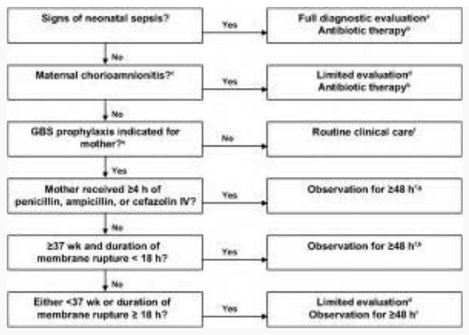
Infection control in neonates guidelines



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Laboratory aid to the diagnosis and therapy of infection in the neonate

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Abstract

Despite the advances in perinatal and neonatal care and use of newer potent antibiotics, the incidence of neonatal sepsis remains high and the outcome is still severe. For years, investigators have sought a test or panel of tests able to identify septic neonates accurately and rapidly in order to obtain an early diagnosis and develop a specific effective treatment for a successful outcome. In addition to the standard procedures (blood, CSF, and urine cultures), such panels have included a combination of haematological investigations (total, differential and immature cell counts), and levels of acute-phase reactants (principally CRP and procalcitonin), and cytokines (such as IL-6 or neutrophil CD64). Furthermore, the science of proteomics and genomics has been applied to the search for biomarkers, production of protein profiles and genetic polymorphisms that can rapidly help the prediction, early diagnosis, and treatment of human diseases, but, for now, data are as yet insufficient to confirm their validity.

Introduction

The high incidence and severe outcome of neonatal sepsis, despite the advances in perinatal and neonatal care and use of newer potent antibiotics, is mainly related to the combination of the neonatal reduced immune defence and the complex interactions between the infecting microorganism and the host response.[1,2] These factors are only partially mitigated by the transplacental passage of IgG antibodies from mother to fetus during intrauterine life. An additional naturally occurring compensatory mechanism is represented by human milk, that after birth maintains the mother-newborn immunological link by providing a host of protective components.[3]

Sepsis is a pathogen initiated but a cytokine-mediated condition in which immune, inflammatory, and coagulation homeostasis is disturbed.[4] The evolution of disease and clinical symptoms are dependent upon a complex and delicate balance between the pro-inflammatory and anti-inflammatory factors. The inflammatory cytokines (TNF-α, IL-1β, IL-6, IL-8, IL-15, IL-18, MIF) and growth factors (IL-3, CSFs), and their secondary mediators, including nitric oxide, thromboxanes, leukotrienes, platelet-activating factor, prostaglandins, and complement, cause activation of the coagulation cascade, the complement cascade, and the production of prostaglandins, leukotrienes, proteases and oxidants. Most of the short (from systemic inflammatory response syndrome - SIRS, and disseminated intravascular coagulation - DIC, to septic shock, and multiple organ dysfunction syndrome - MODS) and long term complication (respiratory, growth and neurological sequelae[5]) of neonatal sepsis are strictly associated to the effects of these mediators,[1,6] not counterbalanced by an adequate synthesis of anti inflammatory cytokines, as TNFsr, IL-1ra, IL-1rII, IL-10, TGF-β2.

Diagnosis of infection

The isolation of microorganisms from blood, cerebrospinal fluid (CSF) or urine remains the gold standard for definitive diagnosis, however, confirmation or exclusion of positive cultures requires days, and more importantly, the sensitivity of the culture methods is frequently low, due to the concomitant antibiotic therapy, or to the combination of small blood sample volume and low colony counts. When a 0.5 mL blood sample is obtained for culture (a likely occurrence in NICUs), the probability to isolate organisms is 0.39 with one CFU/mL, 0.67 with two CFU/mL, 0.87 with four. A count of at least 4 CFU/mL and one ml blood volume are necessary to reach a probability of 0.98.[7,8]

In addition, in neonates the clinical signs of sepsis are poor, late and non specific, particularly in preterm infants, in whom the onset of sepsis may be acute and clinical course can quickly deteriorate.

Therefore, early diagnosis of a life-threatening disease like neonatal sepsis, is the mandatory prerequisite for a timely treatment.[10]

For years, investigators have sought a test or panel of tests able to identify septic neonates accurately and rapidly while awaiting culture results, in order to obtain an early diagnosis and develop a specific effective treatment for a successful outcome.

Diagnostic test characteristics significantly change depending on sensitivity, specificity and predictive value. In relation to neonatal infection, these terms can be defined as follows:[12]

- Sensitivity (positive test/positive diagnosis): if infection is present, how often is the test result abnormal?
- Specificity (negative test/negative diagnosis): if infection is absent, how often is the test result normal?
- Positive predictive value (positive diagnosis/positive test): if the test result is abnormal, how often is infection present?
- Negative predictive value (negative diagnosis/negative test): if the test result is normal, how often is infection absent?
- Likelihood ratio, positive test result: if the result is abnormal, how much does that result raise the pretest probability of disease?
- Likelihood ratio, negative test result: if the result is normal, how much does that result lower the pretest probability of disease?

Large (>5-10) or small (<0.1-0.2) likelihood ratios significantly raise or minimize the probability of the disease being present.

The true positive rate (sensitivity) may be graphically plotted against the false positive rate (1 - specificity) for the different possible cut-off points of a diagnostic test, in order to obtain a Receiver Operating Characteristic (ROC) curve. The area under an ROC curve is a measure of test accuracy, the closer the curve follows the left-hand border and then the top border of the ROC space, the more accurate the test.[13]

Diagnostic tests with maximal (100%) sensitivity and negative predictive value are desirable for diagnosis of neonatal sepsis. In other words, if infection is present, the result would always be abnormal; if the result is normal, infection would always be absent. The reduced specificity and positive predictive value are usually acceptable because over treatment with antibiotics on the basis of a false-positive result is likely to be of limited harm compared with withholding therapy on the basis of a false-negative result. Although this approach seems reasonable given the dire outcome of a missed diagnosis, improvement in diagnostic accuracy should diminish the exposure of healthy neonates to the risks of unwarranted antibiotic treatment, decrease antibiotic resistances, and reduce the length and cost of hospital stays.[14] Nonspecific laboratory investigations for the diagnosis of invasive bacterial infections remain the most important diagnostic aid for the management of septic neonates[14] (Table 1).

White blood cell counts and ratios

Total leukocyte count (>20000 or <5000), dif-

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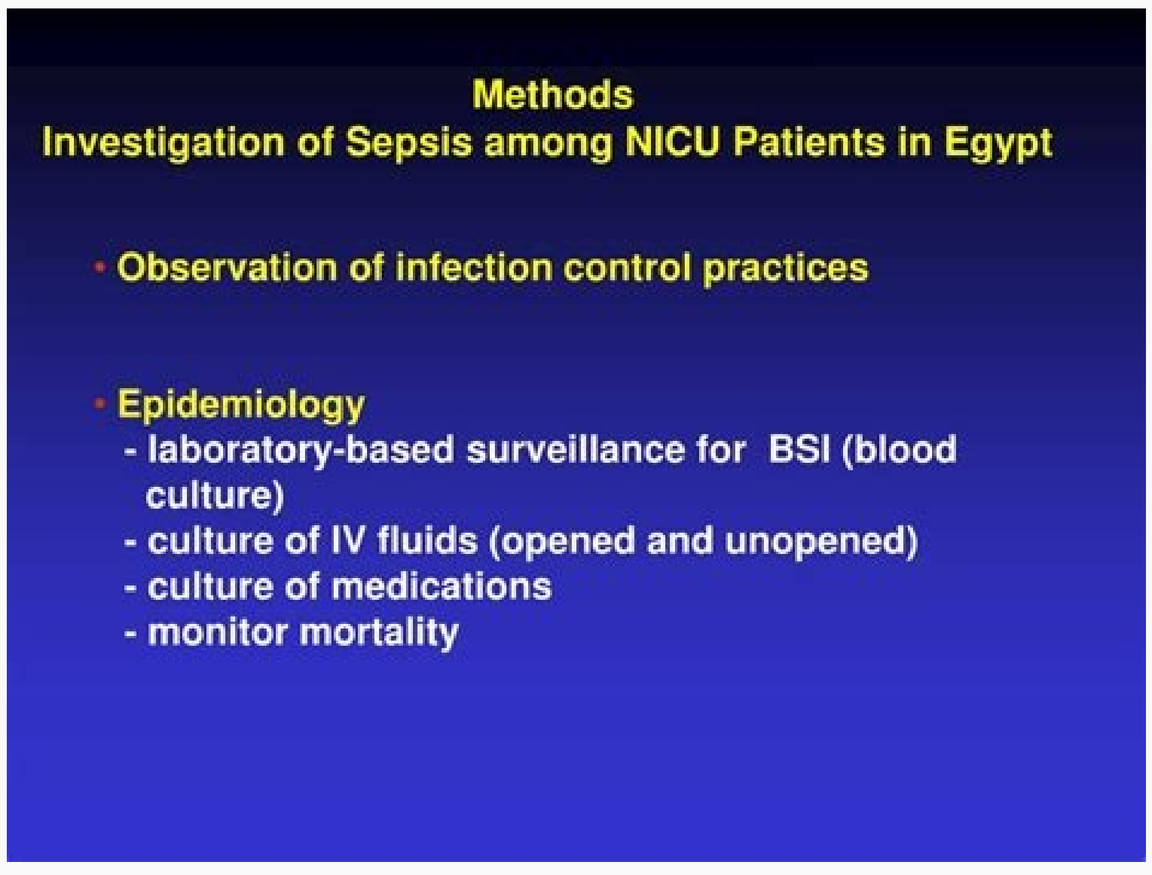
Study	Study group	Duration of the study	Prevalence (virus-positive/examined individuals)	Detected viruses
Cenna et al., 2017, USA	All infants evaluated for LOS	26 month	29/357 (8%), 3 infants were co-infected with more than one virus	RSV (n = 14), HRV (n = 11), others (n = 7)
Kidszun et al., 2017, Germany	All infants evaluated for LOS	43 month	6/137 (6.8%)	Picornavirus (n = 4), RSV (n = 2)
Caserta et al., 2017, USA	All infants in the NICU <36 weeks PMA	2 month	4/618 (0.6%), 50% asymptomatic	RSV (n = 1), HRV (n = 1), coronavirus 4 (n = 1), Influenza B (n = 1)
Zinna et al., 2016, UK	Retrospective case-control study of infants with PCR positive RVI	6 years	95/275	HRV (n = 68), parainfluenza virus type 3 (n = 6), RSV (n = 5), others (n = 19)
Kidszun et al., 2014, Germany	All infants evaluated for LOS	19 month	6/60 (10%)	Picornavirus (n =5), RSV (n = 1)
Ronchi et al., 2014, USA	All infants evaluated for LOS	12 month	8/100 (8%)	Entero-rhinoviruses (n = 2), HRV (n = 2), coronavirus (n = 2), parainfluenza viruses (n = 2)
Bennett et al., 2012, USA	All infants in the NICU <33 weeks PMA	12 month	26/50 (52%), 30% asymptomatic	Parainfluenza viruses (n = 20), RSV (n = 15), metapneumovirus (n = 9), others (n = 11)
Diniz et al., 2009, Portugal	Infants with acute respiratory failure and need of mechanical ventilation <37 weeks PMA	2 years	23/78 (29.5%)	RSV (n = 11), influenza A (n = 8), co-infection with 2 viruses (n = 4)

Mode of Transmission	Reservoir/Source	Transmission	Organism (Examples)
Direct contact	Patients, health care workers	Direct physical contact	CONS, *Staphylococcus aureus*, gram-negative organisms, viruses
Indirect contact	Medical devices, equipment (gloves, stethoscopes, soap dispensers, pumps)	Passive via an intermediate object	Gram-negative organisms, respiratory syncytial
Droplet	Patients, health care workers	Via large-particle droplets (>5 µm) transferring the germ through the air when the source and patient are close (sneezing, suctioning)	*Bordetella pertussis*, influenza virus, *Neisseria meningitidis*
Airborne	Patients, health care workers, dust	Germs contained within nuclei (<5 µm) evaporated from droplets or within dust particles, through air, within the same room or over a long distance (breathing)	*Mycobacterium tuberculosis*, *Legionella* spp.
Common vehicle	Food, water, or medication	Contaminated inanimate vehicle is a vector for transmission of the microbial agent to multiple patients (contaminated water, infusions, feedings)	Hepatitis B virus, gram-negative organisms, *Candida*



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Description of HICPAC recommendation categories. Rank Description Category IA Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies. Category IB Strongly recommended for implementation and supported by certain experimental, clinical, or epidemiologic studies and a strong theoretical rationale. Category IC Required by state or federal regulation, or representing an established association standard. (Note: Abbreviations for governing agencies and regulatory citations are listed, where appropriate. Recommendations from regulations adopted at state levels are also noted. Recommendations from AIA guidelines cite the appropriate sections of the standard). Category II Suggested for implementation and supported by suggestive clinical or epidemiologic studies, or a theoretical rationale. Unresolved Issue No recommendation is offered. No consensus or insufficient evidence exists regarding efficacy. AirC.I. Air-Handling Systems in Health-Care FacilitiesC.II. Construction, Renovation, Remediation, Repair, and DemolitionC.III. Infection-Control and Ventilation Requirements for PE RoomsC.IV. Infection-Control and Ventilation Requirements for AII RoomsC.V. Infection-Control and Ventilation Requirements for Operating RoomsC.VI. Other Potential Infectious Aerosol Hazards in Health-Care FacilitiesWaterD.I. Controlling the Spread of Waterborne MicroogranismsD.II. Routine Prevention of Waterborne Microbial Contamination Within the Distribution SystemD.III. Remediation Strategies for Distribution System Repair or EmergenciesD.IV. Additional Engineering Measures as Indicated by Epidemiologic Investigation for Controlling Waterborne, Health-Care–Associated Legionnaires DiseaseD.V. General Infection-Control Strategies for Preventing Legionnaires DiseaseD.VI. Preventing Legionnaires Disease in Protective Environments and Transplant UnitsD.VII. Cooling Towers and Evaporative CondensersD.VIII. Dialysis Water Quality and DialysateD.IX. Ice Machines and IceD.X. Hydrotherapy Tanks and PoolsD.XI. Miscellaneous Medical Equipment Connected to Water SystemsEnvironmental servicesE.I. Cleaning and Disinfecting Strategies for Environmental Surfaces in Patient-Care AreasE.II. Cleaning Spills of Blood and Body SubstancesE.III. Carpeting and Cloth FurnishingsE.IV. Flowers and Plants in Patient-Care AreasE.V. Pest ControlE.VI. Special PathogensEnvironmental samplingF.I. General InformationF.II. Air, Water, and Environmental-Surface SamplingLaundry and beddingG.I. Employer ResponsibilitiesG.II. Laundry Facilities and EquipmentG.III. Routine Handling of Contaminated LaundryG.IV. Laundry ProcessG.V. Microbiologic Sampling of TextilesG.VI. Special Laundry SituationsG.VII. Mattresses and PillowsG.VIII. Air-Fluidized BedsAnimals in health-care facilitiesH.I. General Infection-Control Measures for Animal EncountersH.II. Animal-Assisted Activities, Animal-Assisted Therapy, and Resident Animal ProgramsH.III. Protective Measures for Immunocompromised PatientsH.IV. Service AnimalsH.V. Animals as Patients in Human Health-Care FacilitiesH.VI. Research Animals in Health-Care FacilitiesRegulated medical wasteI.I. Categories of Regulated Medical WasteI. II. Disposal Plan for Regulated Medical WastesI.III. Handling, Transporting, and Storing Regulated Medical WastesI.IV. Treatment and Disposal of Regulated Medical WastesI.V. Special Precautions for Wastes Generated During Care of Patients with Rare Diseases Edit: An * indicates recommendations that were renumbered for clarity. The renumbering does not constitute change to the intent of the recommendations. Recommendations for air-handling systems by ID number and category. # Recommendation Category C.I.A. Use AIA guidelines as minimum standards where state or local regulations are not in place for design and construction of ventilation systems in new or renovated health-care facilities. Ensure that existing structures continue to meet the specifications in effect at the time of construction. (AIA: 1.1.A, 5.4) IC C.I.B. Monitor ventilation systems in accordance with engineers' and manufacturers' recommendations to ensure preventive engineering, optimal performance for removal of particulates, and elimination of excess moisture. (AIA: 7.2, 7.31.D, 8.31.D, 9.31.D, 10.31.D, 11.31.D, EPA guidance) IB, IC C.I.B.1. Ensure that heating, ventilation, air conditioning (HVAC) filters are properly installed and maintained to prevent air leakages and dust overloads. IB C.I.B.2. Monitor areas with special ventilation requirements (e.g., AII or PE) for ACH, filtration, and pressure differentials. (AIA: 7.2.C7, 7.2.D6) * Develop and implement a maintenance schedule for ACH, pressure differentials, and filtration efficiencies using facility-specific data as part of the multidisciplinary risk assessment. Take into account the age and reliability of the system. * Document these parameters, especially the pressure differentials. IB, IC C.I.B.3. Engineer humidity controls into the HVAC system and monitor the controls to ensure proper moisture removal. (AIA: 7.31.D9) * Locate duct humidifiers upstream from the final filters. * Incorporate a water-removal mechanism into the system. * Locate all duct takeoffs sufficiently down-stream from the humidifier so that moisture is completely absorbed. IC C.I.B.4. Incorporate steam humidifiers, if possible, to reduce potential for microbial proliferation within the system, and avoid use of cool mist humidifiers. II C.I.B.5. Ensure that air intakes and exhaust outlets are located properly in construction of new facilities and renovation of existing facilities. (AIA: 7.31.D3, 8.31.D3, 9.31.D3, 10.31.D3, 11.31.D3) * Locate exhaust outlets >25 ft. from air-intake systems. * Locate outdoor air intakes ≥6 ft. above ground or ≥3 ft. above roof level. * Locate exhaust outlets from contaminated areas above roof level to minimize recirculation of exhausted air. IC C.I.B.6. Maintain air intakes and inspect filters periodically to ensure proper operation. (AIA: 7.31.D8) IC C.I.B.7. Bag dust-filled filters immediately upon removal to prevent dispersion of dust and fungal spores during transport within the facility. * Seal or close the bag containing the discarded filter. * Discard spent filters as regular solid waste, regardless of the area from which they were removed. IB C.I.B.8. Remove bird roosts and nests near air intakes to prevent mites and fungal spores from entering the ventilation system. IB C.I.B.9. Prevent dust accumulation by cleaning air-

duct grilles in accordance with facility- specific procedures and schedules when rooms are not occupied by patients. (AIA: 7.31.D10) IC, II C.I.B.10. Periodically measure output to monitor system function; clean ventilation ducts as part of routine HVAC maintenance to ensure optimum performance. (AIA: 7.31.D10) II C.I.C. Use portable, industrial-grade HEPA filter units capable of filtration rates in the range of 300–800 ft3/min. to augment removal of respirable particles as needed. II C.I.C.1. Select portable HEPA filters that can recirculate all or nearly all of the room air and provide the equivalent of ≥12 ACH. II C.I.C.2. Portable HEPA filter units previously placed in construction zones can be used later in patient-care areas, provided all internal and external surfaces are cleaned, and the filter's performance verified by appropriate particle testing. II C.I.C.3. Situate portable HEPA units with the advice of facility engineers to ensure that all room air is filtered. II C.I.C.4. Ensure that fresh-air requirements for the area are met. II C.I.D. Follow appropriate procedures for use of areas with through-the-wall ventilation units. (AIA: 8.31.D1, 8.31.D8, 9.31.D23, 10.31.D18, 11.31.D15) IC C.I.D.1. Do not use such areas as PE rooms. (AIA: 7.2.D3) IC C.I.D.2. Do not use a room with a through-the-wall ventilation unit as an AII room unless it can be demonstrated that all required AII engineering controls required are met. (AIA: 7.2.C3) IC C.I.E. Conduct an infection-control risk assessment (ICRA) and provide an adequate number of AII and PE rooms (if required) or other areas to meet the needs of the patient population. (AIA: 7.2.C, 7.2.D) IA, IC C.I.F. When UVGI is used as a supplemental engineering control, install fixtures * on the wall near the ceiling or suspended from the ceiling as an upper air unit; * in the air-return duct of an AII room; or * in designated enclosed areas or booths for sputum induction. II C.I.G. Seal windows in buildings with centralized HVAC systems and especially with PE areas. (AIA: 7.2.D3) IB, IC C.I.H. Keep emergency doors and exits from PE rooms closed except during an emergency; equip emergency doors and exits with alarms. II C.I.I. Develop a contingency plan for backup capacity in the event of a general power failure. (Joint Commission on Accreditation of Healthcare Organizations [JCAHO]: Environment of Care [EC] 1.4) IC C.I.I.1. Emphasize restoration of proper air quality and ventilation conditions in AII rooms, PE rooms, operating rooms, emergency departments, and intensive care units. (AIA: 1.5.A1; JCAHO: EC 1.4) IC C.I.I.2. Deploy infection-control procedures to protect occupants until power and systems functions are restored. (AIA: 5.1, 5.2; JCAHO: EC 1.4) IC C.I.J. Do not shut down HVAC systems in patient-care areas except for maintenance, repair, testing of emergency backup capacity, or new construction. (AIA: 5.1, 5.2.B, C) IB, IC C.I.J.1. Coordinate HVAC system maintenance with infection-control staff to allow for relocation of immunocompromised patients if necessary. (AIA: 5.1, 5.2) IC C.I.J.2. Provide backup emergency power and air-handling and pressurization systems to maintain filtration, constant ACH, and pressure differentials in PE rooms, AII rooms, operating rooms, and other critical-care areas. (AIA: 1.5, 5.1, 5.2) IC C.I.J.3. For areas not served by installed emergency ventilation and backup systems, use portable units and monitor ventilation parameters and patients in those areas. II C.I.J.4. Coordinate system startups with infection-control staff to protect patients in PE rooms from bursts of fungal spores. (AIA: 5.1, 5.2) IC C.I.J.5. Allow sufficient time for ACH to clean the air once the system is operational (Appendix B, Table B.1). (AIA: 5.1, 5.2) IC C.I.K. HVAC systems serving offices and administration areas may be shut down for energy conservation purposes, but the shutdown must not alter or adversely affect pressure differentials maintained in laboratories or critical-care areas with specific ventilation requirements (i.e., PE rooms, AII rooms, operating rooms). II C.I.L. Whenever possible, avoid inactivating or shutting down the entire HVAC system at one time, especially in acute-care facilities. II C.I.M. Whenever feasible, design and install fixed backup ventilation systems for new or renovated construction for PE rooms, AII rooms, operating rooms, and other critical care areas identified by ICRA. (AIA: 1.5.A1) IC Edit: These recommendations contain minor edits in order to clarify the meaning. The edits do not constitute any change to the intent of the recommendations. * Indicates a change to the numbering system. ~ Indicates a text change. Recommendations for construction and demolition by ID number and category. # Recommendation Category C.II.A. Establish a multidisciplinary team that includes infection-control staff to coordinate demolition, construction, and renovation projects and consider proactive preventive measures at the inception; produce and maintain summary statements of the team's activities. (AIA: 5.1) IB, IC C.II.B. Educate both the construction team and the health-care staff in immunocompromised patient-care areas regarding the airborne infection risks associated with construction projects, dispersal of fungal spores during such activities, and methods to control the dissemination of fungal spores. IB C.II.C. Incorporate mandatory adherence agreements for infection control into construction contracts, with penalties for noncompliance and mechanisms to ensure timely correction of problems. (AIA: 5.1) IC C.II.D. Establish and maintain surveillance for airborne environmental disease (e.g., aspergillosis) as appropriate during construction, renovation, repair, and demolition activities to ensure the health and safety of immunocompromised patients. IB C.II.D.1. Using active surveillance, monitor for airborne fungal infections in immunocompromised patients. IB C.II.D.2. Periodically review the facility's microbiologic, histopathologic, and postmortem data to identify additional cases. IB C.II.D.3. If cases of aspergillosis or other health-care–associated airborne fungal infections occur, aggressively pursue the diagnosis with tissue biopsies and cultures as feasible. IB C.II.E. Implement infection-control measures relevant to construction, renovation, maintenance, demolition, and repair. (AIA: 5.1, 5.2) IB, IC C.II.E.1. Before the project gets underway, perform an ICRA to define the scope of the project and the need for barrier measures. (AIA: 5.1) * Determine if immunocompromised patients may be at risk for exposure to fungal spores from dust generated during the project. * Develop a contingency plan to prevent such exposures. IB, IC C.II.E.2. Implement infection-control measures for external demolition and construction activities. * Determine if the facility can operate temporarily on recirculated air; if feasible, seal off adjacent air intakes. * If this is not possible or practical, check the low-efficiency (roughing) filter banks frequently and replace as needed to avoid buildup of particulates. * Seal windows and reduce wherever possible other sources of outside air intrusion (e.g., open doors in stairwells and corridors), especially in PE areas. IB C.II.E.3. Avoid damaging the underground water distribution system (i.e., buried pipes) to prevent soil and dust contamination of the water. (AIA: 5.1) IB, IC C.II.E.4. Implement infection-control measures for internal construction activities. (AIA: 5.1, 5.2) * Construct barriers to prevent dust from construction areas from entering patient-care areas; ensure that barriers are impermeable to fungal spores and in compliance with local fire codes. * Block and seal off return air vents if rigid barriers are used for containment. * Implement dust control measures on surfaces and by diverting pedestrian traffic away from work zones. * Relocate patients whose rooms are adjacent to work zones, depending upon their immune status, the scope of the project, the potential for generation of dust or water aerosols, and the methods used to control these aerosols. IB, IC C.II.E.5. Perform those engineering and work-site related infection-control measures as needed for internal construction, repairs, and renovations: (AIA: 5.1, 5.2) IB, IC C.II.E.5.a. Ensure proper operation of the air-handling system in the affected area after erection of barriers and before the room or area is set to negative pressure. IB C.II.E.5.b. Create and maintain negative air pressure in work zones adjacent to patient-care areas and ensure that required engineering controls are maintained. ~ IB C.II.E.5.c. Monitor negative air flow inside rigid barriers. ~ IC C.II.E.5.d. Monitor barriers and ensure the integrity of the construction barriers; repair gaps or breaks in barrier joints. ~ IC C.II.E.5.e. Seal windows in work zones if practical; use window chutes for disposal of large pieces of debris as needed, but ensure that the negative pressure differential for the area is maintained. ~ IC C.II.E.5.f. Direct pedestrian traffic from construction zones away from patient-care areas to minimize the dispersion of dust. ~ IB C.II.E.5.g. Provide construction crews with * designated entrances, corridors, and elevators whenever practical; * essential services [e.g., toilet facilities], and convenience services [e.g., vending machines]; * protective clothing [e.g., coveralls, footgear, and headgear] for travel to patient-care areas; and * a space or anteroom for changing clothing and storing equipment. ~ IB C.II.E.5.h. Clean work zones and their entrances daily by * wet-wiping tools and tool carts before their removal from the work zone; * placing mats with tacky surfaces inside the entrance; and * covering debris and securing this covering before removing debris from the work zone. ~ IB C.II.E.5.i. In patient-care areas, for major repairs that include removal of ceiling tiles and disruption of the space above the false ceiling, use plastic sheets or prefabricated plastic units to contain dust; use a negative pressure system within this enclosure to remove dust; and either pass air through an industrial grade, portable HEPA filter capable of filtration rates ranging from 300–800 ft3/min., or exhaust air directly to the outside. ~ IB C.II.E.5.j. Upon completion of the project, clean the work zone according to facility procedures, and install barrier curtains to contain dust and debris before removal of rigid barriers. ~ IB C.II.E.5.k. Flush the water system to clear sediment from pipes to minimize waterborne microorganism proliferation. ~ IB C.II.E.5.l. Restore appropriate ACH, humidity, and pressure differential; clean or replace air filters; dispose of spent filters. ~ IC C.II.F. Use airborne-particle sampling as a tool to evaluate barrier integrity. II C.II.G. Commission the HVAC system for newly constructed health-care facilities and renovated spaces before occupancy and use, with emphasis on ensuring proper ventilation for operating rooms, AII rooms, and PE areas. (AIA: 5.1; ASHRAE: 1 1996) IC C.II.H. No recommendation is offered on routine microbiologic air sampling before, during, or after construction or before or during occupancy of areas housing immunocompromised patients. Unresolved issue C.II.I. If a case of health-care–acquired aspergillosis or other opportunistic environmental airborne fungal disease occurs during or immediately after construction, implement appropriate follow-up measures. IB C.II.I.1. Review pressure differential monitoring documentation to verify that pressure differentials in the construction zone and in PE rooms were appropriate for their settings. (AIA: 5.1) IB, IC C.II.I.2. Implement corrective engineering measures to restore proper pressure differentials as needed. (AIA: 5.1) IB, IC C.II.I.3. Conduct a prospective search for additional cases and intensify retrospective epidemiologic review of the hospital's medical and laboratory records. IB C.II.I.4. If there is no evidence of ongoing transmission, continue routine maintenance in the area to prevent health-care–acquired fungal disease. IB C.II.J. If there is epidemiologic evidence of ongoing transmission of fungal disease, conduct an environmental assessment to determine and eliminate the source. IB C.II.J.1. Collect environmental samples from potential sources of airborne fungal spores, preferably using a high-volume air sampler rather than settle plates. IB C.II.J.2. If either an environmental source of airborne fungi or an engineering problem with filtration or pressure differentials is identified, promptly perform corrective measures to eliminate the source and route of entry. IB C.II.J.3. Use an EPA-registered anti-fungal biocide (e.g., copper-8-quinolinolate) for decontaminating structural materials. IB C.II.J.4. If an environmental source of airborne fungi is not identified, review infection control measures, including engineering controls, to identify potential areas for correction or improvement. IB C.II.J.5. If possible, perform molecular subtyping of Aspergillus spp. isolated from patients and the environment to establish strain identities. II C.II.K. If air-supply systems to high-risk areas (e.g., PE rooms) are not optimal, use portable, industrial-grade HEPA filters on a temporary basis until rooms with optimal air-handling systems become available. II Edit: These recommendations contain minor edits in order to clarify the meaning. The edits do not constitute any change to the intent of the recommendations. * Indicates a change to the numbering system. ~ Indicates a text change. Recommendations for ventilation requirements for PE rooms by ID number and category. # Recommendation Category C.III.A. Minimize exposures of severely immunocompromised patients (e.g., solid organ transplant patients or allogeneic neutropenic patients) to activities that might cause aerosolization of fungal spores (e.g., vacuuming or disruption of ceiling tiles). IB C.III.B. Minimize the length of time that immunocompromised patients in PE are outside their rooms for diagnostic procedures and other activities. IB C.III.C. Provide respiratory protection for severely immunocompromised patients when they must leave PE for diagnostic studies and other activities; consult the most recent revision of CDC's Guidelines for Prevention of Health-Care–Associated Pneumonia for information regarding the appropriate type of respiratory protection. II C.III.D. Incorporate ventilation engineering specifications and dust-controlling processes into the planning and construction of new PE units. IB, IC C.III.D.1. Install central or point-of-use HEPA filters for supply (incoming) air. (AIA: 5.1, 5.2, 7.2.D) IB, IC C.III.D.2. Ensure that rooms are well sealed by * properly constructing windows, doors, and intake and exhaust ports; * maintaining ceilings that are smooth and free of fissures, open joints, and crevices; * sealing walls above and below the ceiling, and * monitoring for leakage and making necessary repairs. (AIA: 7.2.D3) IB, IC C.III.D.3. Ventilate the room to maintain ≥12 ACH. (AIA: 7.2.D) IC C.III.D.4. Locate air supply and exhaust grilles so that clean, filtered air enters from one side of the room, flows across the patient's bed, and exits from the opposite side of the room. (AIA: 7.31.D1) IC C.III.D.5. Maintain positive room air pressure (≥2.5 Pa [0.01-inch water gauge]) in relation to the corridor. (AIA: Table 7.2) IB, IC C.III.D.6. Maintain airflow patterns and monitor these on a daily basis by using permanently installed visual means of detecting airflow in new or renovated construction, or using other visual methods (e.g., flutter strips, or smoke tubes) in existing PE units. Document the monitoring results. (AIA: 7.2.D6) IC C.III.D.7. Install self-closing devices on all room exit doors in protective environments. (AIA: 7.2.D4) IC C.III.E. Do not use laminar air flow systems in newly constructed PE rooms. II C.III.F. Take measures to protect immunocompromised patients who would benefit from a PE room and who also have an airborne infectious disease (e.g., acute VZV infection or tuberculosis). C.III.F.1. Ensure that the patient's room is designed to maintain positive pressure. ~ IC C.III.F.2. Use an anteroom to ensure appropriate air balance relationships and provide independent exhaust of contaminated air to the outside, or place a HEPA filter in the exhaust duct if the return air must be recirculated. (AIA: 7.2.D1, A7.2.D) IC C.III.F.3. If an anteroom is not available, place the patient in AII and use portable, industrial- grade HEPA filters to enhance filtration of spores in the room. II C.III.G. Maintain backup ventilation equipment (e.g., portable units for fans or filters) for emergency provision of ventilation requirements for PE areas and take immediate steps to restore the fixed ventilation system function. (AIA: 5.1) IC Edit: An * indicates recommendations that were renumbered for clarity. The renumbering does not constitute change to the intent of the recommendations. Recommendations for ventilation requirements for AII rooms by ID number and category. # Recommendation Category C.IV.A. Incorporate certain specifications into the planning, and construction or renovation of AII units. IB, IC C.IV.A.1. Maintain continuous negative air pressure (2.5 Pa [0.01-inch water gauge]) in relation to the air pressure in the corridor; monitor air pressure periodically, preferably daily, with audible manometers or smoke tubes at the door (for existing AII rooms) or with a permanently installed visual monitoring mechanism. Document the results of monitoring. (AIA: 7.2.C7, Table 7.2) IB, IC C.IV.A.2. Ensure that rooms are well-sealed by properly constructing windows, doors, and air- intake and exhaust ports; when monitoring indicates air leakage, locate the leak and make necessary repairs. (AIA: 7.2.C3) IB, IC C.IV.A.3. Install self-closing devices on all AII room exit doors. (AIA: 7.2.C4) IC C.IV.A.4. Provide ventilation to ensure ≥12 ACH for renovated rooms and new rooms, and ≥6 ACH for existing AII rooms. (AIA: Table 7.2) IC C.IV.A.5. Direct exhaust air to the outside, away from air-intake and populated areas. If this is not practical, air from the room can be recirculated after passing through a HEPA filter. (AIA: Table 7.2) IC C.IV.B. Where supplemental engineering controls for air cleaning are indicated from a risk assessment of the AII area, install UVGI units in the exhaust air ducts of the HVAC system to supplement HEPA filtration or install UVGI fixtures on or near the ceiling to irradiate upper room air. II C.IV.C. Implement environmental infection-control measures for persons with known or suspected airborne infectious diseases. C.IV.C.1. Use AII rooms for patients with or suspected of having an airborne infection who also require cough-inducing procedures, or use an enclosed booth that is engineered to provide * ≥12 ACH; * air supply and exhaust rate sufficient to maintain a 2.5 Pa [0.01-inch water gauge] negative pressure difference with respect to all surrounding spaces with an exhaust rate of ≥50 ft3/min.; and * air exhausted directly outside away from air intakes and traffic or exhausted after HEPA filtration prior to recirculation. (AIA: 7.15.E, 7.31.D23, 9.10, Table 7.2) IB, IC C.IV.C.2. Although airborne spread of viral hemorrhagic fever (VHF) has not been documented in a health-care setting, prudence dictates placing a VHF patient in an AII room, preferably with an anteroom to reduce the risk of occupational exposure to aerosolized infectious material in blood, vomitus, liquid stool, and respiratory secretions present in large amounts during the end stage of a patient's illness. * If an anteroom is not available, use portable, industrial-grade HEPA filters in the patient's room to provide additional ACH equivalents for removing airborne particulates. * Ensure that health-care workers wear face shields or goggles with appropriate respirators when entering the rooms of VHF patients with prominent cough, vomiting, diarrhea, or hemorrhage. II C.IV.C.3. Place smallpox patients in negative pressure rooms at the onset of their illness, preferably using a room with an anteroom if available. II C.IV.D. No recommendation is offered regarding negative pressure or isolation rooms for patients with Pneumocystis carinii pneumonia. Unresolved issue C.IV.E. Maintain back-up ventilation equipment (e.g., portable units for fans or filters) for emergency provision of ventilation requirements for AII rooms and take immediate steps to restore the fixed ventilation system function. (AIA: 5.1) IC Recommendations for ventilation requirements for operating rooms by ID number and category. # Recommendation Category C.V.A. Implement environmental infection-control and ventilation measures for operating rooms. C.V.A.1. Maintain positive-pressure ventilation with respect to corridors and adjacent areas. (AIA: Table 7.2) IB, IC C.V.A.2. Maintain ≥15 ACH, of which ≥3 ACH should be fresh air. (AIA: Table 7.2) IC C.V.A.3. Filter all recirculated and fresh air through the appropriate filters, providing 90% efficiency (dust-spot testing) at a minimum. (AIA: Table 7.3) IC C.V.A.4. In rooms not engineered for horizontal laminar airflow, introduce air at the ceiling and exhaust air near the floor.120, 357, 359 (AIA: 7.31.D4) IC C.V.A.5. Do not use UV lights to prevent surgical-site infections. IB C.V.A.6. Keep operating room doors closed except for the passage of equipment, personnel, and patients, and limit entry to essential personnel. IB C.V.B. Follow precautionary procedures for TB patients who also require emergency surgery. IB, IC C.V.B.1. Use an N95 respirator approved by the National Institute for Occupational Safety and Health (NIOSH) without exhalation valves in the operating room. (Occupational Safety and Health Administration [OSHA]; 29 Code of Federal Regulations [CFR] 1910.134,139) IC C.V.B.2. Intubate the patient in either the AII room or the operating room; if intubating the patient in the operating room, do not allow the doors to open until 99% of the airborne contaminants are removed (Appendix B, Table B.1). IB C.V.B.3. When anesthetizing a patient with confirmed or suspected TB, place a bacterial filter between the anesthesia circuit and patient's airway to prevent contamination of anesthesia equipment or discharge of tubercle bacilli into the ambient air. IB C.V.B.4. Extubate and allow the patient to recover in an AII room. IB C.V.B.5. If the patient has to be extubated in the operating room, allow adequate time for ACH to clean 99% of airborne particles from the air (Appendix B, Table B.1) because extubation is a cough-producing procedure. IB C.V.C. Use portable, industrial-grade HEPA filters temporarily for supplemental air cleaning during intubation and extubation for infectious TB patients who require surgery. II C.V.C.1. Position the units appropriately so that all room air passes through the filter; obtain engineering consultation to determine the appropriate placement of the unit. II C.V.C.2. Switch the portable unit off during the surgical procedure. II C.V.C.3. Provide fresh air as per ventilation standards for operating rooms; portable units do not meet the requirements for the number of fresh ACH. II C.V.D. If possible, schedule infectious TB patients as the last surgical cases of the day to maximize the time available for removal of airborne contamination. II C.V.E. No recommendation is offered for performing orthopedic implant operations in rooms supplied with laminar airflow. Unresolved issue C.V.F. Maintain backup ventilation equipment (e.g., portable units for fans or filters) for emergency provision of ventilation requirements for operating rooms, and take immediate steps to restore the fixed ventilation system function. (AIA: 5.1) IB, IC Recommendations for infectious aerosol hazards by ID number and category. # Recommendation Category C.VI.A. In settings where surgical lasers are used, wear appropriate personal protective equipment, including N95 or N100 respirators, to minimize exposure to laser plumes. (OSHA; 29 CFR 1910.134,139) IC C.VI.B. Use central wall suction units with in-line filters to evacuate minimal laser plumes. II C.VI.C. Use a mechanical smoke evacuation system with a high-efficiency filter to manage the generation of large amounts of laser plume, when ablating tissue infected with human papilloma virus (HPV) or performing procedures on a patient with extrapulmonary TB. II Recommendations for controlling waterborne microoganisms by ID number and category. # Recommendation Category D.I.A. Practice hand hygiene to prevent the hand transfer of waterborne pathogens, and use barrier precautions (e.g., gloves) as defined by other guidelines. IA D.I.B. Eliminate contaminated water or fluid environmental reservoirs (e.g., in equipment or solutions) wherever possible. IB D.I.C. Clean and disinfect sinks and wash basins on a regular basis by using an EPA-registered product as set by facility policies. II D.I.D. Evaluate for possible environmental sources (e.g., potable water) of specimen contamination when waterborne microorganisms (e.g., NTM) of unlikely clinical importance are isolated from clinical cultures (e.g., specimens collected aseptically from sterile sites or, if post-procedural, colonization occurs after use of tap water in patient care). IB D.I.E. Avoid placing decorative fountains and fish tanks in patient-care areas; ensure disinfection and fountain maintenance if decorative fountains are used in the public areas of the health care facility. IB Recommendations for prevention of waterborne microbial contamination by ID number and category. # Recommendation Category D.II.A. Maintain hot water temperature at the return at the highest temperature allowable by state regulations or codes, preferably ≥124°F (≥51°C), and maintain cold water temperature at

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