An APIC Guide

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Guide to the Elimination of Multidrug-resistant *Acinetobacter baumannii* Transmission in Healthcare Settings

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Acinetobacter baumannii, magnified 1,546x. Public Health Image Library, ID# 10096. Courtesy of CDC/Janice Haney Carr.

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Foreword

The writers of this guide encourage readers to consult the references we have provided at the end of each section. We have identified many recent articles and technologies to help the infection preventionist (IP) be aware of all current and emerging information on creating a program to eliminate the transmission of multidrug-resistant *Acinetobacter baumannii* (MDR Ab) in his or her facility.

Guide Overview

Purpose and Scope

The purpose of this guide is to provide the infection preventionist (IP) with a summary of the latest articles, studies, outbreak experiences, applicable guidelines and tools to manage and eliminate transmission of multidrug-resistant *Acinetobacter baumannii* (MDR Ab) in healthcare settings.

Specifics related to pathogenesis, surveillance, resistance patterns and environmental controls as covered in this document provide the IP with current advanced knowledge imperative to the transmission elimination process.

Special healthcare settings—long-term care, ambulatory care, and pediatrics—are addressed at the end of the guide. In all sections of the guide, the use of the term "patient" refers to a patient, resident or client in a healthcare setting.

Key Concepts

- The facility-wide risk assessment guides the development and implementation of a comprehensive MDR Ab prevention and elimination plan.
- The completed risk assessment identifies the facility's burden of MDR Ab and the risk of transmission within the facility. The IP incorporates this information into the development of the MDR Ab infection prevention plan.
- The development of the infection prevention plan requires an understanding of the attributes of MDR Ab so that effective interventions are targeted.

Background

In past decades, *Acinetobacter* infections have been sporadically identified in hospitalized patients and healthcare-related outbreaks.[1,2,3] These infections have occurred most often in critically ill patients receiving invasive medical interventions such as central lines, arterial lines, and mechanical ventilation. In more recent years, *Acinetobacter* has been increasingly recognized as a significant healthcare-associated, opportunistic, multidrug-resistant pathogen.[4] Widespread public awareness of the risk of *Acinetobacter* infection in healthcare has escalated, primarily as a result of the media attention given infections in military populations serving in the Middle East (dubbed "Iraqibacter" by the media).[5]

Acinetobacter species are ubiquitous in nature and have been found on or in soil, water, animals and humans.[6] *Acinetobacter baumannii* is known to be recoverable from the skin, throat and rectum of humans, and has been reported to be a healthcare-acquired colonizer of the respiratory tract. According to the Centers for Disease Control and Prevention (CDC), the species *A. baumannii* accounts for nearly 80% of reported Acinetobacter infections.[7]

Acinetobacter is capable of surviving for extended periods of time on inanimate surfaces. This prolonged survival in the healthcare environment—along with multidrug resistance, colonization potential, and contact transmission (hands, instruments, equipment)—are some of the challenging factors in *Acinetobacter* prevention and control. When outbreaks occur, and/or when *Acinetobacter* survives due to incomplete cleaning and becomes endemic to a healthcare setting, the difficulties encountered in implementing successful sustainable eradication can severely challenge the limited resources of the IP. Pinpointing an outbreak source may require extensive "detective" work

when the source is not obvious. For example, one reported outbreak of MDR Ab eventually found the source to be associated with pulsatile lavage wound therapy.[8] It should be noted that in approximately 50% of reported outbreaks, the source could not be identified.[2]

Elimination of an identified source may require multiple or novel interventions, such as the introduction of a new disinfectant technology (for example, hydrogen peroxide vapor) to interrupt an ongoing MDR Ab outbreak at a long-term acute care facility.[9] The reader is encouraged to follow the peer-reviewed literature closely for reports of the efficacy of these and other emerging technologies which may ultimately provide more efficacious room decontamination than is now achieved using traditional cleaning methods.

Definitions

MDR *Acinetobacter baumannii* (MDR Ab): *A. baumannii* with multidrug resistance to more than two of the following five drug classes: antipseudomonal cephalosporins (ceftazidime or cefepime), antipseudomonal carbapenems (imipenem or meropenem), ampicillin/sulbactam, fluoroquinolones (ciprofloxacin or levofloxacin), and aminoglycosides (Gentamicin, tobramycin, or amikacin).[4] This definition is given for the purposes of this document; readers may wish to refer to a local antibiogram when defining multidrug-resistant Ab in their own facilities.

Pan-drug resistant *Acinetobacter baumannii: A. baumannii* with additional antimicrobial resistance in all drug classes, plus resistance to polymyxin and/or colistin [10,11] (note there is no standardized definition of pan resistant Acinetobacter baumannii the authors could find, please review references given)

Ambulatory care: Healthcare rendered for acute or chronic diseases, and for surgical interventions where a patient's length of stay is less than 24 hours.

Cohort for MDR Ab: Placement of residents/patients colonized or infected with MDR Ab in rooms (cohorted) with other MDR Ab residents/patients.

Cohort staffing related to MDR Ab: Assignment of personnel to care only for residents/patients known to be colonized or infected with MDR Ab.

Colonization with MDR Ab: Presence of MDR Ab in or on body without signs or symptoms of active infection.

Contact Precautions: Transmission-based Precautions method recommended by the Centers for Disease Control and Prevention (CDC). This method requires barrier precautions and personal protective equipment (PPE) for direct contact with residents/patients or contaminated equipment.

Contamination: Presence of a potentially infectious agent on a surface, on a material, or in a fluid.

Endemic: A baseline rate established by ongoing surveillance of the usual frequency of an organism, infection or disease in a given setting.

Epidemic: A higher incidence than usual of an organism, infection or disease in a defined population in a given period of time.

Healthcare-associated infection (HAI): An infection that develops in a patient/resident in a healthcare setting, and the infection was not present or incubating at the time of admission.

Incidence of MDR Ab: Number of new cases of MDR Ab colonization or infection identified in a specific population in a given time period. New cases can be defined as occurring three days or more after admission to the facility.[12]

Long-term care facility (LTCF): A healthcare setting that provides rehabilitative, restorative, and/or ongoing skilled nursing care to patients or residents in need of assistance with activities of daily living. Long-term care facilities include nursing homes, rehabilitation facilities, inpatient behavioral health facilities, and long-term chronic care hospitals.

Long-term acute care (LTAC): A healthcare setting that manages complex medical care and rehabilitation of patients with multiple acute healthcare needs.

Outbreak of MDR Ab: An increase in the incidence of MDR Ab cases in a healthcare setting above the endemic level, or a cluster of new MDR Ab cases that are epidemiologically linked.

Prevalence of MDR Ab: The total number of patients with MDR Ab infection or colonization in a given population at a point in time.

Reservoir: Any animate or inanimate surface in which an infectious agent may survive to become a source of transmission to a susceptible host.

Surveillance: The ongoing systematic collection, analysis and interpretation of healthcare data.

Standard Precautions: Precautions taken to protect against exposure to blood and potentially infectious body fluids when caring for patients/residents. These precautions are always taken without regard for the diagnosis or perceived diagnosis and are never discontinued.

Terminal cleaning: Comprehensive, deep cleaning of a patient room at the time of discharge from the healthcare setting or termination of transmission-based precautions based on the policy of the facility.[13]

Guide Overview References

[1] Beck-Sagué CM, Jarvis WR, Brook JH, Culver DH, Potts A, Gay E, Shotts BW, Hill B, Anderson RL, Weinstein MP. Epidemic bacteremia due to *Acinetobacter baumannii* in five intensive care units. Am J Epidemiol. 1990 Oct;132(4):723–733.

[2] Villegas MV, Hartstein AI. *Acinetobacter* outbreaks,1977-2000. Infect Control Hosp Epidemiol. 2003 Apr;24(4):284–295.

[3] Lortholary O, Fagon JY, Hoi AB, Slama MA, Pierre J, Giral P, Rosenzweig R, Gutmann L, Safar M, Acar J. Nosocomial acquisition of multiresistant *Acinetobacter baumannii*: risk factors and prognosis. Clin Infect Dis. 1995 Apr;20(4):790–796.

[4] Peleg AY, Seifert H, Paterson DL. *Acinetobacter baumannii*: emergence of a successful pathogen. Clin Microbiol Rev. 2008 Jul;21(3):538–582.

[5] Davidson M. The Iraqibacter: Medical experts wary of dangerous germ now striking war wounded troops. American Legion Magazine, 2008 Mar 1. Available at: http://www.legion.org/magazine/1516/medical-experts-wary-dangerous-germ-now-striking-war8209wounded-troops

[6] Beavers SF, Blossom DB, Wiemken TL. *et al.* Comparison of risk factors for recovery of *Acinetobacter baumannii* during outbreaks at two Kentucky hospitals, 2006. Public Health Rep. 2009 Nov-Dec;124(6):868–874.

[7] Centers for Disease Control and Prevention (CDC). Overview of drug-resistant *Acinetobacter* infections in healthcare settings. Available at: http://www.cdc.gov/ncidod/dhqp/ar_acinetobacter.html

[8] Maragakis LL, Cosgrove SE, Song X, Kim D, Rosenbaum P, Ciesla N, Srinivasan A, Ross T, Carroll K, Perl TM. An outbreak of multidrug-resistant Acinetobacter baumannii associated with pulsatile lavage wound treatment. JAMA. 2004 Dec 22;292(24):3006–3011.

[9] Ray A. "The use of vaporized hydrogen peroxide room decontamination in the management of an outbreak of multidrug-resistant *Acinetobacter baumannii*." 36th Annual APIC Educational Conference and International Meeting Proceedings, Fort Lauderdale, FL. 2009 Jun 10.

[10] Hsueh PR, Teng LJ, Chen CY, Chen WH, Yu CJ, Ho SW, et al. Pandrug-resistant *Acinetobacter baumannii* causing nosocomial infections in a university hospital, Taiwan. Emerg Infect Dis. 2002;8:827–832.

[11] Valencia R, Arroyo LA, Conde M, Aldana JM, Torres MJ, Fernández-Cuenca F, Garnacho-Montero J, Cisneros JM, Ortíz C, Pachón J, Aznar, J. Nosocomial outbreak of infection with pan-drug-resistant *Acinetobacter baumannii* in a tertiary care university hospital. Infect Control Hosp Epidemiol. 2009 Mar;30(3):257–263.

[12] Cohen A., *et al.* Recommendations for metrics for multidrug-resistant organisms in healthcare settings: SHEA/HICPAC Position Paper. Infect Control Hosp Epidemiol. 2008;29:1099–1106.

[13] American Society for Healthcare Environmental Services (ASHES). Practice Guidance for Healthcare Environmental Cleaning. 2008;5.9:62.

Laboratory Considerations—Epidemiology—Pathogenicity

The genus *Acinetobacter* is a member of the family Moraxellaceae in the order Pseudomonadales.[1] More than 25 species within the genus *Acinetobacter* have been described; however, member species in this genus are difficult to differentiate and only some have been officially named. The most important species of this genus in human pathology is *Acinetobacter baumannii*. This organism is a member of a group of phenotypically similar species that are often grouped together in the *A.calcoaceticus-A.baumannii* complex. In healthcare settings, the organisms in this group are the ones generally implicated in outbreaks and hospital-associated infections.[2] There have been occasional reports of opportunistic infections in immunocompromised individuals caused by *A. lwoffii* and other species.[3,4]

Bacteria in the genus *Acinetobacter* are strictly aerobic, gram negative bacteria. On gram stain, they are described as coccobacillary, having an intermediate shape between a rod (bacillus) and a sphere (coccus).

Acinetobacter bacteria often appear more bacillus-like during growth phase and from fluids. They are often seen in pairs, and although gram-negative, will sometimes appear gram-variable on a gram stain. They readily grow in culture on standard microbiology media at temperatures between 20 and 30 degrees C. They are non-motile bacteria, oxidase-negative, usually nitrate- negative, and are non-lactose fermenting, although they can be partially lactose fermenting when grown on MacConkey's agar.

Most clinical microbiology laboratories identify members of the genus *Acinetobacter* at the level of the following groups:

- *Acinetobacter calcoaceticus-baumannii complex*: glucose-oxidizing non-hemolytic (*A.baumannii* can be identified by OXA-51 serotyping)[5]
- *Acinetobacter lwoffii*: non glucose-oxidizing, non-hemolytic
- *Acinetobacter haemolyticus*: hemolytic

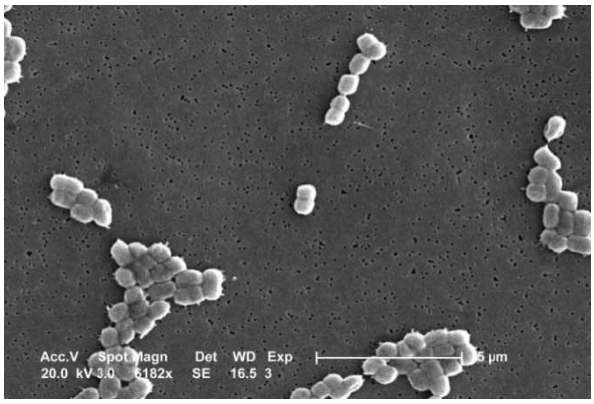

Figure 1. Scanning Electron Micrograph of clusters of Acinetobacter baumannii bacteria under a magnification of 6,182x. Content provider: CDC/ Janice Haney Carr. Creation Date: 2007. Photo at Public Health Library: http://phil.cdc.gov/phil/home.asp; search *"Acinetobacter."*

The Clinical and Laboratory Standards Institute (CLSI) has published susceptibility testing interpretations for *Acinetobacter* in the monograph Performance Standards for Antimicrobial Susceptibility Testing: Nineteenth Informational Supplement CLSI M100-S19 (2009). In Table 2B-2 "*Acinetobacter spp.*," incubation is required in ambient air, 20–24 hours, at 35 ± 2 degrees C. Zone diameters and MIC interpretations for antimicrobial agents in nine classes are provided in this table.[6] Additional considerations for laboratorians are available in a review article by Peleg, Seifert, and Paterson.[7]

Specimen Collection

Clinical Culture

There are no special specimen collection requirements related to clinical culture. Refer to the clinical laboratory's specimen manual for the appropriate collection method and supplies.

Patient Screening (Surveillance) Culture Specimens

In outbreak situations, surveillance cultures of patients involved in the outbreak or who are deemed at risk for colonization/infection with the outbreak organism are often part of the planned intervention. A recent investigation into the effectiveness of screening cultures by Marchaim et al. found that detection of MDR Ab in surveillance (screening) cultures was suboptimal (around 55%), with a low sensitivity even when surveillance cultures were obtained from six body sites (throat, nose, skin, wounds, rectum, endotracheal aspirates). In addition, these reseachers reported that persistent carriage of MDR Ab occurs in a substantial proportion of patients.[8]

At this time, a specific recommendation regarding best practice for surveillance cultures is not available, in part due to the lack of verified effectiveness of screening protocols. However, the decision to use screening cultures may be part of an enhanced intervention when rates are increasing, when an outbreak is identified, or when exogenous sources of colonization pressure are suspected or identified (e.g., nursing home transfers to acute care). It is important to keep in mind that detection effectiveness will be enhanced if a number of body sites are screened. Candidate body sites for screening cultures may include the nose, the throat, skin sites such as the axilla and/or groin, the rectum, open wounds and endotracheal aspirates.

When screening cultures are deemed necessary, apply the following components:

- Use a pre-determined standardized collection protocol, including sites to be cultured
- Collaborate with laboratory regarding supplies
- Collaborate with laboratory regarding timing of collection for optimal delivery and set-up
- Collaborate with laboratory regarding appropriate test order (as screening test)
- Collaborate with laboratory regarding test result, comment, or immediate notifications as appropriate
- Include protocol specific actions when target organism is found (private room, cohorting of patients and/or staff, roommate considerations, precautions/isolation, other)
- Implement protocols with appropriate communication and staff training as necessary

Environmental Specimens

When the environment can play a role in an outbreak situation, environment or equipment culturing may be used to identify an ongoing source of the outbreak organism. Culture swabs, usually pre-moistened with liquid culture media or phosphate buffered saline, and water source samples collected in sterile test tubes, can be obtained from the suspect environment or equipment. However, the recovery of *Acinetobacter* using the swabbing method has been suggested to be sub-optimal, and the use of pre-moistened sterile gauze pads,[9] or "sponge sticks" prepackaged in neutralizing buffer have been reported to maximize chance of recovery from environmental/equipment surfaces and crevices.[10]

Genotypic Testing of *Acinetobacter*

MDR Ab that has been isolated from clinical or surveillance culture may be saved by the microbiology laboratory for possible additional analysis. The IP should know the capability of the laboratory used by the facility for storing and strain testing during outbreaks. If this option is not available, the IP should know what contacts to make to accomplish this in the event of outbreaks. When characterizing endemic *Acinetobacter*, identifying a common source of contamination, and/or in outbreak situations, specialized laboratory testing may be of great value. Although not normally available in hospital laboratories, strain typing (serotyping, multilocus enzyme electrophoresis) or DNA-based methodologies (such as polymerase chain reaction, ribotyping, or pulse field gel electrophoresis) may be available from public health, university-based, or reference laboratories. It is beyond the scope of this guide to review these techniques, but many references are available to guide the laboratorian and IP when further characterization is needed.[11,12,13,14]

Epidemiology

Acinetobacter species are widely distributed in nature and are recoverable readily from moist and dry surfaces. *Acinetobacter* can be found in soil, sewage, water, consumables (including fruits and vegetables), and on healthy skin and other body sites. The organism is relatively resistant to low humidity (drying) conditions and has been shown to be readily recoverable from dry environmental niches.[15,16] *A. baumannii*, a species often identified in healthcare infections and outbreaks, can remain viable in dry environmental conditions for a few weeks to a month or more.[2]

Community-acquired pneumonia and other infections (meningitis, cellulitis, bacteremia) due to *Acinetobacter* have been noted and, in some instances, may be related to underlying conditions (e.g., alcoholism, diabetes, cancer).[17,18,19] *Acinetobacter* infections during wartime (e.g., Korean and Vietnam wars) and during times of natural disasters have been previously described.[20,21] In the recent decade, infectious complications have occurred in soldiers acquiring *Acinetobacter* from the environment or during hospitalization in non-native locales. This became apparent with the increase in wound and other infections caused by multidrug-resistant strains of this organism in troops wounded and treated while in Iraq, Kuwait and Afghanistan. Wounded troops, upon return to their native countries, have received care in facilities (hospitals, rehabilitation centers)—some of which experienced subsequent outbreaks and, as a result, established endemicity with a transplanted multidrug-resistant strain in some of these settings.[22,23,24,25]

Acinetobacter from a healthcare environment may be acquired as a colonizer of healthy or non-immunocompromised individuals, or as opportunistic pathogens of compromised and debilitated patients. In a prospective five-month study by Corbella et al.[26], cultures of axilla, rectal and pharyngeal areas were obtained from patients in a critical care unit. In more than half of the 73 patient cohort, screening cultures became positive (time of "onset" from <48 hours up to 1 week). In nearly one-third of the cohort, *Acinetobacter* was subsequently isolated from clinical cultures. The study authors identified the digestive tract as a significant reservoir of Acinetobacter acquired in that healthcare setting.

Clinical infection with *Acinetobacter* in healthcare settings often relate to invasive procedures and underlying or debilitating conditions. Prior antibiotic use, prolonged hospitalization, high APACHE II score, colonization pressure (a unit with high incidence of *Acinetobacter*), and enteral feeding have all been implicated in risk of *Acinetobacter* infection.[2,17] Hospital-associated *Acinetobacter* respiratory tract infections, including ventilator-associated pneumonia, urinary tract infection related to urinary catheters, bloodstream infections, and wound infections have all been well documented in medical literature.[27,28] In addition, there have been reports of *Acinetobacter* meningitis, endocarditis, osteomyelitis, and corneal perforation and infection associated with peritoneal dialysis.

The distribution and types of infections caused by *Acinetobacter* also can show variation per location and by seasonality.[2] The SENTRY report of 2001 validated the geographic differences across the world for endemic strain and antimicrobial resistance to the most frequently chosen antimicrobials (carbapenems, fluoroquinolones, and aminoglycosides).[29,30] Antibiograms at the facility and local levels can be expected to be unique to the source, and should be maintained and updated in order to assist providers caring for patients with *Acinetobacter* infections.

As an environmental organism, it is not difficult to understand that *Acinetobacter* transmission in healthcare settings has an environmental component. The ability of *Acinetobacter* to participate in biofilm formation promotes durability in and on surfaces and may contribute to continuation of environmental sources during outbreaks.[31,32]

Contamination in healthcare environments has been identified on many surfaces and equipment, including suctioning equipment, washbasins, bedrails, bedside tables, ventilators, sinks, pillows, mattresses, hygroscopic bandages, resuscitation equipment, and trolleys.[17] The hands of healthcare workers frequently touch these objects in patient environments. Hands become the vectors of transmission if scrupulous compliance to all components of applicable Standard Precautions and Transmission-based Precautions are not applied.[2]

There has been a published report of a healthcare worker exposure to MDR Ab that resulted in clinical pneumonia.[33] Prevention of exposures requires strict compliance to the use of personal protective equipment (PPE) to prevent exposure and transmission.

Pathogenicity

Acinetobacter spp. can colonize almost any human body site either transiently or as normal flora. *A. baumannii* is an emerging opportunistic pathogen in healthcare settings, and its presence can signify important pathology when identified in clinical culture, especially in an immunocompromised patient. Host contributions to pathogenicity include a history of alcoholism, smoking, and chronic lung disease.[34] Invasive procedures such as mechanical ventilation, catheters (bloodstream and urinary) and surgery are well characterized predisposing events. *Acinetobacter* can cause suppurative infection in any organ or tissue, and in the lungs, has been associated with multilobar infection, cavitation, and pleural effusion.[35]

Inherent bacterial virulence factors are not well elucidated, although it is known that the organism is encapsulated, which may enable it to "escape" phagocytosis, and the production of an exopolysaccharide protects it from other innate immune mechanisms.[7] The ability of this organism to participate in biofilms at epithelial cell interfaces, and its innate iron acquisition systems for survival in a host's iron-poor environment also contribute to its pathogenicity.[32,36]

A. baumannii infections are even more difficult to manage when the infecting strain exhibits multidrug resistance. In recent decades, carbapenem resistance has been one of the main challenges in managing *Acinetobacter* healthcare-associated infections.[27,29,30] In addition, there have recently been reports of outbreaks with pan-resistant *A. baumannii* (additional resistance to polymyxin and colistin).[30,37,38]

A major resistance factor is the intrinsic carbapenem-hydrolyzing oxacillinase enzyme, causing resistance to carbapenems and penicillins. The expression of this resistance may vary. Additional drug resistance strategies of drug-resistant *Acinetobacter* strains include porins, pencillin-binding protein modifications, aminoglycoside-modifying enzymes, plasmid-mediated quinolone resistance, and an efflux pump mechanism.[39] Susceptibility testing of *Acinetobacter* isolates is an essential component of clinical culture that can assist decisions regarding appropriate treatment and prevention of treatment failure.

Laboratory Considerations References

[1] Schreckenberger PC, Daneshvar MI, Weyant RS, Hollis DG. *Acinetobacter, Achromobacter, Chryseobacterium, Moraxella,* and other nonfermentative gram-negative rods. In: Murray PR, Baron EJ, Jorgensen JH, Pfaller MA, Yolken RH, editors. Manual of clinical microbiology. 8th ed. Washington, DC: American Society for Microbiology Press, 2007:770–779.

[2] Fournier PE, Richet H. The epidemiology and control of *Acinetobacter baumannii* in health care facilities. Clin Infect Dis. 2006 Mar 1;42(5):692–699.

[3] Tega L, Raieta K, Ottaviani D, Russo GL, Blanco G, Carraturo A. Catheter-related bacteremia and multidrug-resistant *Acinetobacter lwoffii* [letter]. Emerg Infect Dis. [serial on the Internet]. 2007 Feb. Available at: http://www.cdc.gov/EID/content/13/2/355.htm

[4] Ku SC, Hsueh PR, Yang PC, Luh KT. Clinical and microbiological characteristics of bacteremia caused by *Acinetobacter lwoffii*. Eur J Clin Microbiol Infect Dis. 2000;19:501–505.

[5] Turton JF *et al.* Identification of *Acinetobacter baumannii* by detection of the *bla*OXA-51-like carbapenemase gene tntrinsic to this species. J Clin Microbiol. 2006;44(8):2974–2976.

[6] Clinical and Laboratory Standards Institute. Performance Standards for Antimicrobial Susceptibility Testing; Nineteenth Informational Supplement. CLSI document M100-S19. 2009. Available at: http://www.clsi.org/source/orders/free/m100-s19.pdf

[7] Peleg AY, Seifert H, Paterson DL. *Acinetobacter baumannii*: Emergence of a successful pathogen. Clin Microbiol Rev. 2008 Jul;21(3):538–582. Available at: http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=2493088&blobtype=pdf

[8] Marchaim D, Navon-Venezia S, Schwartz D, Tarabeia J, Fefer I, Schwaber MJ, Carmeli Y. Surveillance cultures and duration of carriage of multidrug-resistant *Acinetobacter baumannii*. J Clin Microbiol. 2007 May;45(5):1551–1555. Epub 2007 Feb 21. Available at: http://www.pubmedcentral.nih.gov/picrender.fcgi?artic=1865886&blobtype=pdf

[9] Corbella X, Pujol M, Argerich MJ, Ayats J, Sendra M, Peña C, Ariza J. Environmental sampling of *Acinetobacter baumannii*: Moistened swabs versus moistened sterile gauze pads. Infect Control Hosp Epidemiol. 1999 Jul;20(7):458–460.

[10] Linda K. Goss, MSN, ARNP, CIC, COHN-S, University of Louisville Hospital/Infection Control, Louisville, KY, personal communication, July 8, 2009.)

[11] Saeed, S, Fakih G, Riederer K, Shah AR, Khatib R. Interinstitutional and intrainstitutional transmission of a strain of *Acinetobacter baumannii* detected by molecular analysis: comparison of pulsed-field gel electrophoresis and repetitive sequence-based polymerase chain reaction. Infect Control Hosp Epidemiol. 2006;27:981–983.

[12] Ecker JA, Massire C, Hall TA, *et al.* Identification of *Acinetobacter* species and genotyping of *Acinetobacter baumannii* by multilocus PCR and mass spectrometry. J Clin Microbiol. 2006 Aug;44(8):2921–2932.

[13] Valentine SC, Contreras D, Tan S, Real LJ, *et al.* Phenotypic and molecular characterization of *Acinetobacter baumannii* clinical isolates from nosocomial outbreaks in Los Angeles County, California. J Clin Microbiol. 2008 Aug;46(8):2499–2507.

[14] Tenover FC, Arbeit RD, Goering RV, Mickelsen PA, Murray BE, Persing DH, Swaminathan B. Interpreting chromosomal DNA restriction patterns produced by pulsed-field gel electrophoresis: criteria for bacterial strain typing. J Clin Microbiol. 1995 Sept;33(9):2233–2239.

[15] Wendt C, Dietze B, Dietz E, Rüde H. Survival of *Acinetobacter baumannii* on dry surfaces. J Clin Microbiol. 1997 Jun;35(6):1394–1397.

[16] Jawad A, Seifert H, Snelling AM, Heritage J, Hawkey PM. Survival of *Acinetobacter baumannii* on dry surfaces: comparison of outbreak and sporadic isolates. J Clin Microbiol. 1998 Jul;36(7):1938–1941.

[17] Joly-Guillou ML. Clinical impact and pathogenicity of *Acinetobacter*. Clin Microbiol Infect. 2005 Nov;11(11):868–873.

[18] Anstey NM, Currie BJ, Hassell M, Palmer D, Dwyer B, Seifert H. Community-acquired bacteremic *Acinetobacter* pneumonia in tropical Australia is caused by diverse strains of *Acinetobacter baumannii*, with carriage in the throat in at-risk groups. J Clin Microbiol. 2002 Feb;40(2):685–686.

[19] Falagas ME, Karveli EA, Kelesidis I, Kelesidis T. Community-acquired *Acinetobacter* infections. Eur J Clin Microbiol Infect Dis. 2007 Dec;26(12):857–868.

[20] Murray CK, *et al. Acinetobacter* infection: what was the true impact during the Vietnam conflict? Clin Infect Dis. 2006;43:383–384.

[21] Oncül O, *et al.* Hospital-acquired infections following the 1999 Marmara earthquake. J Hosp Infect. 2002 May;51(1):47–51.

[22] Sebeny PJ, Riddle MS, Petersen K. *Acinetobacter baumannii* skin and soft-tissue infection associated with war trauma. Clin Infect Dis. 2008 Aug 15;47(4):444–449.

[23] Davis KA, Moran KA, McAllister CK, Gray PG. Multidrug-resistant *Acinetobacter* extremity infections in soldiers. Emerg Infect Dis. [serial on the Internet]. 2005 Aug;11:1218–1224. Available at: http://www.cdc.gov/ncidod/eid/vol11no08/05-0103.htm

[24] Centers for Disease Control and Prevention (CDC). *Acinetobacter baumannii* infections among patients at military medical facilities treating injured U.S. service members, 2002-2004. MMWR Morb Mortal Wkly Rep. 2004 Nov;53(45):1063–1066.

[25] Turton JF, *et al.* Comparison of *Acinetobacter baumannii* isolates from the United Kingdom and the United States that were associated with repatriated casualties of the Iraq conflict. J Clin Microbiol. 2006 July;44(7):2630–2634.

[26] Corbella X, *et al.* Epidemiological significance of cutaneous, pharyngeal, and digestive tract colonization by multiresistant *Acinetobacter baumannii* in ICU patients. J Hosp Infect. 1997 Dec;37(4):287–295.

[27] Maragakis LL, Perl TM. *Acinetobacter baumannii*: epidemiology, antimicrobial resistance, and treatment options. Clin Infect Dis. 2008 Apr 15;46(8):1254–1263.

[28] Villegas MV, Hartstein AI. *Acinetobacter* outbreaks,1977-2000. Infect Control Hosp Epidemiol. 2003 Apr;24(4):284–295.

[29] Gales AC, Jones RN, Forward KR, Linares J, Sader SH, Verhoef J. Emerging importance of multidrug-resistant *Acinetobacter* species and *Stentrophomonas maltophilia* as pathogens in seriously ill patients: geographic patterns, epidemiological features and trends in the SENTRY Antimicrobial Surveillance Program (1997–1999). Clin Infect Dis. 2001;32(Suppl 2):104–113. Available at: http://www.journals.uchicago.edu/doi/pdf/10.1086/320183

[30] Van Looveren M, Goossens H. ARPAC Steering Group. Antimicrobial resistance of *Acinetobacter* spp. in Europe. Clin Microbiol Infect. 2004 Aug;10(8):684–704.

[31] Tomaras AP, Dorsey CW, Edelmann RE, Actis LA. Attachment to and biofilm formation on abiotic surfaces by *Acinetobacter baumannii*: Involvement of a novel chaperone-usher pili assembly system. Microbiology. 2003 Dec;149(Pt 12):3473–84

[32] Lee HW, Koh YM, Kim J, Lee JC, Lee YC, Seol SY, Cho DT, Kim J. Capacity of multidrug-resistant clinical isolates of *Acinetobacter baumannii* to form biofilm and adhere to epithelial cell surfaces. Clin Microbiol Infect. 2008 Jan;14(1):49–54. Epub 2007 Nov 13.

[33] Whitman TJ, *et al.* Occupational transmission of *Acinetobacter baumannii* from a United States serviceman wounded in Iraq to a health care worker. Clin Infect Dis. 2008 Aug 15;47(4):439–443.

[34] Talbot GH, Bradley J, Edwards JE Jr., Gilbert D, Scheld M, Bartlett JG. Bad bugs need drugs: an update on the development pipeline from the Antimicrobial Availability Task Force of the Infectious Diseases Society of America. Clin Infect Dis. 2006 Mar 1;42(5):657–658. Epub 2005 Jan 25.

[35] Urban C, Sega-Maurer, Rahal JJ. Considerations in control and treatment of nosocomial infections due to multidrug-resistant *Acinetobacter baumannii*. Clin Infect Dis. 2003 May 15;36(10):1268–1274. Epub 2003 May 1.

[36] Dorsey CW, Tomaras AP, Connerly PL, Tolmasky ME, Crosa JH, Actis LA. 2004. The siderophore-mediated iron acquisition systems of *Acinetobacter baumannii* ATCC 19606 and *Vibrio anguillarum* 775 are structurally and functionally related. Microbiology. 2004;150:3657–3667.

[37] Hsueh PR, Teng LJ, Chen CY, Chen WH, Yu CJ, Ho SW, *et al.* Pandrug-resistant *Acinetobacter baumannii* causing nosocomial infections in a university hospital, Taiwan. Emerg Infect Dis. 2002;8:827–832.

[38] Valencia R, Arroyo LA, Conde M, Aldana JM, Torres MJ, Fernández-Cuenca F, Garnacho-Montero J, Cisneros JM, Ortíz C, Pachón J, Aznar, J. Nosocomial outbreak of infection with pan-drug-resistant *Acinetobacter baumannii* in a tertiary care university hospital. Infect Control Hosp Epidemiol. 2009 Mar;30(3):257–263.

[39] Bonomo RA, Szabo D. Mechanisms of Multidrug Resistance in *Acinetobacter* Species and *Pseudomonas aeruginosa*. Clin Infect Dis. 2006;43:S49–S56.

Risk Assessment

The purpose of a risk assessment is to evaluate the degree or magnitude of pathogen transmission or hospital association infection risk within the facility.[1] The completed risk assessment is used to develop facility and unit-specific strategies to reduce transmission and infection risk to patients/residents, staff and visitors. This requires consistent surveillance, ongoing monitoring, effective policies and protocols, and enhanced interventions when appropriate.

Key Concepts

- The risk assessment is a part of the infection prevention and control program's assessment of the potential for the spread of infection in the facility.
- Risk assessment is based on identified risk group/population/location, surveillance data evaluation, prevalence calculations, and incidence rates.
- The risk assessment is reviewed and updated annually.
- The risk assessment identifies the appropriate data collection for the facility.
- Data collection is ongoing so that trends in transmission and/or infections are monitored and investigated promptly.
- Evaluation of risk assessment data is linked to clearly defined outcome or process measures for the management of MDR Ab in the facility.

Background

Performing a risk assessment is an important first step in determining organism prevalence, transmission level and unique risk factors within a facility. A facility's infection prevention and control program must have a system to monitor and investigate causes of healthcare-associated infection and community-acquired infection, as well as the manner of spread or transmission of infections within the facility. An effective program will provide timely recognition and analysis of infection clusters and increases in incidence, identify changes in prevalence of organisms, and conduct an annual risk assessment based on facility data[2]. Surveillance data collected to monitor and investigate infections in the facility provides the basis of the risk assessment.

- The HICPAC guideline "Management of Multidrug-Resistant Organisms (MDRO) in Healthcare Settings, 2006"[3] recommends monitoring trends in the incidence of a target MDRO. Surveillance is consistently performed over time and surveillance data is evaluated using appropriate statistical methods. This assessment results in accurate data analysis that can demonstrate trends in resident acquisition of these organisms and in rates of infection.
- The HICPAC MDRO guideline also recommends intensified interventions to prevent MDRO transmission and infection when the incidence or prevalence of MDROs are not decreasing despite implementation of, and correct adherence to, the routine control measures. Surveillance during a period of intensified infection prevention interventions will demonstrate whether the strategies implemented are effective.

Organism Risk—Location-specific Factors

Acinetobacter geographic data related to risk groups or populations may be available from local public health department surveillance or investigations. Other sources of location or population specific factors may be found in published data from facilities of similar demographic and geographic characteristics. When available, this data

may help in identifying possible high-risk groups, populations or services of relevance to a given facility. In some instances, a facility will identify a risk group while investigating a cluster of cases (for example, long-term ventilator patients admitted from an LTAC) to include in the risk assessment for this organism.

Risk—Patient-specific Factors

In their review of healthcare-associated *Acinetobacter*, Fournier and Richet identified the following as risk factors for epidemic *A. baumannii* infections and/or colonizations: High APACHE II score, enteral feeding, prematurity, length of stay, contaminated parenteral solutions, blood products administration, stay in ward with high *Acinetobacter* endemicity, high ward workload, previous antibiotic treatment (carbapenems, fluoroquinolones, third generation cephalosporins, aminoglycosides, and procedures such as surgery, ventilation, and use of catheters.[4] Ongoing surveillance of sporadic, endemic, and outbreak situations should include identification of patients, and known or suspected risk factors. These findings are included in the *Acinetobacter* risk assessment.

Performing the Risk Assessment

Preparation for the risk assessment requires identifying and obtaining:

- Administrative support
- Facility technical support
- Resources such as laboratory and pharmacy capabilities
- Infection prevention and control staffing (FTE) and/or hours assigned to infection prevention and control
- Public health support as applicable
- Current infection prevention and control interventions (e.g., hand hygiene, contact precautions, etc.)
- Measurement parameters for the current interventions
- Comprehensive line list of identified colonized and infected patients

The baseline determination of the risk for the facility may start with known high-risk populations, but the ongoing facility surveillance may detect other risk groups. This information is used to validate and, when appropriate, to enhance the facility's surveillance prevention and control program. After the baseline is determined, surveillance and data evaluation is ongoing and provides the comparative basis for annual assessment, trends, and identification of outbreaks.

Developing Risk Assessment Outcomes and Measures

When the facility risk assessment shows that transmission and/or infection rates are increasing, additional infection prevention interventions should be implemented. Consequently, an important aspect of the infection prevention plan is the choice of appropriate and quantifiable outcomes or goals. Clear expectations of the infection prevention plan implementation must be expressed in measurable terms.

Example of outcome measure:

- decrease healthcare-associated *Acinetobacter* infections in the ventilator unit by X% in the next six months

Example of process measure:

- increase compliance with Contact Precautions on the ventilator unit to the __% level as measured by the monthly isolation compliance monitor

Standardizing Data Collection

Data collection necessary for the outcome or process measurements must be clear and appropriate for the measure. A staff team responsible for data collection needs to be well educated about the collection process. Standardize the process so that data collection is consistent and accurate.[5]
(See Surveillance section.)

Taking Actions Based on Findings

Once the data is collected and evaluated, results of outcomes and process measures must be shared with key stakeholders. Involve key stakeholders in identifying and implementing interventions when the results indicate a need to improve rates or stop an outbreak. Once the interventions have been implemented, reanalyze to determine the success of the interventions and, if needed, implement additional interventions to improve the process as necessary.

Recommendations

Using the facility-specific *Acinetobacter* risk assessment:

- Establish baseline prevalence and, when applicable, incidence rates for the whole facility or for a specific unit using available data (clinical culture, history, screening culture)
- Identify high-risk populations and/or units based on incidence rates, local demographic risk data, or known risk factors from scientifically based evidence
- Evaluate data over time for the facility and/or specific units to characterize prevalence or transmission rates
- Identify clusters in transmission in risk populations and/or units to determine if enhanced interventions may be appropriate
- Based on surveillance and risk assessment, finalize, implement, and reanalyze based on an intervention plan developed with key stakeholders

Risk Assessment References

[1] Lee TB, Montgomery OG, Marx J, Olmsted RN, Scheckler WE. Recommended practices for surveillance: Association for Professionals in Infection Control and Epidemiology (APIC), Inc. Am J Infect Control. 2007;35(7):427–440.

[2] Arias,K , Soule,B. eds. Infection Prevention and Control Workbook, 2nd ed. Joint Commission. 2010.

[3] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S165–193.

[4] Fournier PE, Richet H. The Epidemiology and Control of *Acinetobacter baumannii* in Health Care Facilities. Clin Infect Dis. 2006 Mar 1;42(5):692–699.

[5] Cohen AL, *et al.* Recommendations for metrics for multidrug-resistant organisms in healthcare settings. SHEA/HICPAC Position Paper. Infect Control Hosp Epidemiol. 2008;29(10):901-913. Available at: http://www.journals.uchicago.edu/doi/pdf/10.1086/591741

Surveillance

The surveillance program for MDR Ab provides the definitions, measurements and data analysis needed to evaluate the success of infection prevention and control programs and of any appropriate intensified interventions taken to eliminate the transmission of MDR Ab.

MDR Ab Surveillance Basics

Surveillance requires an organized process of collecting, tabulating and consolidating data. The collected information is then evaluated, analyzed and reported to the appropriate persons, committees and/or government agencies as necessary. The elements of a routine surveillance program include:[1,2]

- Selection of surveillance methodology (laboratory results, observational monitor, etc.)
- Definition of the population(s) to be studied
- Choice of the outcome or process to monitor
- Selection of time period
- Selection of surveillance definitions
- Selection of data elements to be collected
- Choice of methods for data analysis
- Development of methods for data collection and management
- Identification of key stakeholders to receive surveillance report
- Development of written surveillance plan

MDR Ab Surveillance Methodology is targeted (focused) surveillance.[3]

Population is the complement of patients in the healthcare setting(s) being surveyed.
Indicator/monitor is MDR Ab infection and colonization in the healthcare population.
Time period must be sufficient to accrue an adequate number of cases for a valid analysis.
Surveillance criteria include the case definition and definitions of the numerator and denominator for the rate calculations.

Surveillance criteria must be clear and consistent throughout the surveillance period. Any change in definitions will affect the data by preventing accurate comparison to previously gathered data. Examples of changes that could affect surveillance include instituting a new active surveillance culture program, closure or merging of a patient unit, and/or change in the sensitivity or specificity of MDR Ab testing methods. Evaluation of MDR Ab surveillance must take into account any changes that have occurred.

MDR Ab Case Definition: Any patient/resident with a positive laboratory culture, or history of a positive laboratory culture, for Multidrug-resistant *Acinetobacter baumannii*. (See definitions.)

Document each case in MDR Ab surveillance records. Commonly used documentation methods include recording of cases on the MDR Ab Line Listing (see Appendix A: Multidrug-resistant *Acinetobacter baumannii* Surveillance Line Listing) or case entry in electronic surveillance software.[4]

Incidence Surveillance

Numerator: Number of newly identified patients with MDR Ab who meet the case definition.

Sample case definition for surveillance in a unit: MDR Ab isolated from culture obtained greater than or equal to 72 hours after admission to the unit, no history, and the patient was not incubating at the time of admission

Denominator: The denominator can be derived from average daily census for indicated timeframe in the facility or unit being monitored, and is often calculated per 1,000 patient days.

$$\frac{\text{\# of new MDR Ab identified patients on the unit during the month}}{\text{\# of patient days on the unit/month} \times 1{,}000}$$

= incidence of healthcare-associated MDR Ab rate per 1,000 unit patient days

NOTE: In an outpatient population or ambulatory setting, use the following formula:

# of new infections / 1,000 ***patient visits***

Data elements for MDR Ab Surveillance

Data elements include demographic and personal information that will be useful in characterizing MDR Ab cases.[4] (See Appendix A.)

These elements include patient age and sex, admission date, location/room number, location from which the patient was admitted (another hospital, LTC healthcare setting, LTAC, home, ambulatory setting, dialysis, etc.), onset date or first positive culture date(s), culture source(s) and site(s), antibiotic susceptibility patterns and presence of known MDR Ab risk factors as published in the literature.

Other MDR Ab surveillance data elements to be collected may include procedures performed, use of invasive devices, underlying conditions and diseases, colonization status (if known), and clinical signs and symptoms of infection. Information related to known or suspected MDR Ab risk factors for a certain geographic region or demographic population (e.g., hemodialysis patients, ventilator units, wound care units, etc.) should also be collected.

Methods of data collection may be real time or retrospective. Most data collection is a function of identification of MDR Ab from clinical culture, MDR Ab surveillance culture, or PCR testing if available. Additional data from enhanced surveillance includes pulsed field gel electrophoresis (PFGE) information on isolates or other genotypic laboratory analysis, and antimicrobial susceptibility testing per isolate as appropriate per antibiogram analyses.

Surveillance Data Management

Maintain a line listing or other data management system for all patients identified with MDR Ab. The line listing should contain all of the elements listed above in the Data Elements section.[5]

Essential Notification of positive MDR Ab from Culture or History

"Flagging" of MDR Ab-positive patients is an important component of MDR Ab surveillance programs, and is a tier 1 surveillance recommendation in the HICPAC 2006 MDRO guideline. Laboratories should have an alert

notification methodology for MDR Ab that includes the IP as well as the patient's healthcare provider(s). An immediate alert of MDR Ab history is essential at time of admission and at the time of transfer to another patient unit, another service or a different healthcare setting.

Facilities using electronic medical records may have programs that automatically flag MDR Ab patients on admission. Facilities that do not have access to an electronic flagging system should develop an admission process feature that will identify a patient with an MDR Ab history. There should also be a transfer communication system that notifies transferring facilities of positive MDR Ab patients/residents. Some hospitals and long-term care facilities have had success with a notification box on a transfer sheet that notes MDROs, including MDR Ab. Other facilities have a "phone tree" to facilitate phone/e-mail communication between infection prevention departments.

MDR Ab Reports

The IP should collaborate with the laboratory regarding MDR Ab result notification.[6] Laboratory reports of MDR Ab must clearly identify the isolate as "multidrug-resistant" in addition to including a susceptibility report as appropriate to the culture methodology. Communication regarding positive cultures may also include predetermined comments regarding the infection prevention intervention to use for patients with MDR Ab, and the instructions for notifying the clinical unit or medical provider.

Surveillance References

[1] Lee TB, Montgomery OG, Marx J, Olmsted RN, Scheckler WE. Recommended practices for surveillance: Association for Professionals in Infection Control and Epidemiology (APIC), Inc. Am J Infect Control. 2007;35(7):427–440.

[2] Arias, Kathleen. Surveillance. APIC *Text of Infection Control and Epidemiology. 3rd ed.* Washington, DC: Association for Professionals in Infection Control and Epidemiology, Inc. 2009: Chapter 3 1–17

[3] Perl, T, Pottinger, J. Herwalt, L. Basics of Surveillance: An Overview. Lautenbach,E. Woeltje, K eds. Practical Handbook for Healthcare Epidemiologists. 2nd ed. Thorofare, NJ. Slack.2004:45–66

[4] Siegel JD, Rhinehart E, Jackson M, Linda C. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Available online at www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf.

[5] Cohen AL, *et al.* Recommendations for metrics for multidrug-resistant organisms in healthcare settings. SHEA/HICPAC Position Paper. Infect Control Hosp Epidemiol. 2008; 29(10):901–913. Available at: http://www.journals.uchicago.edu/doi/pdf/10.1086/591741

[6] Arias, Kathleen, eds. Surveillance Programs in Healthcare Settings. 2nd ed. Washington,DC APIC, 2009

Antibiotic Stewardship and Antibiograms

Key Concepts

- Antibiotic use, whether clinically appropriate or not, unavoidably introduces a selective survival advantage to non-susceptible strains of microbes and leads to development/expression of antibiotic resistance.
- The pace of development of new antibiotics is not keeping up with the pace of emergence of antibiotic-resistant strains.
- A multifaceted antibiotic stewardship initiative is seen as a contributory element in the fight to prevent emergence of antibiotic resistant strains and to preserve existing therapeutic options for treating infections.
- Antibiograms are used to assess changes in multidrug resistance of MDR Ab isolates from specific facilities or units, and to provide data for antimicrobial stewardship initiatives.

Overview

Like all living entities, microbes continuously face challenges to their own survival as conditions in their environment or ecosystem change. They are constantly subjected to survival selection pressure in a true Darwinian sense, and in order to survive, they acquire, develop or evolve specific coping mechanisms that give them a selective advantage *vis-a-vis* their competition.

Unlike many living entities; however, microbes have an evolutionary advantage, in that their "life cycle" is often very short and they have a seemingly infinite number of opportunities for even a single advantageous genetic mutation to occur. In addition, microbes have often been found capable of acquiring or sharing extra-chromosomal genetic material, including antibiotic-resistance factors, between related and unrelated species through a variety of mechanisms. This genetic "nimbleness" enables microbes to respond very quickly to changes in their environment that adversely affect their survival. In the context of healthcare settings and patient care in general, the presence of infection or colonization, followed by antibiotic therapy, represents a significant change in the ecosystem that can trigger the development or emergence of resistant strains in response. Thus, the use of antibiotics may have certain unintended consequences, and decisions regarding the use of antibiotics should be approached with consideration of both the benefit to the patient and the potential adverse consequences.

Experts in infectious diseases, clinical pharmacy, infection prevention and clinical microbiology have long promoted effective antibiotic stewardship as one tool to prevent or delay the emergence of antibiotic-resistant organisms. The key elements or strategies of an antibiotic stewardship program were described by Fishman[1] and are summarized below:

Elements of Antibiotic Stewardship

Education

Physician/prescriber education regarding the compelling rationale for antibiotic stewardship and the various elements of the stewardship program as they apply to antibiotic use is essential to the success of the program. Prescriber education can take place through both formal and informal channels and can include internal fliers, such as a "Pharmacy Newsletter", direct one-on-one consultative sessions, presentations at section meetings and the development and dissemination of written prescribing guidelines.

Formulary Restriction

Use of a closed formulary, that is, one in which only certain drugs are available for physicians to prescribe, is a highly effective tool in antibiotic stewardship. Formulary choices should be made in consideration of local antibiotic resistance trends in addition to site and pathogen-specific incidence data. These trends should be continuously monitored and recorded in an antibiogram, and the formulary should be periodically adjusted as conditions warrant. However, even a restricted formulary will include broad spectrum antibiotics with a concomitant potential for their misuse, especially in cases of empiric treatment awaiting culture and sensitivity results. There should be a mechanism in place to facilitate reconciliation of empiric therapy with subsequent culture and sensitivity results, and opportunities to switch to a narrower spectrum antibiotic should be promoted.

Prior Approval Programs

These programs require the prescribing physician to obtain some form of approval or permission before the antibiotic will be dispensed. This approach may require a verbal communication to justify a proposed treatment, or it may involve pre-printed order forms, automatic stop orders, etc. Prior approval programs are the most restrictive of control systems as well as one of the more cost effective approaches to antibiotic stewardship. In its most restrictive form, expert individuals who are familiar with the nuances of minimum inhibitory concentration (MIC) interpretation, the pathogens and drug tissue availability and pharmacokinetics serve as "gatekeepers." The benefits of prior approval programs include better control of antibiotic costs[2] and improved patient outcomes.[3]

Streamlining

This term refers to the automatic switching from broad-spectrum empiric therapy to narrower-spectrum agents when the culture and sensitivity results become available. With the growing integration of clinical information systems and data mining tools, pharmacy and laboratory data can often be merged and opportunities to adjust antibiotics, eliminate redundant therapies and change intravenous (IV) to oral (PO) administration routes can occur without active effort on the part of the clinician.

Antibiotic Cycling

This is the practice of rotating two or more classes of formulary drugs on a regular basis. Basically, by regularly altering the antibiotic selection pressure; the hope is to prevent microbes from having sufficient "incentive" and time to become resistant. Alternatively, in areas where resistance is already a problem, rotating antibiotics hypothetically removes the selective advantage the resistant organisms possess when compared to non-resistant strains. The more treatable, non-resistant strains will theoretically outdo the resistant strains. While there are some studies that tend to support antibiotic cycling as a means to control/slow the emergence of resistance, [4,5,6] this still remains controversial, as at least two mathematical models have suggested that antibiotic cycling is either ineffective[7] or may in fact lead to increased resistance.[8] Accordingly, if antibiotic cycling is used as a part of an overall antibiotic stewardship program, resistance data should be carefully monitored to facilitate early detection of undesired trends. Cycling is not routinely recommended. (see Guideline Recommendations for Antimicrobial Stewardship Programs)

Automated (Computer-assisted) Prescribing

The hospital's computer systems provide comprehensive information (and advice) to the clinician with respect to antibiotic selection and dosing by taking into consideration the patient's laboratory values (e.g., liver or renal function), their existing drug prescription profile and culture and sensitivity results.[9] This process requires data extraction and collation from the various clinical data bases and the application of pre-determined decision algorithms to support the recommendations. As these expert clinical systems evolve, computer-assisted prescribing may become more heavily relied upon by clinicians and, as a consequence, bring about less variation in antibiotic prescribing patterns.

Guideline Recommendations for Antimicrobial Stewardship Programs

The 2007 guideline from the Infectious Diseases Society of America (IDSA) and the Society for Healthcare Epidemiology of America (SHEA) recommends two core strategies for hospital antimicrobial stewardship programs:

- Prospective audit of antimicrobial use with direct interaction and feedback to the prescribing physician
- Formulary restriction and preauthorization requirements can lead to, significant reductions in antimicrobial use and may be beneficial as part of a response to a healthcare associated outbreak (B-III)

In addition, the guide proposes positive impact from any of a number of supplementary strategies, including education related to clinical treatment strategies, streamlining or de-escalating of empiric antibiotic therapy based on culture results, evidence-based practice guidelines derived from local organism-specific resistance patterns, antimicrobial order forms with automatic stops requiring physician justification for continuation, computer-assisted programs. The guide concludes that there is insufficient evidence to routinely recommend antibiotic cycling or combination therapy to prevent resistance at the present time.

MDR Ab Management and Antimicrobial Stewardship

It is unclear whether antibiotic control measures and stewardship can contribute directly to the elimination of an outbreak of MDROs or MDR-Ab. However, based on the contribution that the use of extended spectrum cephalosporins and quinolones have had on the development of antibiotic resistance in *Acinetobacter baumannii*[10], and the demonstrated control of *Clostridium difficile* infection achieved by restricting antibiotic usage[11] it is prudent to develop an antimicrobial stewardship plan in healthcare facilities. It is the normal role of the Pharmacy and Therapeutics Committee to establish the facility formulary, develop treatment protocols, and monitor drug utilization. In conjunction with the microbiology laboratory, infectious disease experts, and infection preventionists, a careful monitor for trends in increasing resistance in microbes may prevent or at least delay the rapid development of multi-drug resistance thus extending the useful life of currently available antibiotics.

Antibiogram: Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data

Susceptibility (Sensitivity/Resistance) Patterns

A reported susceptibility pattern for each MDR Ab isolate is essential. It should be readily and quickly accessible by physicians and caregivers. Not only are these data essential for patient treatment regimens, but they are also valuable in MDR Ab surveillance and in the epidemiologic investigation of outbreaks.

Antibiogram

Unlike the bacterial susceptibility of a single isolate, antibiograms are used to track changing sensitivity patterns and are based on collated susceptibility data from many isolates derived from patient clinical cultures. Compiling an antibiogram is usually done by the microbiology laboratory using data accrued from clinical culture in a facility or from a specific unit. For the *A.baumannii* antibiogram, susceptibility results from multiple (minimum of 30) *A. baumannii* isolates are compiled during a specified timeframe (usually one year) and updated at least annually. The resulting antibiogram reflects the antibiotic sensitivity patterns for *A. baumannii* within that facility or unit.

Antibiograms can be used by physicians to guide decisions regarding appropriate empiric antimicrobial treatment choices at times when a susceptibility report is not yet available. Just as important, they can be used by the infection preventionist to assess changes in *A. baumannii* antimicrobial resistance specific to the facility and/or to units, and provide data for antimicrobial stewardship initiatives.

The Clinical and Laboratory Standards Institute (CLSI) is a recognized authority in quality assurance of laboratory testing. Antibiograms must follow the standards that have been established by CLSI and published in CLSI M39-A2.[12]

References

[1] Fishman N. Antibiotic Stewardship. *Am J Infect Control* 2006;34:S55–63.

[2] John JF, Fishman NO. Programmatic role of the infectious diseases physician in controlling antimicrobial costs in the hospital. *Clin Infect Dis* 1997;24:471-485.

[3] Frank MO, Batteiger BE, Sorensen SJ, et al. Decrease in expenditures and selected nosocomial infections following implementation of an antimicrobial-prescribing improvement program. *Clin Perform Qual Health Care* 1997;5:180–188.

[4] Gerding DN, Larson TA. Aminoglycoside resistance in gram-negative bacilli during increased amikacin use. Comparison of experience in 14 United States hospitals with experience in the Minnesota Veterans Administration Medical Center. *Am J Med* 1985;79:1–7.

[5] Young EJ, Sewell CM, Coza MA, Clarridge JE. Antibiotic resistance patterns during aminoglycoside restriction. *Am J Med Sci* 1985;290:223–227.

[6] Raymond DP, Pelletier SJ, Crabtree TD, et al. Impact of a rotating empiric antibiotic schedule on infectious mortality in an intensive care unit. *Crit Care Med* 2001;29:1101–1108.

[7] Bergstrom Lo M, Lipsitch M. Ecological theory suggests that antimicrobial cycling will not reduce antibiotic resistance in hospitals. *Proc Natl Acad Sci* USA 2004;101:13285–90.

[8] Magee JT. The resistance ratchet: theoretical implementations of cyclic selection pressure. *J Antimicrobial Chemother* 2005;56:427-30.

[9] McGregor JC, Weekes E, Forrest GN, Standiford HC, Perencevich EN, Furuno JP, Harris AD. Impact of a Computerized Clinical Decision Support System on Reducing Inappropriate Antimicrobial Use: a Randomized Control Trial. *J Am Med Inform Assoc.* 2006 Jul–Aug;13(4):378–84.

[10] Fournier PE, Richet H. The Epidemiology and Control of Acinetobacter baumannii in Health Care Facilities. *Clinical Infectious Diseases* 2006;42:692–9.

[11] McNulty C, Logan M Donald IP, et al. Successful control of Clostridium difficile infection in an elderly care unit through use of a restrictive antibiotic policy. *J Antimicrobial Chemother* 1997;40:707–11.

[12] Clinical and Laboratory Standards Institute. Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data: Approved Guideline, 2nd ed. CLSI document M39-A2. Reston, VA: Clinical and Laboratory Standards Institute; 2005.

Standard and Transmission-based Precautions

The main goal of MDR Ab infection prevention and management program is the prevention of the transmission of MDR Ab in a healthcare setting. Using Transmission-based (Contact) Precautions in addition to Standard Precautions is an important component of the infection prevention intervention to reduce the risk of MDR Ab transmission within the healthcare setting.

Background

In 1996, the Centers for Disease Control and Prevention (CDC) developed an approach to reduce transmission of microorganisms. This approach—named "Standard Precautions and Transmission-based Precautions"—was based on elements of the previously established "Universal Precautions (UP)" and "Body Substance Isolation (BSI)" guidelines, but added an emphasis on an infection's mode of transmission, to enhance the isolation process. Standard Precautions instruct healthcare workers to protect themselves against all body fluids except sweat by use of PPE. Standard Precautions are always used, and Transmission-based Precautions are used as a supplement to address specific organisms. The HICPAC 2006 multidrug-resistant organism (MDRO) guideline[1] and the HICPAC 2007[2] guideline for isolation precautions continue to promote the use of Transmission-based Precautions as an appropriate approach to MDRO control.

Key Concepts

- Pathogenic organisms exist in reservoirs within a healthcare care setting.
- Pathogenic organisms have different modes of transmission.
- Techniques that impact transmission of MDR Ab must be implemented in the healthcare setting.
- Compliance with Standard Precautions and Transmission-based Precautions breaks the chain of infection by interrupting transmission of pathogenic organisms, including MDR Ab.

Modes of MDR Ab Transmission

The most common mechanism of transmission attributed to MDR Ab is contact transmission. Contact transmission is divided into two subgroups, direct and indirect.[3]

Direct transmission can occur when MDR Ab is transferred from an MDR Ab colonized or infected person to another person without a contaminated intermediate object or person.

Indirect transmission is the transfer of an infectious agent through a contaminated intermediate object or person.

In healthcare, transmission is most commonly associated with MDR Ab contaminated skin, body fluids, equipment, or environment. *Although anything that contacts a contaminated patient or object can be the source of transmission, the most common vehicles of MDR Ab spread in healthcare settings are the hands of healthcare staff.*

A. baumannii outbreaks often involve environmental contamination of items such as suctioning equipment, ventilators, shower trolleys, washbasins, infusion pumps, pillows and mattresses, bedrails, sinks, resuscitation equipment, bedside tables, hygroscopic bandages, and stainless steel carts.[4]

Hand Hygiene

Hand hygiene is the keystone of any infection prevention and control program, and plays an integral role in reducing the transmission and occurrence of infection. All healthcare settings must have a comprehensive hand hygiene program and policies and procedures in place. The importance of hand hygiene in the elimination of MDR Ab transmission should be greatly stressed to all hospital healthcare staff. It is strongly recommended that the IP review the following documents for information to create a comprehensive hand hygiene program:

- HICPAC "Guideline for Hand Hygiene in Healthcare Settings, 2002."[5]
- World Health Organization (2009) "WHO Guidelines on Hand Hygiene in Health Care." The guideline is meant to be used by healthcare facilities, managers, and developers of policies for institutions. The HICPAC "Guideline for Hand Hygiene in Healthcare Settings, 2002" was used as a basis for this document, with the addition of new topics and information.[3]
- The Joint Commission authored a monograph entitled "*Measuring Hand Hygiene Adherence: Overcoming the Challenges*." In collaboration with infection prevention organizations, including APIC, hand hygiene guidelines and strategies were reviewed to determine approaches for implementing and measuring adherence to hand hygiene compliance best practice. The monograph offers information on the issues involved in hand hygiene observation, presents examples of successful programs, and offers realistic solutions for improvement activities.[6]

Major components of a hand hygiene program[5]

1. Implement a hand hygiene program including all levels of healthcare providers and other patient contact workers.[7,8,9]
2. Educate visitors to wash their hands, or use an alcohol-based hand rub on entering and leaving the room.[3] (See Appendix B: Safe Donning and Removal of Personal Protective Equipment.)
3. Wear gloves for all contact with blood, body fluids and moist body surfaces.
   - Remove gloves after caring for patient, and use hand hygiene.
   - Change gloves when moving from a contaminated site to a clean site on the same patient.
   - Remove gloves and use hand hygiene before care of the next patient.
4. Always perform hand hygiene after removing gloves.[3]
5. Perform hand hygiene before and after contact with a patient.
6. Perform hand hygiene before and after contact with the patient's environment.
7. Monitor compliance with hand hygiene for all levels of staff. Provide feedback of compliance rates based on observations or volume of hand hygiene products used.[8,9,10,11]
8. Hold healthcare care providers and administrators accountable for implementing a culture that supports and promotes appropriate hand hygiene practices.[3,12,13,14]
9. Gloves[3,15] should be worn to protect against contact with body fluids.
   - HCWs should know how to properly don and remove gloves.
   - Gloves are removed and hand hygiene performed after caring for one patient before caring for another patient.
   - Gloves are changed when moving from a more contaminated area of a patient's body to a less contaminated area.
   - Gloves are not worn in the hall.
   - Gloves are removed and hand hygiene performed if gloves become torn or punctured.

There is no standardized method for monitoring hand hygiene compliance. There are many good resources that provide tools or forms for monitoring of hand hygiene. These forms can be customized for the facility and based on the monitoring system. It is important to monitor staff for hand hygiene compliance, post signs and reminders, have convenient hand hygiene stations and supplies available, and provide educational venues.[14,15,16]

Before touching a patient

1. Before clean/aseptic procedures
2. After body fluid exposure/risk
3. After touching a patient
4. After touching patient surroundings

Issues Associated with Hand Hygiene

Artificial Fingernails

Several studies have been done on the harboring of pathogens by artificial nails. There is evidence that wearing artificial nails can result in carriage of Gram-negative organisms and yeast.[17,18] It is recommended that persons giving patient care not wear artificial nails or extenders. Natural nails should be kept short, approximately ¼ inch long.[5]

Jewelry

Studies have shown increased presence of colonization of organisms under rings as compared to other areas of the hand without rings. Rings with rough surfaces may remain dirty in crevasses after washing hands; rings may tear gloves and may possibly injure patients during care. The consensus recommendation to healthcare settings is to strongly discourage the wearing of rings and jewelry when giving patient care.[19]

Patient Placement and Contact Precautions

In LTAC and LTCF settings, a patient with MDR Ab should be placed in a private room. If this option is not available, the patient should be cohorted with another patient infected with the same organism. If neither of these options are available, the patient should be placed in a room with another patient who is considered low risk for acquisition of MDR Ab. Examples would be patients with no wounds, no invasive devices, not immunocompromised, etc.[1]

- In hospitals and LTAC facilities, Contact Precautions are used for all patients identified as having MDR Ab infection or colonization.
- In LTCFs, the individual patient's clinical situation and the incidence of MDR Ab in the facility should be considered when deciding to implement or modify Contact Precautions.
- In ambulatory care settings and home care, use Standard Precautions.[1]

Basics of Contact Precautions

(See Appendix B)

- Don gloves before or immediately upon entry to room. Change gloves after contact with infectious material.
- Change gloves when moving from a contaminated body site to a clean body site.
- Remove gloves and decontaminate hands before leaving a patient's room.

- After glove removal and hand hygiene, ensure that hands do not touch potentially contaminated surfaces or items in the patient's room.
- Remove gloves and decontaminate hands before performing care for another patient.
- Don gowns before or immediately upon entry to the room/cubicle.
- Remove gloves before removing gown.
- After gown removal, ensure that hands and clothing do not contact potentially contaminated environmental surfaces or equipment.
- Ensure that hands/clothing do not become contaminated during removal.

Mouth, Nose, Eye Protection

- Wear masks, eye shields and/or goggles when performing procedures involving respiratory droplets and secretions, and in any situation where the potential for splashes or spray is present.
- Removing masks and face protection after removing gloves can be safely done if the clean parts (ties, straps) are the only things touched during removal.
- Perform hand hygiene.

Considerations When Patients on Contact Precautions Leave Their Rooms

- When an MDR Ab colonized or infected patient has uncontained drainage or body secretions, limit movement or transport of the patient from the room to essential purposes only.
- If patient must leave his or her room, ensure that precautions are maintained.
- Notify receiving department, unit, or common area of patient's isolation status prior to transporting the patient.
- Help patient to perform hand hygiene.
- Have patient wear clean clothing or patient gown.
- Adequately contain wounds or non-intact skin.
- For incontinent patients, ensure containment of urine or stool.
- After performing patient care activities, dispose of contaminated PPE and perform hand hygiene prior to transporting resident from the room.
- Ensure that clothing and skin do not contact potentially contaminated environmental surfaces—including the patient's wheelchair—that could result in possible transfer of the microorganism to other patients or environmental surfaces.
- Notify transport destination staff of arrival of patient on Contact Precautions.
- Don clean, appropriate PPE when directly assisting the patient at the transport destination.
- Ensure that transport destination staff members comply with the elements of Contact Precautions and environmental/equipment cleaning.

Linens and laundry

- Take care when handling linen so as not to aerosolize potential infective material.
- Bag linen at the bedside.

References

[1] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Am J Infect Control. 2007 Dec;35(10 Suppl 2): S165–193.

[2] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S65–164.

[3] WHO Guidelines on Hand Hygiene in Health Care. Geneva: World Health Organization. 2009

[4] Fournier PE, Richet H. The epidemiology and control of *Acinetobacter baumannii* in health care facilities. Clin Infect Dis. 2006 Mar 1;42(5):692–699.

[5] HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Guideline for Hand Hygiene in Health-Care Settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/ IDSA Hand Hygiene Task Force. MMWR Recomm Rep. 2002;51(RR16):1–45. Available at: http://www.cdc.gov/ncidod/ dhqp/g1_handhygiene.html

[6] Measuring hand hygiene adherence: overcoming the challenges. The Joint Commission. Observing Adherence to Hand Hygiene Guidelines. Chapter 3:21.

[7] Gordin FM, Schultz ME, Huber RA, Gill JA. Reduction in nosocomial transmission of drug-resistant bacteria after introduction of an alcohol-based hand rub. Infect Control Hosp Epidemiol. 2005;26:650–653.

[8] MacDonald A, Dinah F, MacKenzie D, Wilson A. Performance feedback of hand hygiene, using alcohol gel as the skin decontaminant, reduces the number of inpatients newly affected by MRSA and antibiotic costs. J Hosp Infect. 2004;56:56–63.

[9] Pittet D, Allegranzi B, Sax H, *et al.* Evidence-based model for hand transmission during patient care and the role of improved practices. Lancet Infect Dis. 2006;6:641–652.

[10] McGuckin M, Taylor A, Martin V, Porten L, Salcido R. Evaluation of a patient education model for increasing hand hygiene compliance in an inpatient rehabilitation unit. Am J Infect Control. 2004;32:235–238.

[11] McGuckin M, Waterman R, Storr J, *et al.* Evaluation of a patient-empowering hand hygiene programme in the UK. J Hosp Infect. 2001;48:222–227.

[12] Goldmann D. System failure versus personal accountability—the case for clean hands. N Engl J Med. 2006;355:121–123.

[13] Gawande A. On Washing Hands. N Engl J Med. 2004;350:1283–1286.

[14] Pittet D, Hugonnet S, Harbarth S, *et al.* Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Lancet. 2000;356:1307–1312.

[15] Institute for Healthcare Improvement. How-to guide: improving hand hygiene. A guide for improving practices among health care workers. Cambridge, MA: Institute for Healthcare Improvement. 2006. Available at: http://www.ihi.org/NR/ rdonlyres/E12206F9-6A81-4520-B92F-4BCB844133C2/3266/HandHygieneHowtoGuide.pdf

[16] University of Geneva Hospitals, Geneva. Switzerland Hand Hygiene Campaign. Swiss-NOSO (Nosokomiale Infektionen und Spitalhygiene). 2006. Available at: http://www.hopisafe.ch/next.html

[17] Pottinger J, Burns S, Manske C. Bacterial carriage by artificial versus natural nails. Am J Infect Control. 1989;17:340–344.

[18] Hedderwick SA, *et al.* Pathogenic organisms associated with artificial fingernails worn by health care workers. Infect Control Hosp Epidemiol. 2000;21:505–509.

[19] WHO Guidelines on Hand Hygiene in Health Care. Patient Safety. Geneva: World Health Organization. Practical issues and potential barriers to optimal hand hygiene practices. Chapter 23:132.

The Environment

Environmental and Equipment Cleaning and Disinfection

A. baumannii has emerged as an important healthcare-associated pathogen.[1] Hospitals have experienced outbreaks and, in some hospital settings, this organism has become endemic. Environmental contamination has a recognized role in the transmission of *A. baumannii* infections. In the event of an outbreak, environmental testing can be performed as a method to determine the spread or persistence of the organism and also the efficacy of the cleaning agent. Testing of the environment requires standardized methods of specimen collection and laboratory testing to facilitate identification of *A. baumannii* in the environment. Acinetobacter species are able to grow at various temperatures and pH conditions, which allows them to persist in either moist or dry conditions in the hospital healthcare environment.

Studies have shown that *A. baumannii* strains could be isolated from a hospital bed rail for nine days after the discharge of an infected patient.[2] In another study, Wendt et al. showed that *A. baumannii* strains isolated from dry sources had better survival rates than strains isolated from wet sources.[3] *Acinetobacter spp.* have been identified on some inanimate hospital objects for up to five months. Ventilators, suctioning equipment, mattresses, sinks and portable radiology equipment are some of the more common sources that remain colonized for extended periods.

Environmental Services

Cleaning and disinfection protocols are effective tools for providing and maintaining consistent management of environmental contamination with antimicrobial resistant pathogens. All personnel directly or indirectly involved in patient care, including environmental services, must be aware of multidrug resistant organisms, including MDR Ab and its role in contamination of the environment.

An environmental cleaning and disinfection plan includes policies or protocols that specify appropriate use of cleaning and disinfecting products. The plan must specify that environmental surfaces be cleaned with the proper dilution and amount of the standard facility-approved disinfecting agents, with compliance to contact times. Protocols should be in place for rooms of patients who are placed in isolation on precautions, with daily cleaning, terminal cleaning and enhanced cleaning during outbreak situations.[4]

Proper cleaning and/or disinfecting of electronic equipment is necessary. Personal care electronic equipment and multi-use electronic items, including any equipment used during delivery of patient care and mobile devices that are moved in and out of residents' rooms, may have special manufacturer instructions for meeting cleaning and disinfection requirements. Training staff to carefully follow manufacturer instructions is an important safety component of an effective cleaning and disinfection process and protection of equipment.[5]

An environmental cleaning and disinfection plan should include policies or protocols that specify a defined schedule of environmental cleaning. Daily cleaning of patient rooms by trained environmental staff is an essential policy component. Healthcare facilities can assign dedicated environmental staff to targeted patient care areas to provide consistency of appropriate cleaning and disinfection procedures. Monitoring of staff, education and reinforcement of training is required to maintain appropriate cleaning and disinfection of the environment.

A facility or specific units in a facility that are experiencing high or increasing infection rates should consider increasing the frequency of cleaning and disinfection. It is important to stress that high-touch areas undergo effective cleaning and disinfection.[4] High-touch areas include, but are not limited to, bed rails, light switches, over-bed tables, bedside commodes, bathroom fixtures in the resident's room, doorknobs, any equipment in the immediate area of the resident, and any equipment that is multi-use between residents. In addition, it is important to make sure the floor is cleaned completely, including the moving of equipment to allow for access to all surfaces.

Equipment cleaning that is not performed by environmental services staff must be clearly delegated to the appropriate healthcare staff per facility protocols. For instance, respiratory therapists may be responsible for cleaning respiratory equipment. Facility cleaning and disinfection policy or protocol will address the specific patient care staff responsibility for disinfection of equipment that may be taken from one resident to another.

Environmental Cleaning

Environmental cleaning and equipment cleaning/disinfection done effectively will help reduce the risk of transmission of MDR Ab.[6] Properly trained environmental services staff, the use of approved disinfectants/germicides, effective protocols and/or checklists are key elements in the management of MDR Ab.

- Proper use of cleaning and disinfection products (EPA-registered disinfectant) requires that product manufacturer's instructions and contact times to be carefully observed. If wipes are used, staff should be aware that a separate wipe is needed between areas so that cross-transmission is prevented.
- All personnel must take responsibility for ensuring that the environment and equipment is appropriately cleaned and disinfected in between patient interactions. Communicating this to the staff is important to successfully control the spread of MDR Ab. All staff, including nurses, respiratory therapists, radiology techs and phlebotomists, among others, will need education regarding the appropriate cleaning of critical equipment used for patients. Manufacturers' recommendations should be followed to avoid any damage to equipment.
- Dedicate non-critical medical equipment to the MDR Ab patient.

Environmental cleaning should be done daily or more frequently, depending on the situation, and include a focus on high-touch areas. (See Appendix D: Daily High Touch Cleaning Checklist)

Outbreak Situation—Intensify Environmental Cleaning Efforts

- Ensure the use of patient-dedicated non-critical equipment.
- Reinforce environmental staff cleaning procedures.
- Consider placing dedicated cleaning staff to outbreak areas.
- Monitor cleaning performance by environmental staff using observation and/or use of fluorescent staining. (Consider adenosine triphosphate bioluminescense assay as a means to monitor cleaning effectiveness.[7, 8])
- Ensure consistent cleaning and disinfection of high-touch areas (checklists can be used to guarantee consistency).
- Perform environmental cultures if the environment is implicated in transmission of the MDR Ab.
- Vacate and perform intensive cleaning of the unit if transmission of the organism continues and the environment is suspect,.
- Consider hypochlorite solution use (effective in controlling outbreak situations).

Terminal Cleaning

There is no information in the HICPAC Isolation (2007) or MDRO (2006) guidelines regarding terminal cleaning of rooms after Contact Precautions are discontinued. Terminal cleaning has been adopted by some facilities as a mechanism to ensure successful removal of organisms from the environment between patients. For those facilities choosing to adopt terminal cleaning, guidance in the 1996 Guidelines for Isolation Precautions in Hospitals[9], which preceded the 2007 isolation guide, specifically addressed the concept of a terminal cleaning as follows: "The room, or cubicle, and bedside equipment of patients on Transmission-based Precautions are cleaned using the same procedures used for patients on Standard Precautions, unless the infecting microorganism(s) and the amount of environmental contamination indicates special cleaning. In addition to thorough cleaning, adequate disinfection of bedside equipment and environmental surfaces (e.g., bedrails, bedside tables, carts, commodes, doorknobs, faucet handles) is indicated for certain pathogens, which can survive in the inanimate environment for prolonged periods of time."

Terminal cleaning is also addressed by the American Society for Healthcare Environmental Services (ASHES)[4] in its publications.

- Hypochlorite solutions have been reported as effective in controlling outbreak situations.

Monitoring Environmental Cleaning

Use of a monitoring tool to assess the cleaning effectiveness of environmental staff will ensure consistency in cleaning and disinfection procedures. Monitoring should include an assessment of the cleaning of high-touch areas[10] and surfaces in close proximity to the patient, including bedrails, nurse call lights, carts, doorknobs, bedside commodes, bedside tables and faucet handles.

The use of a standardized environmental cleaning checklist[11] may increase efficacy of cleaning. A checklist can also serve as a training tool for new staff, and as the basis for a cleaning monitor. When cleaning monitors indicate inadequacy of cleaning on a unit or throughout a facility, an enhanced or updated checklist that addresses the inadequacies should be implemented as an intervention to improve cleaning outcomes.

A Suggested Technique for Monitoring and Improving Room/Area Cleaning

A new and different approach to monitoring was tried by 3 hospitals to evaluate cleaning.[12] Gel containing material that fluoresces under a black light can be applied to targeted high-touch sites. Sites can be chosen based on the CDC's recommendations for improved cleaning of high-touch areas that are frequently contaminated with hospital-associated pathogens. Apply the gel before routine cleaning has been completed or terminal cleaning has been completed, and mark the selected surfaces. After the next cleaning, shine a black light on the marked surfaces to determine if the high-touch areas have been cleaned. Use of this technique allows the observer to determine whether an attempt has been made to sufficiently clean the surface. The observer can determine this by noting which of the following conditions exists:

1. Gel remains with no evidence of removal.
2. Gel partially remains with evidence of attempted removal.
3. Gel has been completely removed.

Educational programs, including feedback of monitoring results, should be provided to environmental cleaning staff. It is important that members of the environmental cleaning staff are recognized as active participants and contributors to a clean and safe patient care environment.

Environmental Information Offering Possibilities to be Considered for Cleaning and Investigation in Outbreak Situations:

Patient Care Area Curtains

Patient care area curtains (curtains around the patient's bed) are addressed here due to the fact they may become contaminated and possibly become a source of pathogen transmission.[13] Curtains are frequently touched by patients, visitors and healthcare workers. They are frequently touched by persons wearing contaminated gloves. People may not perform hand hygiene after touching curtains. In many healthcare institutions, the curtains are not cleaned or changed on a consistent basis. Curtains contaminated by carbapenem-resistant *A. baumannii* and MRSA have been found in recent studies, although the contribution to transmission of pathogens is not known.[14]

Mattresses and Pillows

Standard mattresses and pillows can become contaminated with body substances during patient care if the covers of these items become compromised. Mattress covers should be replaced when torn, and mattresses should be replaced if they are visibly stained and/or torn. Wet mattresses, in particular, can be a substantial environmental source of microorganisms. Infections and colonizations caused by *Acinetobacter* spp., MRSA, and *Pseudomonas aeruginosa* have been described, especially among burn patients. All mattresses that become damp or wet should be removed. Pads and covers should be cleaned and disinfected between patients. Pillows and their covers should be easily cleanable, preferably in a hot water laundry cycle.[9]

Cleaning Wipes/Disinfectant Cloths

It is essential, as with all cleaning products, to know what a product can do and how to properly use it. A study published in 2009 examined the use of two wipes available to hospitals, and their effectiveness against both methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* from contaminated surfaces.[15] Sodium hypochlorite based wipes, when used according to manufacturer's instructions, are effective against Ab.[16] It was found the wipes could reduce the bacteria from a surface; however, there was the potential for spreading the bacteria by continuing to use the same wipe on different surfaces. The recommendation from this study: "We recommend that a wipe not be used on more than one surface, that it be used only on a small area, and that it be discarded immediately after use, to reduce the risk of microbial spread—a one-wipe, one-application per surface policy."[13]

Dry Environment

Experiments were done to test the ability of *Acinetobacter* to survive in a dry environment. It was found the organism could survive four months or more in dry conditions. It is concluded by the authors that in prolonged outbreaks, the patient's environment may play a role, and intense cleaning and disinfection may be needed to end the outbreak.[3]

Dust

Recent studies have shown that MDR Ab is able to survive in dry conditions. Dust contaminated with MDR Ab can become a possible source for transmission of this organism. Investigations into two outbreaks in an acute care facility were, in time, traced to respiratory equipment. When the equipment was cleaned and dust filters were replaced, the outbreaks ended.[16]

Water Pipes

An outbreak of MDR Ab in an ICU was suspected to originate in the water or faucet area of the sinks located in the unit. Further investigation revealed that the clonal strain of the MDR Ab was in the horizontal pipe system,

which could potentially contaminate any of the sinks located in the unit. This paper demonstrates that an outbreak can persist despite increased interventions such as hand hygiene and education until the reservoir of the organism is identified and eliminated. An interesting approach to eradication of the organism was suggested by the hospital engineer. The approach consisted of using bleach in all sinks connected to the system, at certain designated times, and treating all sinks simultaneously. Once this was done, the outbreak ceased.[17]

Toys

All healthcare facilities should have policies and procedures in place for the care and cleaning of toys. All toys offered to children should be washable or cleanable. Toys can become contaminated and potentially transmit organisms.[18] Due to the potential of toys to transmit Ab, procedures for cleaning and disinfection are required.[19]

Use of New Technologies—An Oral Presentation at APIC 2009 Annual Educational Conference & International Meeting

During January 2008, a cluster of three patients with MDR Ab was detected in a 24-bed long-term acute care hospital ward in Cleveland, Ohio. The isolates were multidrug-resistant with identical antibiotic susceptibility profiles. Despite tightening of basic infection control measures—including improved hand hygiene and use of PPE, prolonged isolation and cohorting of affected patients, and a change in disinfectant product—five new cases occurred in March 2008. An environmental survey revealed that swabs of high-touch objects (the call bell, bedrail, and bedside table) obtained from seven patient rooms grew MDR Ab on culture. Given the environmental contamination pattern within the immediate patient environment and high attack rate, the unit was closed to admissions and vaporized hydrogen peroxide technology (VHP) was utilized to serially decontaminate rooms. In addition to the use of the VHP technology as a supplement to terminal cleaning, subsequent steps included upgrading surface disinfectants and hand hygiene products. An intensive educational program in combination with innovative strategies was required to break the cycle of Ab transmission within the facility.

Note: Hydrogen peroxide vapor (VHP) is a new technology that is being used and evaluated in many different areas.[20, 21, 22]

References

[1] Abbo A, Navon-Venezia S, Hammer-Muntz O, Krichali T, Siegman-Igra Y, Carmeli Y. Multidrug-resistant *Acinetobacter baumannii*: abstract and introduction. Emerg Infect Dis. 2005;11(1):22–29.

[2] Catalano M, Quelle LS, Jeric PE, DiMartino A, Maimonet SM. Survival of *Acinetobacter baumannii* on bed rails during an outbreak and during sporadic cases. J Hosp Infect. 1999;42:27–35.

[3] Wendt,C, Dietze, B, Dietz,E, Ruden, H. Survivial of *Acinetobacter baumannii* on Dry Surfaces. Journal of Clinical Microbiology 1997; 1394–1397.

[4] Environmental Services Basics. Practice Guidance for Healthcare Environmental Cleaning. American Society for Healthcare Environmental Services (ASHES). Costello P, editor. 2008:6. Available at http://www.ashes.org

[5] Public Health Notification from FDA, CDC, EPA and OSHA: Avoiding Hazards with Using Cleaners and Disinfectants on Electronic Medical Equipment. 2007 Oct 31. Available at: http://www.fda.gov/cdrh/safety/103107-cleaners.html

[6] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S165–193.

[7] Boyce JM, Havill NL, Dumigan DG, Golebiewski M, Balogun O Rizvani R. Monitoring the effectiveness of hospital cleaning practices by use of an adenosine triphosphate bioluminescence assay. Infect Control Hosp Epidemiol. 2009 Jul; 30 (7):678–684.

[8] Cooper RA, Griffith CJ, Malik, RE, Obee P, Looker N. Nonitoriing the effectiveness of cleaning in four British hospitals. Am J Infect Control. 2007 June; 35 (5):338–341.

[9] Garner JS. Hospital Infection Control Practices Advisory Committee (HICPAC). Guideline for isolation precautions in hospitals. Infect Control Hosp Epidemiol. 1996 Jan;17(1):53–80.

[10] Sehulster LM, Chinn RYW, Arduino MJ, Carpenter J, Donlan R, Ashford D, Besser R, Fields B, McNeil MM, Whitney C, Wong S, Juranek D, Cleveland J. Guidelines for environmental infection control in health-care facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Chicago, IL. American Society for Healthcare Engineering/American Hospital Association. 2004. pg 75

[11] APIC Guide to the Elimination of Methicillin-Resistant Staphylococcus aureus (MRSA) Transmission in Hospital Settings. 2007 pg 63

[12] Carling PC, Briggs J, *et al.* An evaluation of patient area cleaning in 3 hospitals using a novel targeting methodology. Am J Infect Control. 2006;34:513–519.

[13] Trillis F, Eckstein E, Budavich R, Pultz MJ, Donskey CJ. Contamination of hospital curtains with healthcare-associated pathogens. Infect Control Hosp Epidemiol. 2008 Nov;29(11):1074–1076.

[14] Das I, Lambert P, Hill D, Noy M, Bion J, Elliott T. Carbapenem-resistant Acinetobacter and role of curtains in an outbreak in intensive care units. J Hosp Infect. 2002;50:110–114.

[15] Williams GJ, Denyer SP, Hosein IK, Hill DW, Maillard J-Y. Limitations of the efficacy of surface disinfection in the healthcare setting. Infect Control Hosp Epidemiol. 2009; 30:570–573.

[16] Bernards AT, Harinck HIJ, Dijkshoorn L, van der Reijden TJK, van den Broek PJ. Persistent *Acinetobacter baumannii*? Look inside your medical equipment. Infect Control Hosp Epidemiol. 2004;25:1002–1004.

[17] La Forgia C, Franke J, Hacek DM, Thomson RB Jr., Robicsek A, Peterson LR. Management of a multidrug-resistant (MDR) *Acinetobacter baumannii* outbreak in an intensive care unit using novel environmental disinfection: A 38-month report. Am J Infect Control. 2010 May; 38(4): 259–263.

[18] Naesens R, Jeurissen A, Vandeputte C, Cossey V, Schuermans A. Washing toys in a neonatal intensive care unit decreases bacterial load of potential pathogens. J Hosp Infect. 2009 Feb;71(2):197–198. Epub 2008 Dec 18.

[19] Avila-Aguero ML, German G, Paris MM, Herrera JF. Safe Toys Study Group. Toys in a pediatric hospital: Are they a bacterial source? Am J Infect Control. 2004 Aug;32(5):287–290.

[20] Boyce J, Havill N, Otter J, *et al.* Impact of hydrogen peroxide vapor room decontamination on *Clostridium difficile* environmental contamination and transmission in a healthcare setting. Infect Control Hosp Epidemiol. 2008;29:723–729.

[21] Otter J, Puchowicz M, Ryan D, *et al.* Feasibility of routinely using hydrogen peroxide vapor to decontaminate rooms in a busy United States hospital. Infect Control Hosp Epidemiol. 2009;30:574–577.

[22] Ray A. "The use of vaporized hydrogen peroxide room decontamination in the management of an outbreak of multidrug-resistant *Acinetobacter baumannii*." 36th Annual APIC Educational Conference and International Meeting Proceedings, Fort Lauderdale, FL. 2009 Jun

Outbreak Recognition and Control

Key Concepts

- *Acinetobacter baumannii* is a resilient organism that can survive for extended periods in the care environment.
- MDR Ab may result in long term colonization, and serve as a potential source for transmission to additional patients.
- Numerous outbreaks of MDR Ab have been reported, many of which have involved many patients and required multiple interventions.
- Reservoir identification, elimination or containment may require the simultaneous and sustained implementation of many of the control measures described below.

Introduction

The emergence and sustained propagation of MDR Ab in healthcare settings has been widely described in the medical literature, with the involvement of almost every type of care setting, ranging from intensive care (most frequent) and step-down units, to general medical-surgical floors and various long-term care entities. Ample evidence demonstrates interfacility transmission of MDR Ab, with point-source introductions of this pathogen followed by numerous secondary cases identified over subsequent months.[1] The escalating impact and importance of *Acinetobacter* infections is evidenced by the fact that roughly 25% of all "nosocomial *acinetobacter* PubMed citations in the past 20 years appeared in 2005 and 2006".[2] In this section, common control strategies are compiled based on reports of successful MDR Ab outbreak control.

What is an Outbreak of MDR Ab?

The prevalence of a given organism is often used to characterize and determine endemic versus epidemic level of the organism's presence in an environment or location. As with many other pathogens, there are no hard-and-fast rules to describe exactly when the MDR Ab outbreak threshold has been crossed. Many investigators are of the opinion that even a single MDR Ab patient represents the potential source for transmission to other patients and for contamination of reusable patient care equipment or the environment. Accordingly, the appearance of a single case of MDR Ab in an area with no previously identified cases should prompt the timely implementation of selected control measures as described below. The appearance of two or more temporally or geographically associated MDR Ab cases should evoke a correspondingly heightened response by the infection preventionist and by the facility.

Antimicrobial Susceptibility

The definition of MDR Ab has been discussed elsewhere in this guide, but it seems prudent at this juncture to introduce an important consideration regarding classification MDR-Ab. Certain strains of MDR Ab have been found to contain as many as 54 resistance genes, with 45 residing on a single "resistance island" alone[3] and at any given time, the expression or relative quiescence of resistance genes is driven in part by antibiotic selection pressure

Clinically, the first indication of a strain's heightened level of resistance typically comes from the microbiology laboratory, which reports the culture and sensitivity test results on a clinical isolate. Antimicrobial susceptibilities as reported on the "sensitivity results" are characterizations of the organism's phenotype (e.g., observable physical or biochemical characteristics, as determined by both genetic makeup and environmental influences) at the time of the

in vitro "sensitivity versus resistance" measurements. An oft-used "tool" in the investigation and control of clusters of pathogens involves the comparison of the antimicrobial susceptibilities of several clinical isolates of the same genus and species. Generally speaking, comparable antimicrobial susceptibilities are taken to be strong evidence of the relatedness of the isolates, and disparate antibiograms are often used to eliminate some isolates from inclusion in the cluster. However, with *Acinetobacter* strains, discriminating between somewhat sensitive strains, MDR Ab strains and pan-resistant Ab strains using antimicrobial susceptibility patterns alone can be problematic. This fact is illustrated by examining unpublished data from an outbreak of pan-resistant Ab that occurred in 2006-2007 in Florida.[4] The antibiotic susceptibility pattern from isolate #1 in Table I, while not radically different from the index case, tended to exclude it from the cluster, which was focused around isolates antibiotic susceptibilities like isolate #2, one of the two index cases in this outbreak. However, subsequent molecular typing using the DiversiLab Acinetobacter DNA Fingerprinting Kit and DiversiLab Analysis Software (Tampa General Hospital, Shannon Moroney, PhD, personal communication) showed that isolate #1 was indistinguishable from the index pan resistant strain. Conversely, isolate #3 was pan-resistant by antibiogram (and thus appeared to be a part of the initial cluster related to the index case), but on molecular typing was found to be a different strain, leading to the conclusion that there were two temporally and geographically overlapping but clonally distinct clusters occurring simultaneously. Thus, while antimicrobial susceptibilities are necessary for patient management decisions, their use in case inclusionary/exclusionary criteria can lead to over- or underestimating the true scope of an outbreak. The infection preventionist is advised to submit suspect isolates for appropriate molecular testing, such as PFGE or other genotypic methodologies that may be available in order to definitively classify the possible outbreak cases.

Critical Elements in the Control of MDR Ab Outbreaks

Administrative Support

Several reported clusters of MDR Ab have involved in excess of 100 patients and lasted for many months.[5, 6] Accordingly, it is essential that key hospital administrative, risk management, financial, clinical and support service leaders are informed of an apparent outbreak MDR Ab as soon as possible and that all are suitably impressed with the potential scope, duration and clinical impact of such an outbreak. The infection preventionist should secure an organizational commitment to support the agreed upon interventions and provide the needed resources. A large cluster that lingers for weeks or months will be costly in terms of added supplies, personnel and laboratory costs, possible unit closures and other possible expenses. Resource commitment and administrative support must be in place to successfully control an outbreak of MDR Ab.

Public Relations

The infection preventionist should seek the involvement of the organization's public/media relations (PR) department, as a sustained outbreak, especially one that involves unit closures and diversion of admissions, will likely come to the attention of the local media. All external communications and media interviews should be channeled through and guided by the organizational PR department.

Table I. Antibiotic and MIC

Isolate	Amp/Sul	Amp	CFZ	CFP	CFT	CTZ	CTR	GE	IM	Lev	Pip/TZ	Tob	Tri/Sul
#1	16I	>32R	>64R	2S	>64R	-	-	>16R	>16R	0.25S	R	4S	-
#2	>32 R	>32R	>64R	>64R	>64R	>64R	>64R	>16R	>16R	>8R	>128R	8I	>320R
#3	>32 R	>32R	>64R	>64R	>64R	>64R	>64R	>16R	>16R	>8R	>128R	8I	>320R

Amp/Sul = Ampicillin/Sulbactam, Amp = Ampicillin, CFZ = Cefazolin, CFP = Cefapime, CFT = Cefotetan, CTZ = Ceftazadime, CTR = Ceftriaxone, GE = Gentamicin, IM = Imipenem, LEV = Levoflox, PIP/TZ = Piperacillin/Tazobactam, Tob = Tobramicin, Trim/Sul = Trimethoprim/Sulfamethoxazole

Clinical Components in the Control of MDR Ab Outbreaks

The following are a series of interventional strategies that have been implemented, usually in conjunction with several others in a "bundle," and have been reported to aid in controlling outbreaks of MDR-AB.[7]

Communication

Reports of inter- and intra-facility transmission of MDR Ab[1] highlight the need for effective communication of a patient's MDR-Ab status at the time of internal transfer, transfer to another facility or even discharge to home. The responsibility should lie with the referring entity to clearly identify the known MDR Ab patient to the receiving entity at the time of transfer in order to facilitate the timely implementation of control measures upon admission. This might involve the development of a standardized "handoff" protocol and documentation that explicitly addresses the patient's overall MDRO history. In addition, the facility should have a method to "flag" both the MDR Ab patient's hard copy medical record as well as their electronic medical record so that it is obvious to the next care team in the event of subsequent readmission to the facility. By doing so, precautionary measures can be (re)instituted without delay.

Education

Every caregiver and support group should receive MDR Ab-specific education as a part of the outbreak control process. Visitors and family should also be educated verbally and printed educational material. (See Appendix C: Patient/Visitor Education Sheet.) They should be reminded of the importance of hand hygiene, proper PPE use, the characteristics of MDR Ab as they relate to transmission, environmental cleaning, equipment reprocessing, etc. All shifts should be included and attendance should be documented.

Reservoir Identification and Elimination

This is a basic tenet of outbreak control and several authors have reported identifying and eliminating specific MDR Ab reservoirs and thus controlling the outbreak. Bernards et al[8] described recovering an outbreak strain of MDR Ab in ventilators and other medical equipment and was able to end the outbreak by dusting the machines and replacing their dust filters. There are multiple reports of both respiratory and non-respiratory care equipment involvement of MDR Ab clusters[9] and the infection preventionist should keep an open mind when searching for a common source reservoir. Ling et al[5] describe controlling an ICU MDR Ab outbreak by first screening all patients in the affected area for the presence of MDR Ab and subsequently cohorting affected patients in contact precautions for D'Agenta, et al[10] reported an increased incidence of MDR Ab among patients cared for in areas where there were higher numbers of pre-existing MDR Ab patients, leading the authors to conclude that cross-transmission from infected patients leads to a higher incidence of newer cases. A similar observation has been made relative to the likelihood of VRE acquisition in areas with high levels of pre-existing VRE, and has been termed "colonization pressure" by Bonten, et al[11].

A previously unrecognized reservoir and mode of transmission was described by Maragakis, et al[12], wherein an outbreak of MDR Ab was associated with pulsatile lavage wound treatment. The authors concluded that there was probable aerosolization and subsequent deposition of the MDR Ab strain on nearby environmental surfaces due to this form of wound treatment. This outbreak was controlled by changes in the infection prevention recommendations of the equipment manufacturer, changes in the PPE worn by the therapist and supplied to the patient, changes in the configuration of the treatment room itself (private room only with readily cleaned surfaces and closed storage), and changes to the post-treatment cleaning regimen.

Patient and environmental surveillance cultures may be used to identify reservoirs such as colonized patients or items in the care environment. Corbella, et al[13] suggested that the use of moistened sterile gauze

pads is more effective for the recovery *Acinetobacter* strains from environmental sources. (See Laboratory Considerations—Epidemiology—Pathogenicity section regarding specimen collection.) The infection preventionist should work closely with the microbiology laboratory to coordinate the collection and processing of environmental samples.

Cohorting of Patients

This involves the placement of several patients with MDR Ab in the same geographical area, possibly one semi-private room, several rooms designated for that purpose or even one or more intensive care units. In each case, the purpose would be to geographically separate patients with MDR Ab from others, and, combined with caregiver cohorting (described below), would physically and operationally segregate infected from non-infected patients.

Cohorting of Caregivers

This practice involves assigning certain caregivers to care only for those patients in the MDR Ab cohort during any given shift. A person assigned to the cohort would not be assigned non-cohort patients. The infection preventionist can expect resistance to this strategy, as normal staffing patterns and ratios may need to be altered, with a corresponding adverse impact on labor costs. In addition, employee satisfaction may suffer if staff assigned to care solely for cohorted patients feel that they are consistently being given undesirable work assignments.

Deferring Admissions and Unit Closure

Several authors have described the need to either close an affected unit for a period of time[5] or defer admissions in order to control an outbreak of MDR-Ab.[14] In part, this assumes the presence of one or more environmental reservoirs within the unit, and that those reservoirs cannot be eliminated while the unit is occupied. Typically, admissions to an affected unit are curtailed until natural attrition allows for the complete closure of the ward. When the unit is closed, equipment may be removed for cleaning and reprocessing, extensive environmental cleaning takes place, and thorough culling of potentially contaminated supplies is accomplished. Again, this is costly control strategy as closing a unit for this reason may result in a loss of bed capacity and income for the facility. Wilks et al[6] described the successful containment of an MDR Ab outbreak without having to resort to unit closure or patient isolation by instead focusing on enhanced environmental cleaning, staff education and hand hygiene.

"Hyperaggressive" Room/Environment Cleaning

Acinetobacter baumannii is known to persist in the environment; it is desiccation-tolerant and has often been recovered from the environment after routine discharge room cleaning. Hypochlorite solutions have been reported as effective in controlling outbreak situations.[19] Label instructions for many of the hospital-grade disinfectant detergent cleaning agents call for surfaces being disinfected to remain wet for up to ten minutes. The standard room turnaround time for discharge cleaning is often less than 30 minutes, leaving little opportunity for sufficient "dwell or contact" time of the disinfectant agents on environmental surfaces, especially vertical surfaces. Furthermore, Environmental Services (ES) personnel are often reluctant (or even prohibited from) cleaning the surface of certain medical equipment, such as IV pumps or monitors. Unfortunately, nursing may be under the impression that these items are being cleaned by EVS; and hence, the items are not being cleaned at all. Because of the strong environmental component of MDR AB, all aspects of room cleaning should be carefully scrutinized, with a determination of how each item is to be cleaned and who is responsible for doing so. Existing cleaning protocols should be reviewed, and how those protocols are

actually put into practice should be observed by the infection preventionist. It might prove useful to create a checklist of all items in the rooms and clearly designate the accountability for cleaning those items upon discharge. Make sure there is sufficient supervisory oversight to verify and document that the room has been cleaned to the required specifications.

On the horizon, there are several emerging technologies under investigation that show promise for effective room decontamination. These include room fogging with hydrogen peroxide vapor (HPV), room fogging with activated hydroxyl radicals (OH^-) derived from hydrogen peroxide, room fogging with a low-concentration mixture of hydrogen peroxide and peroxyacetic acid, and surface exposure to intense ultraviolet light. The reader is encouraged to follow the peer-reviewed literature closely for reports of the efficacy of these technologies that may ultimately provide more efficacious room decontamination than is now achieved using traditional cleaning methods.

Review of Respiratory Care Equipment Reprocessing

There are numerous reports of outbreaks involving respiratory care equipment and supplies.[8,9] The infection preventionist should carefully review all aspects related to respiratory care equipment processing and handling if the investigation reveals that several affected patients are found to have received respiratory care treatments of any kind. This review should include care of bronchoscopes, nebulizers, ventilator circuits, ventilators, incentive breathing devices and liquids used in the treatments. All reprocessing processes should be reviewed to verify standards for cleaning and disinfection of this equipment are being met.

Hand Hygiene Improvement

Hand carriage of MDR Ab, most likely of a transient nature, has been reported in several instances[15,16] and certain healthcare worker hands must be considered as a possible mode of transmission for outbreak strains. Accordingly, healthcare worker hand hygiene must be heavily stressed early on as a part of any outbreak control effort. Either an antimicrobial soap and water or an alcohol-based hand cleanser can be used for this purpose. Healthcare workers should be reminded that gloves are not a substitute for effective hand hygiene and that several studies have shown frequent contamination of caregiver hands after glove removal. Verification by direct observation of hand hygiene compliance may be necessary to influence caregivers to comply with hand hygiene protocols without exception.

Contact Precautions Compliance Improvement

Contact Precautions are a well known control strategy that is implemented in addition to Standard Precautions (used for all patients) in cases of MDRO, including MDR Ab, and is based upon CDC/HICPAC guidelines.[17,18] The purpose of Contact Precautions are to prevent the actual transfer of infectious agents from the patient or the environment to the caregiver, who may in turn either acquire the agent or more likely, serve as a vector for the transport of the agent to a susceptible patient. The key elements of Contact Precautions involve placing the patient in a private room (except when cohorting is unavoidable) and the use of personal protective equipment (PPE), gowns and gloves, by caregivers when entering the room and contact with the patient and/or items potentially contaminated by the patient is anticipated. Since it is often difficult to accurately anticipate whether patient contact will occur, many organizations have simplified the process by specifying PPE use by all persons entering the room. The infection preventionist should work with supply chain management to make sure there are sufficient PPE supplies available *at the point of need* in instances where a cluster of infections may increase usage levels well above the normal. In addition, there should be no exceptions to PPE use: Physicians, nurses, therapists, dietary, social services, case management, pastoral care, etc. all should use the PPE according to the established protocols.

Below is a template to help in the development of a comprehensive plan to control an outbreak of MDR Ab:

Checklist of Potential MDR Ab Control Measures

	Date	Control Measure	Comments
Y N		Administrative support	
Y N		Communication	
Y N		Education	
Y N		Reservoir search and ID, environmental cultures	
Y N		Cohort patients	
Y N		Cohort staff	
Y N		Ward closure/deferred admits	
Y N		Hyper-aggressive room cleaning	
Y N		Equipment reprocessing review	
Y N		Hand hygiene monitoring	
Y N		Contact Precautions & PPE use monitoring	

References

[1] Saeed S, Fakih MG, Reiderer K, Shah AR, Khatib R. Interinstitutional and Intrainstitutional Transmission of a Strain of Acinetobacter baumannii Detected by Molecular Analysis: Comparison of Pulsed-Field Gel Electrophoresis And Repetitive Sequence-Based Polymerase Chain Reaction, *Infect Control Hosp Epidemiol* 2006;27:081–993.

[2] Silvia Munoz-Price L, Weinstein RA. Acinetobacter Infection. *N Engl J Med* 2008;358:1271–81.

[3] Fournier P-E, Vallenet D, Barbe V, et. al. Comparative Genomics of Multidrug Resistance in Acinetobacter baumannii. *PLoS Genet* 2006;2:(1)e7 0062–0072.

[4] Author's personal communication, data

[5] Ling ML, Ang A, Wee M, Wang GCY. A Nosocomial Outbreak of Multiresistant Acinetobacter baumannii Originating From an Intensive Care Unit. *Infect Control Hosp Epidemiol* 2001;22:48–49.

[6] Wilks M, Wilson A, Warwisk S, et al. Control of an Outbreak of Multidrug-Resistant Acinetobacter baumannii-calcoaceticus Colonization and Infection in an Intensive Care Unit (ICU) Without Closing the ICU or Placing Patients in Isolation. *Infect Control Hosp Epidemiol* 2006;27:654–658.)

[7] Rodríguez-Baño J, García L, Ramírez E, Martínez-Martínez L, Muniain M, Fernández-Cuenca F, Beltrán M, Gálvez J, Rodríguez J, Velasco C, et al. Long-term control of hospital-wide, endemic multidrug-resistant Acinetobacter baumannii through a comprehensive "bundle" approach. *Am J Infect Control* 2009;37:715–722.

[8] Bernards AT, Harinck HIJ, Dijkshoorn L, van der Reijden TJK. Persistent Acinetobacter baumannii? Look Inside Your Medical Equipment. *Infect Control Hosp Epidemiol* 2004;25:1002–1004.

[9] Villegas MV, Hartstein AI. Acinetobacter Outbreaks, 1977–2000. *Infect Control Hosp Epidemiol* 2003;24:284–295.

[10] D'Agata EMC, Thayer V, Schaffner W. An Outbreak of Acinetobacter baumannii: The Importance of Cross-Transmission. *Infect Control Hosp Epidemiol* 200;21:588–591.

[11] Bonten NJM, Slaughter S, Ambergen AW, et al. The role of colonization pressure in the spread of vancomycin-resistant enterococci: an important infection control variable. *Arch Intern Med* 1998;158:1127–1132.

[12] Maragakis LL, Cosgrove SE, Xiaoyan S, et al. An Outbreak of Multidrug Resistant Acinetobacter baumannii Associated With Pulsatile Lavage Wound Treatment. *JAMA* 2004;292:3006–3011.

[13] Corbella X, Pujol M, Argerish MJ, et al. Letter to the Editor. *Infect Control Hosp Epid* 1999;20:45–460.

[14] Fierobe L, Lucet J-C, Decre D, et al. An Outbreak of Imipenim-Resistant Acinetobacter baumannii in Critically Ill Surgical Patients. *Infect Control Hosp Epidemiol* 2001;22:35–40.

[15] Bayuga S, Zeana C, Sahni J, Della-Latta P, El-Sadr W, Larson E. Prevalence and antimicrobial patterns of A. baumannii on hands and nares of hospital personnel and patients: the iceberg phenomena again. *Heart Lung* 2002;31:382–390.

[16] Huang YC, Su LH, Wu TL. Outbreak of Acinetobacter baumannii in a neonatal intensive care unit: clinical implications and genotyping analysis. *Pediatr Infect Dis* 2002;21:1105–9.

[17] Siegel JD, Rhinehart E, Jackson M, Linda C. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Available online at www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf.

[18] Seigel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings, June 2007. Available online at www.cdc.gov/ncidod/dhqp/pdf/isolation2007.pdf

[19] La Forgia C, Franke J, Hacek DM, Thomson RB Jr, Robicsek A, Peterson LR. Management of a multidrug-resistant Acinetobacter baumannii outbreak in an intensive care unit using novel environmental disinfection: A 38-month report. Am J Infect Control. 2009 Nov. [Epub ahead of print]

Special Settings: Long-term Care, Ambulatory Care and Pediatrics

Long-term Care Facilities (LTCF)

Colonized and infected residents may become reservoirs and vehicles for MDR Ab transmission to other residents in a facility. The residents can also be a source of transmission when transferred to or from other healthcare settings, including acute care facilities.[1] In a study done in 2006 at Johns Hopkins Hospital, MDR Ab surveillance cultures were obtained on adult patients admitted to five hospital units in order to screen for MDR Ab. Patients admitted from LTCFs, or who had been in LTCFs within the previous six months, were found to be the patient type most likely to be colonized or infected with MDR Ab.[2]

The IP must be aware of MDR Ab reservoirs and populations in the community. The state or local health department will be able to provide this information. This data should be part of the facility risk assessment. MDR Ab-positive patients can be identified from information provided on transfer forms and/or from laboratory results. The IP should arrange with the laboratory contracted by the LTCF to be contacted immediately about any positive culture MDR Ab residents. The MDR Ab information should be entered on a line listing; this information will assist with resident placement, identifying risk factors and calculation of rates.

Newly identified MDR Ab-positive residents should be evaluated for risk factors and for the possibility that the MDR Ab was acquired within the LTCF. Based on surveillance data and evaluation, MDR Ab prevalence and incidence rates can be calculated and analyzed. The facility should be alert for outbreaks or increased transmission of MDR Ab. If transmission is occurring in the facility, the IP must review the infection prevention interventions, assess staff compliance, and intensify education and compliance monitoring as appropriate.

The medical director should be kept informed of MDR Ab prevalence and of any possible transmission of MDR Ab among residents in the facility. MDR Ab incidence rates should be reported at Infection Prevention Committee meetings and, during periods of possible transmission or outbreak, the need for enhanced interventions must be communicated. The IP in an LTCF should be aware of state and local regulations concerning the reporting of outbreaks of MDR Ab and should work closely with the health department and/or a consultant IP as appropriate for assistance in interrupting the outbreak.

The IP and the medical director should be knowledgeable about antimicrobial use in the facility. Antibiograms should be provided by the contracted microbiology lab. "Studies have found substantial inappropriate use of antimicrobials in LTCF residents, ranging from 25-75%."[3] Reports on antibiotic use should be provided to all resident attending physicians and healthcare providers.

Efforts should be taken to place MDR Ab-positive resident in a private room (see also the patient placement section) at time of admission and after a positive culture result on a current resident. A private room may not be possible in all situations, as there are a limited number of private rooms in LTCFs. Therefore, it may be necessary to cohort the resident with another resident known to have the same organism, or place the resident with a low-risk resident who is not currently on antibiotic medication, has no invasive devices, and has no wounds or other major skin disruptions.[4]

The LTCF must have policies and procedures addressing MDROs.[5,6,7,8] The policy should deal with placement, surveillance, isolation precautions, specimen collection and any other issues that may impact transmission of the

organism. Contact Precautions are used to prevent transmission in hospital and LTAC settings. (See Standard Precautions and Transmission-based Precautions section). However, based on the HICPAC MDRO Guideline 2006, use of Contact Precautions for MDROs in the LTCF can be based on the resident's clinical situation and facility resources. Many facilities use Contact Precautions if the resident has an infection with MDR Ab. If the resident is colonized and the clinical situation allows—and the resident can maintain good hygiene, and can follow instructions to prevent transmission—Standard Precautions may be used. The quality of life of LTC residents is associated with socialization and participation in group activities; therefore, modifying the type of precautions that can be safely used with MDR Ab residents is an important consideration.

Hand hygiene is extremely important. Hand hygiene and Standard Precautions or Contact Precautions information/education must be provided for residents and their visitors. Residents should be instructed to perform hand hygiene at appropriate times, and residents who cannot discern when to perform hand hygiene should be assisted in hand hygiene by staff and/or by their families. Family members and other visitors of LTC residents often have more extensive contact with the resident and the resident's environment than visitors of patients in hospital settings.[9] It is not uncommon for visitors to assist LTC residents in care activities, accompany residents to common areas, and visit other residents' rooms. It can be expected; therefore, that LTC visitors may have frequent opportunities to acquire infectious agents from either residents or their environments. It is important to reduce the risk of MDR Ab transmission to visitors, some of whom may be at increased risk of infection due to underlying conditions. It can also be expected that visitors may be a source of transmission of acquired "contamination" via their own hands or from their clothes or accessories. Education of families and other visitors is the first step in ensuring that visitors of MDR Ab-positive residents do not contribute to MDR Ab transmission in the LTC facility.

Environmental cleaning is of great importance in preventing the transmission of organisms.[10] A multidisciplinary approach should be used; all staff should be empowered to maintain a clean environment. Cleaning should be monitored, with special attention to high-touch areas, in the resident's room, halls and activities areas. Staff should have access to cleaning supplies, if needed, at all times. Cleaning of medical equipment should be assigned to whomever can safely perform the cleaning; those cleaning equipment should follow all manufacturers' instructions to prevent harm to the equipment.

Special Settings: Long-term Care References

[1] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S165–193.

[2] Maragakis LL, Tucker MG, Miller RG, Carroll KC, *et al.* Incidence and prevalence of multidrug-resistant *Acinetobacter* using targeted active surveillance cultures. JAMA. 2008 Jun 4;299(21):2513–2514. Available at: http://jama.ama-assn.org/cgi/content/full/299/21/2513

[3] Richards C, Lewis D. Infections in Long Term Care Facilities. Hospital Infections. Bennett & Brachman. W.Jarvis Editor. 5th ed. Wolters Kluwer/ Lippincott Williams & Wilkins. Baltimore. 2007. Chapter 28:476.

[4] Smith P, Bennett G, Bradley S, *et al.* SHEA/APIC Guideline: Infection prevention and control in the long-term care facility. Infect Control Hosp Epidemiol. 2008;29(9):785–814.

[5] Fardo R, Keane J, Taylor K. Nursing Procedures. Policy for Control of Multidrug-Resistant Organism (MDRO) Infection. Section VII:26.

[6] Rosenbaum P, Zeller J, Franck J. Long Term Care. APIC Text of Infection Control and Epidemiology. 3rd ed. 2009 Volume II, Chap 52:1–17.

[7] Arias K. Long-term care outbreaks reported in the long term care setting. Quick Reference to Outbreak Investigation and Control in Health Care Facilities. Jones & Bartlett. 2000 Chapter 4 91–103

[8] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S65–164.

[9] Aureden, K, Burdsall, D. Harris, M., Rosenbaum, P. Guide to the elimination of methicillin-resistant *Staphylococcus aureus* (MRSA) transmission in the long-term care facility. APIC Elimination Guide. 2009.

[10] French, G. Antimicrobial Resistance in Flora and Nosocomial Infections. In Hospital Epidemiology and Infection Control. Mayhall,G. Editor 3rd ed. Lippincott Williams and Wilkins.Philadelphia. 2004 Chapter 91:1620

Ambulatory Care

The Management of Multi-Drug Resistant Organisms in Healthcare Settings, published in 2006, outlines the optimal infection prevention program for the ambulatory care setting.[1] The initial recommendation is to make MDR Ab prevention in the center a priority by implementing systems to communicate information to administration and the health authorities as required. If a patient is infected or colonized with MDR Ab, the facility should communicate this to any facility receiving a patient from the center.

The staff should be educated about MDR Ab, proper hand hygiene, environmental cleaning, and their role in prevention and control within the ambulatory care facility.[2]

The infection prevention program should include the surveillance for, and monitoring of, MDR Ab in the center. Cultures of a site potentially infected should be done pre-procedure and results communicated to the physician and staff. Positive culture patients can be scheduled as the last case of the day.

Ambulatory care staff will use Standard Precautions at all times.[3,4] If the patient or the physician reports MDR Ab prior to the patient arriving at the facility, or a wound is identified during initial assessment, a decision will be made as to whether additional precautions are necessary. The staff is required to use gowns and gloves for contact with all blood or body fluids, including uncontrolled drainage, draining wounds, fecal or urinary incontinence, and contents of drainage bags. In addition, masks should be donned for potential exposure to splash-generating procedures.

If the patient cannot control his or her secretions, the procedure may be rescheduled, or the patient should be separated from the other patients, and Contact Precautions implemented.[5]

After discharge, the environment in contact with the patient should be cleaned and disinfected or sterilized according to recommended guidelines.[2] Intensified interventions should be taken if an outbreak is identified. Strategies may include use of a bleach solution to clean the environment. In addition, it is important to intensify hand hygiene monitoring and education about the transmission of the organism.

Special Settings: Ambulatory Care References

[1] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S165–193.

[2] Friedman C, Petersen K. Organizing for Infection Prevention , Surveillance and Control. Infection Control in Ambulatory Care. Jones and Bartlett Publishers. Sudbury, Mass. 2004 Chapter 24:190.

[3] Peterson K. Ambulatory Care. APIC Text of Infection Control and Epidemiology. Washington,DC 3rd ed. 2009 Volume II, Chapter 49:6.

[4] Bennett G. Infection Prevention Manual for Ambulatory Care. ICP Associates/APIC. Washington,DC.2009; Section 4:4.

[5] Arias K. Ambulatory Care. Quick Reference to Outbreak Investigation and Control in Health Care Facilities. Jones & Bartlett. Gaithersburg, Maryland. 2000; Chapter 5:108.

Pediatrics

Examination of pediatric healthcare associated infections (HAI) reveals this population has unique infection prevention and control challenges.[1,2] Recently, the 2006 National Healthcare Safety Network (NHSN) data identified NICU catheter-related bloodstream infections by birth weight as having a pooled mean of 6.4 per 1,000 catheter days for neonates in the ≤750 g birth weight category.[3] In addition, MDRO colonization in pediatric populations has been well documented in studies such as the PICU and NICU point prevalence surveys by the Pediatric Prevention Network.[4]

Acinetobacter can cause many different types of infections in children. NNIS data from 1992 to 1997 lists the percentage of infections among PICU patients caused by *Acinetobacter spp.*: bacteremia, 2%; pneumonia, 3.1%; lower respiratory infections other than pneumonia, 3.1%; and urinary tract or surgical site infections, <1%.[5] *A. baumannii* can cause outbreaks among high-risk, critically ill pediatric patients, including those on burn units.[6] Like the adult population, *Acinetobacter* colonization and infection risk exists across pediatric populations, varies by host and setting, and is not exclusive to the PICU and NICU.

Pediatric Factors

Vulnerabilities of the pediatric patient are the result of extrinsic and host factors in the midst of developmental care needs.

While physical contact between healthcare workers (HCWs) and adult patients is routine, the care needs of pediatric patients required additional contact. Feeding, holding and playing with children—along with cleaning secretions and changing diapers—require frequent and very close contact with HCWs and other caregivers, including parents who may also fulfill the role of care provider, and family members such as siblings.[7] Establishing partnerships with patient families, in conjunction with providing audience-appropriate health education, is an important component of managing MDR Ab.

Single rooms mitigate the risk of infectious disease transmission and are recommended by The American Institute of Architects 2006 Guidelines for Design and Construction of Health Care Facilities.[8] Non-single patient rooms may become crowded with family, HCWs and visitors. Over time, a patient room may become cluttered with the belongings of family, toys and "get-well" gifts, making thorough cleaning difficult and creating fomites and reservoirs via contamination by MDR Ab. Consider working with the families and the patient to coordinate room re-organization to clean and reduce clutter. In order to facilitate this, it may be necessary to transfer a patient to another room.

Other opportunities for contamination and acquisition may occur during out-of-room therapies and services such as Child Life, spending time in shared rooms and activity centers, attending group functions and school, and visiting gym areas and lactation rooms.[7] Education and collaboration with the patients' care providers such as teachers, physical therapists and social services will enhance sustained mitigations necessary to prevent and control an outbreak.

Pediatric risk factors for colonization and infection by MDR Ab tend to be the same as for adult populations. The exception is in neonate populations, patients with limited vascular access, and those with intense contact with care providers and the environment. As in adult settings, admission to a unit with endemic MDR Ab, prolonged exposure to antimicrobial agents, invasive procedures, underlying conditions and diseases, indwelling and invasive

medical devices and host factors also play a role in colonization and infection.[1, 3, 5, 9, 10] Medically complex populations in the outpatient and ambulatory setting should also be assessed for risk of colonization and infection based on population and setting.[4]

Unfortunately, the availability of appropriate pediatric antibiotics is jeopardized by emerging strains of *Acinetobacter* that are resistant to many commercially available antibiotics.[11]

Neonates

Numerous MDR Ab outbreaks have occurred in neonatal intensive care units (NICU) internationally. These outbreaks have primarily affected patients with low birth weight and preterm neonates within the first four weeks of life who were residing in the NICU.[6]

The paper by Simmonds et al.[6] of an MDR Ab outbreak among extremely low birth weight neonates following the transfer of an extremely premature neonate from a referring hospital describes how it was successfully stopped. Over an outbreak period of 22 days, there were seven patients involved and four patient deaths. All seven patients were ≤750 g extremely low birth weight neonates, who had been born at ≤26 weeks gestational age and were ≤7 days postnatal age at time of exposure.6 In addition to enhanced infection control strategies, three spatially separated cohorts were established. The cohorts included 1) colonized or infected patients, 2) exposed patients, and 3) non-exposed patients. Equipment and care providers were assigned to each cohort. Surveillance cultures were collected at regular intervals from perianal areas, neck-skin folds and tracheal or nasopharyngeal cultures. Exposed and positive patients were managed in contact isolation. Suspect cases prompted consultation with infectious disease and infection control personnel. Compliance with measures was accomplished by observational monitoring, including environmental cleaning. All personnel providing services in the NICU were educated.[6] Transmission via direct and indirect contact modes was successfully interrupted by the measures taken during this outbreak.

Rapid cohorting is essential, because MDR Ab can spread rapidly in the NICU setting due to the environmental persistence of MDR Ab, multiple hosts with immature immune systems, underdeveloped skin, congenital anomalies and prolonged hospitalizations. In addition, infants may have limited vascular access, and catheters may remain in place for extended periods.[5] Further study is warranted to better understand transmission potential due to co-bedding or kangaroo care.[5]

Environment

As part of their development, children interact closely with their environment.[7] Both the environment and the hands of HCWs can become contaminated and serve as reservoirs for MDR Ab. Pathogenic bacteria have been recovered from toys in hospital and other healthcare settings.[1,12–16] Toys have the potential to transmit MDR Ab; therefore, procedures for cleaning and disinfection are required. There must be cleaning procedures for other toy-like items such as floor mats, laptops, mobiles and distraction devices used by Child Life.

In pediatrics, clean floors are important, because young children may spend time on them.[17] Lactation equipment and rooms, baby scales and other equipment can become contaminated;and therefore, require procedures to clean between patients.[4,17] As in the adult setting, environmental contamination of surfaces and equipment contribute to transmission of MDR Ab. A system for monitoring the effectiveness of cleaning should be developed and implemented.[4, 17]

Interfacility patient transfer is a recognized method of introducing MDR Ab into an institution.[9] Patients, equipment and staff that move between facilities can spread MDR Ab. Establish referral hospital communications

to prepare for transfer of a known MDR Ab colonized or infected patient. Plans should be implemented to identify, clean and disinfect equipment from outside hospitals. Staff such as moonlighters, specialists and students should receive documented education on the institution's prevention measures.

Infection Prevention and Control

The prudent practice of infection prevention and control measures mitigate colonization of HCW staff and contamination of the environment.[6,9] A plan for controlling the spread and preventing the establishment of an endemic MDR Ab strain should be developed.[1,4]

Outbreaks of MDR Ab are difficult to control, because patients may become colonized or infected, and environmental contamination can persist. [6,9] Surveillance methods should be identified and implemented for early recognition of the presence of MDR Ab.

As in the adult setting, contact isolation precautions are used to interrupt transmission. To the child and caregiver, the use of masks, which hide facial expressions, can be scary, inhibit communication and prevent visualizing expressions of concern and care. Gowns may draw attention and embarrass the family or patient by being ill fitting or brightly colored. Development of family and patient isolation education, communication and support are important to minimizing challenges associated with the use of personal protective equipment.

Special Settings: Pediatrics References

[1] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S65-164.

[2] National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. Am J Infect Control. 2004 Dec;32(8):470-485.

[3] Smith MJ. Catheter-related bloodstream infections in children. Am J Infect Control. 2008 Dec, 36(10):S173.e1-3.

[4] Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S165-193.

[5] Long SS, Pickering LK, Prober CG. Principles and practice of pediatric infectious diseases. 3rd ed. Philadelphia, PA: Churchill Livingstone Elsevier; 2008.

[6] Simmonds A, Munoz J, Aguero-Rosenfeld M, Carbonaro C, Montecalvo M, Clones B, LaGamma EF: Outbreak of *Acinetobacter* infection in extremely low birth weight neonates. Pediatr Infect Dis J. 2009;28(3):210-214.

[7] Posfay-Barbe KM, Zerr DM, Pittet D. Infection control in paediatrics. Lancet Infect Dis. 2008;8(1):19-31.

[8] Facility Guidelines Institute, Academy of Architecture for Health: 2010 Guidelines for design and construction of health care facilities. Washington, DC: American Institute of Architects.

[9] Fournier PE, Richet H. The epidemiology and control of Acinetobacter baumannii in health care facilities. Clin Infect Dis. 2006 Mar 1,42(5):692-699.

[10] Simon A, Bode U, Beutel K. Diagnosis and treatment of catheter-related infections in paediatric oncology: an update. Clin Microbiol Infect. 2006:12(7):606-620.

[11] Munoz-Price LS, Weinstein RA. *Acinetobacter* infection. N Engl J Med. 2008; 358:1271-1281.

[12] Randle J, Fleming K. The risk of infection from toys in the intensive care setting. Nurs Stand. 2006;20(40):50-54.

[13] Naesens R, Jeurissen A, Vandeputte C, Cossey V, Schuermans A. Washing toys in a neonatal intensive care unit decreases bacterial load of potential pathogens. J Hosp Infect. 2009 Feb;71(2):197-198. Epub 2008 Dec 18.

[14] Little K, Cutcliffe S. The safe use of children's toys within the healthcare setting. Nurs Times. 2006;102(38):34-37.

[15] Fleming K, Randle J. Toys – friend or foe? A study of infection risk in a paediatric intensive care unit. Paediatr Nurs. 2006;18(4):14-18.

[16] Buttery JP, Alabaster SJ, Heine RG, Scott SM, Crutchfield RA, Bigham A, Tabrizi SN, Garland SM: Multiresistant *Pseudomonas aeruginosa* outbreak in a pediatric oncology ward related to bath toys. Pediatr Infect Dis J. 1998;17(6):509-513.

[17] Hota B. Contamination, disinfection, and cross-colonization: are hospital surfaces reservoirs for nosocomial infection? Clin Infect Dis. 2004;39(8):1182-1189.

[18] Youngster I, Berkovitch M, Heyman E, Lazarovitch Z, Goldman M. The stethoscope as a vector of infectious diseases in the paediatric division. Acta Paediatr. 2008;97(9):1253-1255.

Appendix A: Multidrug-resistant *Acinetobacter baumannii (MDR Ab)* Surveillance Line Listing

Patient Name	DOB	M/F	Unit/ Room	Admitted From	Date Admitted	Date of first positive MDR Ab Culture	Site of Infection/ Colonization with MDR Ab	Date Transferred to Another Facility/ Name of Facility	Risk Factors Invasive Devices Procedures/ Dates

Reference: Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. Management of multidrug-resistant organisms in healthcare settings, 2006. Available at: http://www.cdc.gov/ncidod/dhqp/pdf/ar/mdroGuideline2006.pdf. 2006.

Appendix B: Safe Donning and Removal of Personal Protective Equipment (PPE)

DONNING PPE

GOWN

- Fully cover torso from neck to knees, arms to end of wrist, and wrap around the back
- Fasten in back at neck and waist

MASK OR RESPIRATOR

- Secure ties or elastic band at middle of head and neck
- Fit flexible band to nose bridge
- Fit snug to face and below chin
- Fit-check respirator

GOGGLES/FACE SHIELD

- Put on face and adjust to fit

GLOVES

- Use non-sterile gloves for isolation
- Select according to hand size
- Extend to cover wrist of isolation gown

REMOVING PPE

Remove PPE at doorway before leaving patient room, or in anteroom

GLOVES

- Outside surfaces of gloves are contaminated!
- Grasp outside of glove with opposite gloved hand; peel off
- Hold removed glove in gloved hand
- Slide fingers of ungloved hand under remaining glove at wrist

GOGGLES/FACE SHIELD

- Outside surfaces of goggles or face shield are contaminated!
- To remove, handle by "clean" head band or ear pieces
- Place in designated receptacle for reprocessing or in waste container

GOWN

- Gown front and sleeves are contaminated!
- Unfasten neck, then waist ties
- Remove gown using a peeling motion; pull gown from each shoulder toward the same hand; gown will turn inside out
- Hold removed gown away from body, roll into a bundle and discard into waste or linen receptacle

MASK OR RESPIRATOR

- Front of mask/respirator is contaminated – DO NOT TOUCH!
- Grasp ONLY bottom, then top ties/elastics and remove
- Discard in waste container

HAND HYGIENE

- Perform hand hygiene immediately after removing all PPE!

Reference:

Siegel JD, Rhinehart E, Jackson M, Chiarello L. Healthcare Infection Control Practices Advisory Committee. 2007 Guidelines for isolation precautions: preventing transmission of infectious agents in healthcare settings. Available at: http://www.cdc.gov/ncidod/dhqp/pdf/guidelines/isolation2007.pdf.

Appendix C: Patient/Visitor Education about Multidrug-resistant *Acinetobacter baumannii* (MDR Ab)

Acinetobacter (as-i-ne´tō-bak´ter) is a group of bacteria commonly found in soil and water. It can also be found on the skin of healthy people. *Acinetobacter* species are bacteria that can live for long periods of time in the environment. However, if this organism enters the body where it is not normally found, it may cause serious illness.

Not everyone will get an infection from this organism. Healthy people rarely get serious infections from this organism. *Acinetobacter* infections rarely occur outside of healthcare settings. Persons most likely to become ill are:

- Patients who are in the hospital a long time
- Patients who have taken many antibiotics used to kill bacteria
- Patients who are taking medications or have a disease that affects the body's ability to fight infection
- Patients who have been in a nursing home or long-term care setting
- Patients who are on ventilators or machines that help them to breathe
- Patients who are very seriously ill

"Drug-resistant" or "multidrug-resistant" means that the organism has developed a means of fighting or resisting the antibiotics usually used to kill them. Infections then become more difficult to treat.

Acinetobacter can live on the skin and may survive in the environment for several days. **Hand hygiene, the most important infection prevention procedure**, must be performed to prevent spreading the organism from person to person, and from infected objects in the patient's room.

Hand Hygiene Basics for Patients and Visitors:

- Wash your hands with soap and water for 15–20 seconds or use an alcohol hand rub.
- Use the alcohol hand rub as long as you do not have dirty hands.
- If you have dirty hands, use soap and water to clean them.
- Clean your hands before you eat.
- Clean your hands after you use the bathroom or bedpan.
- Clean your hands before you leave your room.
- Family and visitors should clean their hands before they enter and leave your room.
- Family /visitors should clean their hands if they help care for you, and before they eat.
- Do not hesitate to ask staff, family or visitors to wash their hands.

Appendix D: Daily High Touch Cleaning Checklist

Multidrug Resistant *Acinetobacter baumannii*

Environmental Cleaning

Daily cleaning of high touch areas

Area	Yes	No	Comments/ Reason not done
Door knobs			
Bedrails			
Light switches			
Bathroom faucet handles			
Toilet flush Handles			
Wall area around the toilet			
Remote controls			
Phone			
Overbed Tables			
Bedside Stands- top and drawer handles			
Medical Equipment			May be assigned to other personnel such as nurses or Respiratory Services
Call Light Controls			

References:

[1] Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC) 2003 pages 75, 83

[2] Practice Guidance for Healthcare Environmental Cleaning. American Society for Healthcare Environmental Services (ASHES) Patient Room –Occupied Pg 68