semicritical respiratory-care equipment after such items have
   (2) No Recommendation for using tap water as an alternative to sterile water for rinsing reusable semicritical equipment and devices used on the respiratory followed by drying with or without the use of alcohol. UNRESOLVED ISSUE
   b. Use only sterile (not distilled, nonsterile) water to fill reservoirs of devices used for nebulization
   c. Do not use large-volume room-air humidifiers that create aerosols (e.g., by Venturi principle, subjected to high-level disinfection daily and filled only with sterile water (252,702). CATEGORY I

2. Cooling towers
   a. When a new hospital building is constructed, place cooling tower(s) in such a way that the to
   b. For operational cooling towers, install drift eliminators, regularly use an effective biocide, ma records (Appendix D) (421,463,704). CATEGORY IB

3. Water-distribution system
   a. No Recommendation for routinely maintaining potable water at the outlet at greater than or e
   b. No Recommendation for treating water with ozone, ultraviolet light, or heavy-metal ions (457

B. Secondary prevention (response to identification of laboratory-confirmed nosocomial legionellosis)

When a single case of laboratory-confirmed, definite nosocomial Legionnaires disease is identified, OR if a 6-month period, the following procedures are recommended:

1. Contact the local or state health department or CDC if the disease is reportable in the state or if assi
2. If a case is identified in a severely immunocompromised patient (e.g., an organ-transplant recipient) epidemiologic and environmental investigation (as described in II-B-3-b-1 through II-B-5) to deter
3. If severely immunocompromised patients are not being treated in the hospital, conduct an epidemio/identify previous cases, and begin an intensive prospective surveillance for additional cases of noso
   a. If evidence of continued nosocomial transmission is not present, continue the intensive pros
   b. If evidence of continued nosocomial transmission is present:
      (1) Conduct an environmental investigation to determine the source(s) of Legionella sp. by collecting water samples from potential sources of aerosolized Legionella sp. obtained from patients and the environment (241,258,421-427,450,452). CATI
(2) If a source is not identified, continue surveillance for
new cases for at least 2 months, and, depending on the scope of the outbreak, decide either to
decontamination of the hospital's water distribution system, with special attention to the speci
(3) If a source of infection is identified by epidemiologic
and environmental investigation, promptly decontaminate it (465). CATEGORY IB
(a) If the heated-water system is implicated:
   i. Decontaminate the heated-water system either by superheating (i.e., flushing for at leas
      hyperchlorination (i.e., flushing for at least 5 minutes all outlets of the system with water
      warning signs at each outlet being flushed to prevent scald injury to patients, staff, or vi
   ii. Depending on local and state regulations regarding potable water temperature in public
      legionellosis (e.g., immunocompromised patients) either a) maintain potable water at th
      mg/L of free residual chlorine at the tap (385, 428,439,446-449) (Appendix B). CATE
   iii. No Recommendation for treatment of water with ozone, ultraviolet light, or heavy-meta
   iv. Clean hot-water storage tanks and water heaters to remove accumulated scale and sedi
   v. Restrict immunocompromised patients from taking showers, and use only sterile water
      (429). CATEGORY II
(b) If cooling towers or evaporative condensers are
implicated, decontaminate the cooling-tower system (Appendix D) (463). CATEGORY IB
(4) Assess the efficacy of implemented measures in reducing
or eliminating Legionella sp. by collecting specimens for culture at 2-week intervals for 3 mo
(a) If Legionella sp. are not detected in cultures during
3 months of monitoring at 2-week intervals, collect cultures monthly for another 3 months. C.
(b) If Legionella sp. are detected in one or more
cultures, reassess the implemented control measures, modify them accordingly, and repeat the
the same technique used for initial decontamination or a combination of superheating and hy-
(5) Keep adequate records of all infection-control
measures, including maintenance procedures, and of environmental test results for cooling tov

PREVENTION AND CONTROL OF NOSOCOMIAL PULMONARY ASPERGILLOSIS

   I. Staff Education and Infection Surveillance
      A. Staff education
         Educate HCWs about nosocomial pulmonary aspergillosis, especially with respect to immunocomp
B. Surveillance

1. Maintain a high index of suspicion for the diagnosis of nosocomial pulmonary aspergillosis in granulocytopenia (less than 1,000 polymorphonuclear cells/mm³ for 2 weeks or less than 100 (510,511,705). Patients who have received solid-organ transplants and patients who have hemorrhage if they are severely granulocytopenic (472,485,510,706). CATEGORY IB

2. Maintain surveillance for cases of nosocomial pulmonary aspergillosis by periodically reviewing

3. No Recommendation for performing routine, periodic cultures of a) the nasopharynx of high-risk patients (466,478,517,494,520-522). UNRESOLVED ISSUE

VI. Interrupting Transmission of Aspergillus sp. Spores

A. Planning new specialized-care units for patients at high risk for infection

1. When constructing new specialized-care units for patients at high risk for infection, ensure that patien filtration, b) directed room airflow, c) positive air pressure in patients' rooms relative to the air pressure (530,533,537,707,708). CATEGORY IB

   a. Air filtration. Install, either centrally or at the point of use (i.e., at the room-air intake site), HI (473,528-530,533,537,707,708). CATEGORY IB

   b. Directed room airflow. Place air-intake and exhaust ports such that room air comes in from outside (529,530). CATEGORY IB

   c. Well-sealed room. Construct windows, doors, and intake and exhaust ports to achieve complete

   d. Room-air pressure. Ensure that room-air pressure can be maintained continuously above that contraindicated by clinical-care or infection-control considerations (529,530). CATEGORY IB

      1) To maintain positive room-air pressure in relation to the corridor, supply air to the room at a rate that is 10%-20% greater than the rate of air being expelled.

      2) For placement of patients who are at high risk for aspergillosis and who also have an infection (e.g., varicella or infectious tuberculosis) that needs to be protected from the spread of the airborne infection from and acquisition of aspergillosis by the patient (e.g., by air filtration), maintain room-air pressure above that contraindicated by clinical-care or infection-control considerations (529,530). CATEGORY IB

   e. Room-air changes. Ventilate the room to ensure greater than or equal to 12 room-air changes

2. No Recommendation for the preferential installation of a particular system, such as one with ultra-high efficiency (Efficiency (473,528-530,533,537,707,708). UNRESOLVED ISSUE

3. Formulate hospital policies to minimize exposures of high-risk patients to potential sources of Aspergillus sp. Spores and flower arrangements) (466,517,522,527,709-711). CATEGORY IB

4. No Recommendation for prophylactic use of copper-8-quinolinolate biocide in fireproofing materials

B. In existing facilities with no cases of nosocomial aspergillosis

1. Place patients who are at high risk for infection in a protected environment that meets the condition:

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm
2. Routinely inspect air-handling systems in hospital areas in which patients at high risk for infection are housed. Coordinate repairs of the system with the relocation of patients who are at high risk for infection to a safer environment.

3. Minimize the length of time that patients who are at high risk for infection are outside their rooms. Ensure patients wear well-fitting masks capable of filtering Aspergillus sp. spores. CATEGORY IB

4. Prevent dust accumulation by damp-dusting horizontal surfaces on a daily basis, regularly cleaning doors to prevent outside air from entering the room, especially in areas occupied by patients with chronic infections such as tuberculosis. CATEGORY IB

5. Systematically review and coordinate infection-control strategies with personnel in charge of hospital infection control. CATEGORY IB

6. When planning hospital construction and renovation activities, assess whether patients at high risk for infection are housed at construction and renovation sites, and, if so, develop a plan to prevent such exposures (466,522). CATEGORY IB

7. During construction or renovation activities:
   a. Construct barriers between patient-care and construction areas to prevent dust from entering the patient-care areas (67,478,521,522). CATEGORY IB
   b. In construction/renovation areas inside the hospital, create and maintain negative air pressure (e.g., if patients in the adjacent patient-care areas have infectious tuberculosis) (466,478,521,522). CATEGORY IB
   c. Direct pedestrian traffic from construction areas away from patient-care areas to limit the opportunity for dust tracking of dust into patient-care areas (466,478,521,522). CATEGORY IB
   d. Clean newly constructed areas before allowing patients to enter the areas (466,522). CATEGORY IB

8. Eliminate exposures of patients at high risk for aspergillosis to activities that might cause spores of Aspergillus sp. to enter the hospital. CATEGORY IB

9. Eliminate exposures of patients at high risk for aspergillosis to potential environmental sources of Aspergillus sp. (466,517,522,709-711). CATEGORY II

10. Prevent birds from gaining access to hospital air-intake ducts (523). CATEGORY IB

C. The following procedures should be followed if a case of nosocomial aspergillosis occurs:

1. Begin a prospective search for additional cases in hospitalized patients and an intensified retrospective investigation (473,477,478,521,533,537). CATEGORY IB

2. If evidence of continuing transmission is not present, continue routine maintenance procedures to prevent exposure (473,477,478,521,533,537). CATEGORY IB

3. If evidence of continuing Aspergillus sp. infection is present, conduct an environmental investigation to determine the source of infection (473,477,478,521,533,537). CATEGORY IB
   a. Collect environmental samples from potential sources of Aspergillus sp., especially those sources with high spore counts (e.g., using a volume air sampler rather than settle plates) (473,477,478,521,533,537,713). CATEGORY IB
   b. Depending on test availability, perform molecular subtyping of Aspergillus sp. obtained from potential sources (473,477,478,521,533,537,713). CATEGORY IB
   c. If air-handling systems that supply air to areas in which high-risk patients are housed are not available for all patients at high risk for invasive aspergillosis, corrective measures should be taken to ensure these systems are available for all high-risk patients (473,477,478,521,533,537,713). CATEGORY IB
   d. If an environmental source of exposure to Aspergillus sp. is identified, perform corrective measures to prevent further exposures (473,477,478,521,533,537,713). CATEGORY IB
e. If an environmental source of exposure to Aspergillus sp. is not identified, review existing infection prevention and control measures to correct or improve. CATEGORY IB

VII. Modifying Host Risk for Infection

A. Administer cytokines, including granulocyte-colony-stimulating factor and granulocyte-macrophage-stimulating factor, to reduce chemotherapy-induced granulocytopenia (512,513). CATEGORY II

B. No Recommendation for administration of intranasal amphotericin B or oral antifungal agents (including voriconazole) (514,515,714). UNRESOLVED ISSUE

PREVENTION AND CONTROL OF RSV INFECTION

I. Staff Education and Infection Surveillance

A. Staff education

Educate personnel regarding the epidemiology, modes of transmission, and means of preventing transmission of RSV.

B. Surveillance

1. Establish mechanism(s) by which the appropriate hospital personnel are promptly alerted to a possible RSV outbreak.

2. During December-March and periods of increased prevalence of RSV in the community, attend for pediatric patients, especially infants, and for immunocompromised adults who have a respiratory illness.

VIII. Interrupting Transmission of RSV

A. Preventing person-to-person transmission

1. Primary measures for contact isolation

   a. Handwashing. Regardless of whether gloves have been worn, wash hands after contact with respiratory secretions (218,231,553,583-585,594). CATEGORY IA

   b. Wearing gloves.

      (1) Wear gloves while handling patients or respiratory secretions of patients who have confirmed or suspected RSV infection and while handling for respiratory secretions from one another.

      (2) Change gloves a) between contact with different patients and b) after handling respiratory secretions or fomites contaminated with secretions from one another.

   c. Wearing a gown. Wear a gown if clothing could be soiled by the respiratory secretions of a patient. Change the gown after such contact and before caring for another patient (226,589,591,596).

   d. Staffing. Restrict HCWs who are in the acute stages of an upper respiratory illness (i.e., those who have complications from RSV infection, e.g., children who have severe underlying cardiopulmonary disease) (594, 596). CATEGORY IB

   e. Limiting visitors. Do not allow persons who have symptoms of respiratory infection to visit u
2. Controlling RSV outbreaks

   a. Use of private rooms, cohorting, and patient-screening. To control ongoing RSV transmission in rooms if possible, OR perform RSV-screening diagnostic tests on young children at the time of admission. CATEGORY II

   b. Personnel cohorting. During an outbreak of nosocomial RSV, cohort personnel as much as possible with uninfected patients, and vice-versa) (590, 594, 596). CATEGORY II

   c. Postponing patient admission. During outbreaks of nosocomial RSV, postpone elective admissions. CATEGORY II

   d. Wearing eye-nose goggles. No Recommendation for wearing eye-nose goggles during close contact.

PREVENTION AND CONTROL OF INFLUENZA

I. Staff Education and Infection Surveillance

   A. Staff education

      Educate HCWs about the epidemiology, modes of transmission, and means of preventing transmission of influenza.

   B. Surveillance

      1. Establish mechanism(s) by which the appropriate hospital personnel are promptly alerted of a possible influenza outbreak. CATEGORY IB

      2. Arrange for laboratory tests to be available to clinicians, for use when clinically indicated, to make the diagnosis of influenza during November-April (620-625). CATEGORY IB

IX. Modifying Host Risk for Infection

   A. Vaccination

      1. Patients. Offer vaccine to outpatients and inpatients at high risk for complications from influenza, beginning October 1 (647, 648, 717-719). Patients at high risk for complications from influenza include persons greater than 65 years of age; persons with disorders of the pulmonary or cardiovascular systems, diabetes mellitus, renal dysfunction, hemoglobinopathies, or those who have musculoskeletal disorders that impede adequate respiratory function; persons taking aspirin therapy (628); and persons who have severely immunosuppressed patients. CATEGORY IB

      2. Personnel. Vaccinate HCWs before the influenza season begins each year, preferably between mid-October and early November (628). If vaccine supply is limited, give primary emphasis to priority groups. Use additional vaccine to those who initially refused vaccination.CATEGORY IB

   B. Use of antiviral agents. (See Section IV, Controlling Influenza Outbreaks.)

X. Interrupting Person-to-Person Transmission

   A. Keep a patient who has suspected or confirmed influenza in a private room or, unless medically contraindicated, in a room where negative pressure can be provided (613, 614, 616, 720). CATEGORY II

   B. As much as feasible, maintain negative air pressure in rooms of patients for whom influenza is suspected or confirmed, using independent air-supply and exhaust system (613, 614, 616, 720). CATEGORY II

   C. Institute the wearing of masks among persons -- except those immune to the infecting virus strain -- who are in close contact with patients with suspected or confirmed influenza (649, 721). CATEGORY II

   D. As much as possible during periods of influenza activity in the community, the hospital's employee health should be notified of influenza for possible removal from duties that involve direct patient contact. Use more stringent isolation precautions for severely immunosuppressed patients (649, 721). CATEGORY II
E. When community and/or nosocomial outbreaks occur, especially if they are characterized by high attack rates:

1. Restrict hospital visitors who have a febrile respiratory illness. CATEGORY IB
2. Curtail or eliminate elective medical and surgical admissions as necessary. CATEGORY IB
3. Restrict cardiovascular and pulmonary surgery to emergency cases only. CATEGORY IB

XI. Controlling Influenza Outbreaks

A. Determining the outbreak strain

Early in the outbreak, obtain nasopharyngeal-swab or nasal-wash specimens from patients who recently had febrile respiratory illness; prevent contact during and for 2 days after the latter; discontinue treatment (633,631). CATEGORY IB

B. Vaccinating patients and HCWs

Administer current influenza vaccine to unvaccinated patients and HCWs, especially if the outbreak occurs while the vaccine is still effective. CATEGORY IB

C. Administering amantadine or rimantadine

1. When a nosocomial outbreak of influenza A is suspected or identified:
   a. Administer amantadine or rimantadine for prophylaxis to all uninfected patients in the involved unit who are not immunocompromised, 90% effective unless the results of diagnostic tests to identify the infecting strain(s) can be obtained within 24 hours. CATEGORY II
   b. Administer amantadine or rimantadine for prophylaxis to unvaccinated HCWs who do not have previous vaccine exposure or immunodeficiency who are in close contact with patients at high risk for infection (631). CATEGORY II

2. Discontinue amantadine or rimantadine if laboratory tests confirm or strongly suggest that influenza type A is not the cause of the outbreak. CATEGORY IB

3. If the cause of the outbreak is confirmed or believed to be influenza type A AND vaccine has been administered for prophylaxis until 2 weeks after the vaccination (722). CATEGORY IB

4. To the extent possible, do not allow contact between those at high risk for complications from influenza type A and healthy patients or those with other respiratory illnesses; prevent contact during and for 2 days after the latter; discontinue treatment (633,631). CATEGORY IB

D. Interrupting person-to-person transmission of microorganisms. (See Section III, A-E.)

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APPENDIX A Examples of Semicritical Items * Used on the Respiratory Tract

- Anesthesia device or equipment, including:
  1. Face mask or tracheal tube,
  2. Inspiratory and expiratory tubing,
  3. Y-piece,
  4. Reservoir bag, and
  5. Humidifier;
- Breathing circuits of mechanical ventilators;
- Bronchoscopes and their accessories, except for biopsy forceps and specimen brush, which are considered critical;
- Endotracheal and endobronchial tubes;
- Laryngoscope blades;
- Mouthpieces and tubing of pulmonary-function testing equipment;
- Nebulizers and their reservoirs;
- Oral and nasal airways;
- Probes of CO2 analyzers, air-pressure monitors;
- Resuscitation bags;
- Stylets;
- Suction catheters;
- Temperature sensors.

Items that directly or indirectly contact mucous membranes of the respiratory tract; these should be sterilized or

APPENDIX B Maintenance Procedures Used to Decrease Survival and Multiplication of Legionella sp. in Potable-Wa

I. Providing water at greater than or equal to 50 °C at all points in the heated water system, including the taps.

This requires that water in calorifiers (water heaters) be maintained at greater than or equal to 60 °C. In the United King...visitors, and HCWs (446). However, Legionella sp. can multiply even in short segments of pipe containing water at the likelihood of water stagnation and cooling (449,723). Insulation of plumbing to ensure delivery of cold (less than 20 °C multiplication (391). Both "dead legs" and "capped spurs" within the plumbing system provide areas of stagnation and to be removed to prevent colonization (724). Rubber fittings within plumbing systems have been associated with persi:

II. Continuous chlorination to maintain concentrations of free residual chlorine at 1-2 mg/L at the tap

This requires the placement of flow-adjusted, continuous injectors of chlorine throughout the water distribution system results in system leaks and production of potentially carcinogenic trihalomethanes. However, when levels of free residual chlorine are recommended by the Environmental Protection Agency (447,726,727).

- A dead leg is a pipe, or spur, leading from the water recirculating system to an outlet that is used infrequently (i.e., the spur has a wall is removed.

APPENDIX C Culturing Environmental Specimens for Legionella sp.

I. Recommended procedure for collecting and processing environmental specimens for Legionella sp. (728)

A. Collect water (if possible, 1-L samples) in sterile, screw-top bottles, preferably containing sodium thiosulfate as a residual halogen biocide.)

B. Collect culture-swabs of the internal surfaces of faucets, aerators, and showerheads; in a sterile, screw-top taken from the same device from which the sample was obtained.

C. As soon as possible after collection, water samples and swabs should be transported to and processed in a room temperature but must be protected from temperature extremes.

http://www.cdc.gov/mmwr/preview/mmwrhtml/00045365.htm 5/3/2009
D. Test samples for the presence of Legionella sp. by using semi-selective culture media. Use standard labor:
not suitable for environmental samples (729-731). In addition, the use of polymerase chain reaction for id:
specificity of this procedure are available (732).)

Possible samples and sampling sites for Legionella sp. in the hospital (733)

Water samples

- Potable water system
  1. Incoming water main
  2. Water softener
  3. Holding tanks/cisterns
  4. Water heater tanks (at the inflow and outflow sites)
- Potable water outlets (e.g., faucets or taps, showers), especially outlets located in or near case-patients' rooms
- Cooling tower/evaporative condenser
  1. Make-up water (i.e., water added to the system to replace water lost by evaporation, drift, and leakage)
  2. Basin (i.e., area under tower for collection of cooled water)
  3. Sump (i.e., section of basin from which cooled water returns to heat source)
  4. Heat source (e.g., chillers)
- Other sources
- Humidifiers (i.e., nebulizers)
  1. Bubblers for oxygen
  2. Water used for respiratory therapy equipment
  3. Decorative fountains
  4. Irrigation equipment
  5. Fire sprinkler system (if recently used)
  6. Whirlpools/spas

Swabs

- Potable water system
  1. Faucets (proximal to aerators)
  2. Faucet aerators
3. Shower heads

- Cooling towers
  1. Internal components (e.g., splash bars and other fill surfaces)
  2. Areas with visible biofilm accumulation

APPENDIX D Procedure for Cleaning Cooling Towers and Related Equipment *

I. Before chemical disinfection and mechanical cleaning

   A. Provide protective equipment to workers who perform the disinfection, to prevent their exposure to a) chemical disinfector. This may include full-length protective clothing, boots, gloves, goggles, and a full- or half-face mask that contains at least 5 mg/L.

   B. Shut off cooling-tower.
      1. If possible, shut off the heat source.
      2. Shut off fans, if present, on the cooling tower/evaporative condenser (CT/EC).
      3. Shut off the system blowdown (i.e., purge) valve. Shut off the automated blowdown controller, if present.
      4. Keep make-up water valves open.
      5. Close building air-intake vents within at least 30 m of the CT/EC until after the cleaning procedure.
      6. Continue operating pumps for water circulation through the CT/EC.

Chemical disinfection

   A. Add fast-release, chlorine-containing disinfectant in pellet, granular, or liquid form, and follow safety instructions. For example, hypochlorite (Ca(OCl)_2), calculated to achieve initial free residual chlorine (FRC) of 50 mg/L (i.e., 3.0 lbs {1.4 kg} domestic grade NaOCl {3%-5% available Cl} per 1,000 gal of CT/EC water; or 0.6 lb {0.3 kg} Ca(OCl)_2 required. If the volume of water in CT/EC is unknown, it can be estimated (in gallons) by multiplying either the appropriate compounds may be suggested by a water-treatment specialist.

   B. Record the type and quality of all chemicals used for disinfection, the exact time the chemicals were added to the system.

   C. Add dispersant simultaneously with or within 15 minutes of adding disinfectant. The dispersant is best added by Automatic-dishwasher compounds are examples of low or nonfoaming, silicate-based dispersants. Dispersants a

   D. After adding disinfectant and dispersant, continue circulating the water through the system. Monitor the FRC by meter every 15 minutes for 2 hours. Add chlorine as needed to maintain the FRC at greater than or equal to 10 mg/L. 

   E. Two hours after adding disinfectant and dispersant or after the FRC level is stable at greater than or equal to 10 mg/L for 24 hours, drain the system. CT/EC should be contacted regarding local regulations. If a sanitary sewer is not available, consult local or state authorities.
may be dechlorinated by dissipation or chemical neutralization with sodium bisulfite.

G. Refill the system with water and repeat the procedure outlined in steps 2-6 in Section I-B above.

Mechanical cleaning

A. After water from the second chemical disinfection has been drained, shut down the CT/EC.

B. Inspect all water-contact areas for sediment, sludge, and scale. Using brushes and/or a low-pressure water hose, fittings. Replace components as needed.

C. If possible, clean CT/EC water-contact areas within the chillers.

After mechanical cleaning

A. Fill the system with water and add chlorine to achieve FRC level of 10 mg/L.

B. Circulate the water for 1 hour, then open the blowdown valve and flush the entire system until the water is free of chlorine.

C. Drain the system.

D. Open any air-intake vents that were closed before cleaning.

E. Fill the system with water. CT/EC may be put back into service using an effective water-treatment program.

Adapted from information published previously by the Wisconsin Department of Health and Social Services, 1987 (46

Table 1

Note: To print large tables and graphs users may have to change their printer settings to landscape and use a small font size.

TABLE 1. Microorganisms isolated from respiratory tract specimens obtained by various representative methods from adult patients who had a diagnosis of nosocomial pneumonia, by epidemiologic investigation

<table>
<thead>
<tr>
<th>Category</th>
<th>Schaberg (3)</th>
<th>Bartlett (4)</th>
<th>Fagon (5)</th>
<th>Torres (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital type</td>
<td>NNIS and UMH *</td>
<td>Veterans</td>
<td>General</td>
<td>General</td>
</tr>
<tr>
<td>Patients studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilated or nonventilated</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Ventilated</td>
<td>Ventilated</td>
</tr>
<tr>
<td>No. of patients</td>
<td>N/A +</td>
<td>159</td>
<td>49</td>
<td>78</td>
</tr>
<tr>
<td>No. of episodes of pneumonia</td>
<td>N/A</td>
<td>159</td>
<td>52</td>
<td>78</td>
</tr>
<tr>
<td>Specimen(s) cultured</td>
<td>Sputum, tracheal</td>
<td>Transtracheal</td>
<td>Protected</td>
<td>Protected specimen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>aspirate, pleural fluid, blood</td>
<td>brushing, lung aspirate, pleural fluid, blood</td>
<td></td>
</tr>
<tr>
<td>Culture results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No organism isolated</td>
<td>N/A</td>
<td>0</td>
<td>0</td>
<td>54% @</td>
</tr>
<tr>
<td>Polymicrobial</td>
<td>N/A</td>
<td>54% @</td>
<td>40% @</td>
<td>13% @</td>
</tr>
<tr>
<td>No. of isolates</td>
<td>15,499</td>
<td>314</td>
<td>111</td>
<td>N/A</td>
</tr>
<tr>
<td>Aerobic bacteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram-negative bacilli</td>
<td>50% &amp;</td>
<td>46% **</td>
<td>75% **</td>
<td>16% ++</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>17% &amp;</td>
<td>9% **</td>
<td>31% **</td>
<td>5% ++</td>
</tr>
<tr>
<td>Enterobacter sp.</td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Klebsiella sp.</td>
<td>7</td>
<td>23</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>6</td>
<td>14</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Serratia sp.</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Proteus sp.</td>
<td>3</td>
<td>11</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Citrobacter sp.</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Acinetobacter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calcoaceticus</td>
<td>N/A</td>
<td>0</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Haemophilus influenzae</td>
<td>6% &amp;</td>
<td>17% **</td>
<td>10% **</td>
<td>0% ++</td>
</tr>
<tr>
<td>Legionella sp.</td>
<td>N/A</td>
<td>N/A</td>
<td>2% **</td>
<td>2% ++</td>
</tr>
<tr>
<td>Other</td>
<td>N/A</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Pathogens</td>
<td>% Episodes</td>
<td>% Isolates</td>
<td>% Episodes</td>
<td>% Patients</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Gram-positive cocci</td>
<td>17% &amp;</td>
<td>56% **</td>
<td>52% **</td>
<td>4% ++</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>16% &amp;</td>
<td>25% **</td>
<td>33% **</td>
<td>2% ++</td>
</tr>
<tr>
<td>Streptococcus sp.</td>
<td>1</td>
<td>31</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Anaerobes</td>
<td>N/A</td>
<td>35% **</td>
<td>2% **</td>
<td>0</td>
</tr>
<tr>
<td>Peptostreptococcus</td>
<td>N/A</td>
<td>14% **</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Fusobacterium sp.</td>
<td>N/A</td>
<td>10</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Peptococcus sp.</td>
<td>N/A</td>
<td>11</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Bacteroids melaninogenicus</td>
<td>N/A</td>
<td>9</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Bacteroids fragilis</td>
<td>N/A</td>
<td>8</td>
<td>N/A</td>
<td>0</td>
</tr>
<tr>
<td>Fungi</td>
<td>4% &amp;</td>
<td>N/A</td>
<td>0</td>
<td>1% ++</td>
</tr>
<tr>
<td>Aspergillus sp.</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
<td>1% ++</td>
</tr>
<tr>
<td>Candida sp.</td>
<td>4% &amp;</td>
<td>N/A</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Viruses</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* National Nosocomial Infection Surveillance System and University of Michigan Hospitals.
+ Not applicable (i.e., not tested or not supported.)
@ Percentage of episodes.
& Percentage of isolates.
** Percentage of episodes; percentages not additive because of polymicrobial etiology in some episodes.
++ Percentage of patients with pure culture.

---

Table 2

Note: To print large tables and graphs users may have to change their printer settings to landscape and use a small font size.

Table 2. Risk factors and suggested infection-control measures for preventing nosocomial pneumonia

<table>
<thead>
<tr>
<th>Disease/Risk factors</th>
<th>Suggested infection-control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial pneumonia</td>
<td></td>
</tr>
<tr>
<td>Host-related (persons aged &gt;65 yrs)</td>
<td></td>
</tr>
<tr>
<td>Underlying illness</td>
<td>Perform incentive spirometry, positive end-expiratory pressure, or continuous positive airway pressure by face mask.</td>
</tr>
<tr>
<td>-- Chronic obstructive pulmonary disease</td>
<td></td>
</tr>
<tr>
<td>-- Immunosuppression</td>
<td>Avoid exposure to potential nosocomial pathogens; decrease duration of immunosuppression (e.g., by administration of granulocyte macrophage colony stimulating factor G-CSF).</td>
</tr>
<tr>
<td>-- Depressed consciousness</td>
<td>Administer central nervous system depressants cautiously.</td>
</tr>
<tr>
<td>-- Surgery (thoracic/abdominal)</td>
<td>Properly position patients; promote early ambulation; appropriately control pain.</td>
</tr>
<tr>
<td>Device-related</td>
<td></td>
</tr>
<tr>
<td>Properly clean, sterilize or disinfect, and handle devices; remove devices as soon as the indication for their use ceases.</td>
<td></td>
</tr>
<tr>
<td>Endotracheal intubation and mechanical ventilation</td>
<td>Gently suction secretions; place patient in semirecumbent position (i.e., 30 degrees-45 degrees head elevation); use nonalkalinizing gastric cytoprotective agent on patients at risk for stress bleeding; do not routinely change ventilator circuits more often than every 48 hours; drain and discard inspiratory-tubing condensate, or use heat-moisture exchanger if indicated.</td>
</tr>
<tr>
<td>Nasogastric-tube (NGT) placement and enteral feeding</td>
<td>Routinely verify appropriate tube placement; promptly remove NGT when no longer needed; drain residual; place patient in semirecumbent position as described as above.</td>
</tr>
<tr>
<td>Personnel- or procedure-related</td>
<td></td>
</tr>
<tr>
<td>Cross-contamination by hands</td>
<td>Educate and train personnel; wash hands adequately and wear gloves appropriately; conduct surveillance for cases of pneumonia and give feedback to personnel.</td>
</tr>
<tr>
<td>Antibiotic administration</td>
<td>Use antibiotics prudently, especially in patients in intensive-care units.</td>
</tr>
</tbody>
</table>
Legionnaires disease

Host-related

Immunosuppresion Decrease duration of immunosuppression.

Device-related

Contaminated aerosol from devices Sterilize/disinfect aerosol-producing devices before use; use only sterile water for respiratory humidifying devices; do not use cool-mist room-air humidifiers without adequate sterilization or disinfection.

Environment-related

Aerosols from contaminated water supply Hyperchlorinate or superheat hospital water system; routinely clean water-supply system; consider use of sterile water for drinking by immunosuppressed patients.

Cooling-tower draft Properly design, place, and maintain cooling towers.

Aspergillosis

Host-related

Severe granulocytopenia Decrease duration of immunosuppression (e.g., by administration of GMCSF); place patients who have severe and prolonged granulocytopenia in a protected environment.

Environment related

Construction activity Remove granulocytopenic patients from vicinity of construction; if not already done, place severely granulocytopenic patients in a protected environment; make severely granulocytopenic patients wear a mask when they leave the protected environment.

Other environmental sources of aspergilli Routinely maintain hospital air-handling systems and rooms of immunosuppressed patients.

Respiratory syncytial virus infection (RSV)

Host-related

Persons ages <2 yrs; congenital pulmonary/cardiac disease; immunosuppression Consider routine preadmission screening of high-risk patients for severe RSV infection, followed by cohorting of patients and nursing personnel during hospital outbreaks of RSV infection.

Personnel- or procedure-related

Cross-contaminated by hands Educate personnel; wash hands; wear gloves; wear a gown; during outbreaks, use private rooms or cohort patients and nursing personnel, and limit visitors.

Influenza

Host-related

Persons ages >65 yrs; immunosuppression Vaccinate patients who are at high risk before the influenza season begins each year; use amantadine or rimantadine for chemoprophylaxis during an outbreak.

Personnel-related

Infected personnel Before the influenza season each year, vaccinate personnel who provide care for high-risk patients; use amantadine or rimantadine for prophylaxis and treatment during an outbreak.
Table 3. Controlled studies on nosocomial lower respiratory tract infections and other associated outcomes of selective decontamination of the digestive tract

<table>
<thead>
<tr>
<th>Author</th>
<th>Study patients</th>
<th>Diagnostic method</th>
<th>SDD (%)</th>
<th>Controls (%)</th>
<th>SDD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoutenbeek (1984) (155)</td>
<td>Trauma; SDD=63; Controls=59.</td>
<td>Clinical and radiologic; ** TS culture; ++</td>
<td>8</td>
<td>59</td>
<td>&quot;&quot;</td>
</tr>
<tr>
<td>Unertl (1987) (156)</td>
<td>General ICU; SDD=19; Controls=20</td>
<td>Clinical and radiologic; **</td>
<td>21</td>
<td>70</td>
<td>21 @ @</td>
</tr>
<tr>
<td>Kerver (1988) (157)</td>
<td>Surgical ICU; SDD=49; Controls=47.</td>
<td>Clinical and radiologic; **</td>
<td>21</td>
<td>85</td>
<td>&quot;Not&quot;</td>
</tr>
<tr>
<td>Ledingham (1988) (158)</td>
<td>General ICU; SDD=163; Controls=161.</td>
<td>Clinical and radiologic; **</td>
<td>2</td>
<td>11</td>
<td>&quot;&quot;</td>
</tr>
<tr>
<td>Brun-Buisson (1989) (159)</td>
<td>Medical ICU; SDD=36; Controls=50.</td>
<td>Clinical and radiologic; ** TS and PSB culture ++</td>
<td>20</td>
<td>22</td>
<td>3 @ @</td>
</tr>
<tr>
<td>Ulrich (1989) (160)</td>
<td>General ICU; SDD=48; Controls=52.</td>
<td>Clinical and radiologic; **</td>
<td>15</td>
<td>50</td>
<td>GP=78 @ @ GN=3 @ @</td>
</tr>
<tr>
<td>Flaherty (1990) (161)</td>
<td>Cardiac surgery ICU; SDD=51; Controls=56.</td>
<td>Clinical and radiologic; **</td>
<td>2</td>
<td>9</td>
<td>GN=22 @ @</td>
</tr>
<tr>
<td>Godard (1990) (162)</td>
<td>General ICU; SDD=97; Controls=56.</td>
<td>Clinical and radiologic; ** TS and PSB culture ++</td>
<td>2</td>
<td>15</td>
<td>GN=15 @ @</td>
</tr>
<tr>
<td>McClelland (1990) (163)</td>
<td>Renal and respiratory failure; SDD=15; Controls=12.</td>
<td>TS culture. ++</td>
<td>7</td>
<td>50</td>
<td>Nc</td>
</tr>
<tr>
<td>Rodriguez-Roldan (1990) (164)</td>
<td>General ICU; SDD=13; Controls=15.</td>
<td>Clinical and radiologic; ** TS culture ++</td>
<td>Pn=0 @ @ @ Pn=73 @ @ @</td>
<td>&quot;&quot;</td>
<td></td>
</tr>
<tr>
<td>Tetteroo (1990) (165)</td>
<td>Esophageal resection; SDD=56; Controls=56.</td>
<td>Clinical and radiologic; ** culture of bronchial aspirate</td>
<td>2</td>
<td>14</td>
<td>2 @ @</td>
</tr>
<tr>
<td>Aerds (1991) (166)</td>
<td>General ICU; SDD=17; Controls-A=18; Controls-B=21.</td>
<td>Clinical and radiologic; ** TS culture. ++</td>
<td>6</td>
<td>A=78 @ B=62</td>
<td>&quot;&quot;</td>
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<tr>
<td>Blair (1991) (167)</td>
<td>General ICU; SDD=126; Controls=130.</td>
<td>Clinical and radiologic; **</td>
<td>10</td>
<td>35</td>
<td>&quot;&quot; inc</td>
</tr>
<tr>
<td>Foxx (1991) (168)</td>
<td>Cardiac bypass; SDD=12; Controls=12.</td>
<td>TS culture. ++</td>
<td>66</td>
<td>50</td>
<td>Nc</td>
</tr>
<tr>
<td>Hartenauer (1991) (169)</td>
<td>Surgical ICU; ICU-1: SDD=50; Controls=61; ICU-2: SDD=49; Controls=40.</td>
<td>Clinical and radiologic; ** TS culture. ++</td>
<td>ICU-1:10 ICU-2:10</td>
<td>46 @ @</td>
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</tr>
<tr>
<td>Pugin (1991) (170)</td>
<td>Surgical ICU; SDD=25; Controls=27.</td>
<td>Clinical and radiologic; ** TS culture. ++</td>
<td>16</td>
<td>78</td>
<td>&quot;No new microorg&quot;</td>
</tr>
<tr>
<td>Vandenbroucke-Grauls (1991) (171)</td>
<td>ICUs (pooled data); SDD-A=488; Controls-A (historical)=540; SDD-B=225; Controls-B.</td>
<td>Clinical and radiologic; ** TS culture ++</td>
<td>A=7 B=8 A=28 B=45</td>
<td>&quot;No ir microorganism&quot;</td>
<td></td>
</tr>
</tbody>
</table>
### Guidelines for Prevention of Nosocomial Pneumonia

#### Figure_1

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Setting</th>
<th>Description</th>
<th>Clinical Criteria</th>
<th>TS</th>
<th>PSB</th>
<th>BAL</th>
<th>PSB Culture</th>
<th>Culture</th>
<th>Infection</th>
<th>ICU Infections</th>
<th>SDD</th>
<th>Controls</th>
<th>Odds Ratio</th>
<th>CI</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockerill (1992)</td>
<td>Surgical and medical ICUs</td>
<td>Clinical and radiologic; ** TS ++</td>
<td>Pn=5 000</td>
<td>Pn=16 000</td>
<td>16 +++</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Gastinne (1992)</td>
<td>Medical ICU</td>
<td>Clinical and radiologic; ** TS +/- PSB culture; ++</td>
<td>TB=4 000</td>
<td>TB=5 000</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Hammond (1992)</td>
<td>General ICU</td>
<td>Clinical and radiologic; ** TS文化. ++</td>
<td>Pn=15 000</td>
<td>Br=6 000</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocha (1992)</td>
<td>General ICU</td>
<td>Clinical and radiologic; ** TS +/- BAL culture; ++</td>
<td>A=11</td>
<td>B=23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Winter (1992)</td>
<td>Neurosurgical ICU</td>
<td>Clinical and radiologic; ** TS文化. ++</td>
<td>Odds ratio= 0.37; 95% CI 0.31-0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferrer (1994)</td>
<td>Respiratory ICU</td>
<td>Clinical and radiologic; ** TS文化. ++</td>
<td>18</td>
<td>24</td>
<td>Nc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

* Resistant to at least one antimicrobial in the SDD regimen.
+ During the study period.
@ ICU=intensive care unit.
& SDD=selective digestive-tract decontamination.
**: Clinical criteria included temperature >38 C, purulent bronchorrhea, WBC >(12,000-15,000/mm^3). Radiologic criterion was evidence of new and progressive infiltrate(s).
++ TS=tracheal secretions; PSB=protected-specimen brushing; BAL=bronchoalveolar lavage.
@@ Percentage of patients infected or colonized with gram-positive (GP) and/or gram-negative (GN) bacillary organisms at a site; S=percentage of patients with coagulase-negative staphylococcal infection or colonization.
&& Median.
*** Infection-related.
+++ Percentage of isolates; GP=percentage of gram-positive isolates; GN=percentage of gram-negative bacillary isolates.
@@@ Pn=pneumonia; TB=tracheobronchial infection; Br=bronchial infection.
@@@@ Control-A=patients given penicillin (ampicillin, piperacillin, or flucloxacillin) for clinical infection(s); Control-B meta-analysis.
++++ In ICU.
@@@@@@ However, at 4 weeks, the oropharyngeal cultures of 13% of SDD patients and 5% of control patients had methicillin-resistant colonized with enterococci.
@@@@@@@ Computed using data from 3,836 patients and 526 events, 260 in SDD patients and 366 in control patients.
***** CI=confidence interval.
+++++ However, bronchial colonization with MRSA occurred in 45% of SDD patients and 21% of control patients.

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FIGURE 1. Pathogenesis of nosocomial bacterial pneumonia

- Host factors
- Antimicrobials and other medications
- Surgery
- Invasive device
- Contaminated respiratory therapy, testing, and anesthesia equipment
- Cross-colonization (hand, glove)
- Inadequate device disinfection/sterilization
- Contaminated water, solutions
- Cranopharyngeal colonization
- Gastric colonization
- Contaminated-aerosol generation
- Aspiration
- Inhalation
- Lung defenses are overcome
- Translocation
- Bacteremia
- Pneumonia