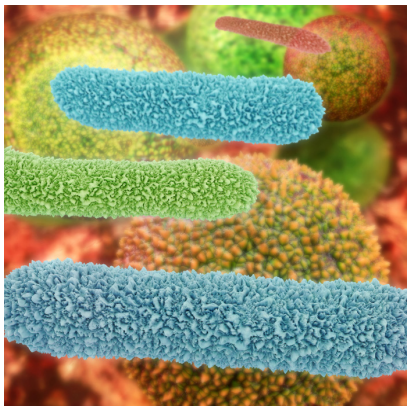
"Hospital Acquired Infections"

August 2014

Hospital Acquired infections continue to be a significant issue, and necessitates periodic reviews & updates. Our goal in this lesson is to describe this challenging & significant problem. The objectives of this lesson are such that upon completion:



Pharmacists will be able:

1. Discuss the important nosocomial infections.
2. Interpret pathophysiology & microbiology associated with HAIs.
3. Relate preventable measures to reduce HAIs.

Technicians will be able to:

1. Understand the meaning of "Nosocomial Infections."
2. Relate biological issues represented by nosocomial infections.
3. Describe general treatment methods for nosocomial infections.

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INTRODUCTION

Hospital-acquired Infections (HAI) or nosocomial infections are infectious complications that patients acquire from a hospital stay. These can be devastating and even fatal. In a recent prevalence study, it was found that there were over 700,000 HAIs in United States acute care hospitals in 2011, with over 75,000 patients dying from these infections. The most common infections were pneumonia (22%) and surgical site infections (22%), but closely followed by gastrointestinal infections (17%), urinary tract infections (13%) and blood stream infections (10%). Over half of the HAIs occurred outside of the intensive care unit. The most common causes of these infections were *Clostridium difficile* (12%), methicillin-resistant *Staphylococcus aureus* (MRSA) (11%), Klebsiella (10%), *Escherichia coli* (9%), Enterococcus (9%), and Pseudomonas (7%).(1) The annual direct medical costs associated with HAIs range from 35 to 45 billion dollars. (2) The infections related to transmitted organisms in the hospital environment are considered to be preventable and certain infections are no longer reimbursable by the center for Medicare and Medicaid Services (CMS).

During the past decade, there has been increased awareness and efforts of understanding and preventing infections in the hospital environment. Transmission within a healthcare setting requires the interplay of three elements: (1) the source of the infectious agent, (2) the susceptible host with a portal entry receptive to the organisms and (3) a mode of transmission for the infectious agent. The Center for Disease Control and Prevention (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC) have published guidelines to promote the prevention of transmitting infectious agents in the healthcare setting to patients.(3) These guidelines are the standard of care for all institutions including hospitals, long-term facilities, ambulatory settings and home care. The hospital environment is filled with pathogenic organisms. These organisms can be found on the hands of healthcare providers, on doorknobs, keyboards, or even on medical equipment. The human reservoirs include patients, healthcare providers and household members and visitors. The source individuals may have an active infection, or may be colonized (either transiently or chronically) with pathogenic organisms. Infection with pathogenic organisms is a complex interplay between the host and the infectious agent. Some hosts are susceptible to symptomatic disease from exposure to pathogenic organisms, whereas some hosts remain asymptomatic. The immune status of the patient at the time of the exposure to an infectious agent, interaction between pathogen, and the virulence factors are important predictors of an individual's outcome. Underlying patient factors such as age, co-morbid conditions, immune status, malignancy and transplants can increase the susceptibility to infection. Medications that alter endogenous gastrointestinal flora (i.e. antimicrobial agents, gastric acid suppression, corticosteroids, immunosuppressive drugs, and chemotherapeutic agents) can also increase a patient's risk to develop an infection. The skin is also an important defense to prevent infections; surgical procedures and radiation therapy may impair this defense. Indwelling devices such as urinary catheters, endotracheal tubes, central venous and arterial catheters and synthetic implants allow the development of nosocomial infections by allowing the organisms to bypass the natural defenses. The foreign devices provide surfaces that facilitate the development of biofilms. Biofilms provide a surface that allow the adherence of microorganisms and often prevent antimicrobial activity. Infections associated with an invasive procedure or device is a result of either the patient's endogenous flora or transmission from within the healthcare facility.

INFECTION CONTROL IN THE HOSPITAL SETTING

The hospital environment plays a crucial role in exposing patients to various microorganisms. Because pathogens can be found on the hands of healthcare workers and in the hospital surroundings, multiple measures have been studied to reduce this burden and subsequently lower the rates of nosocomial infections. (3).

HAND HYGIENE

Adherence to appropriate infection control practices decreases transmission of pathogens. One key measure of infection control is proper hand hygiene. It is an essential part of "Standard Precautions." The details of Standard Precautions can be found in the CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC) guidelines (3). Hand hygiene includes both hand washing with soap, plain or antiseptic, and use of alcohol-based products that do not use water. Alcohol-based products used for hand disinfection are preferred over soap and water because of their superior microbial activity, reduced drying of the skin and convenience. It is important to note that certain organisms are resilient to the alcohol-based products such *C.difficile*. Hand washing with soap and water is recommended over alcohol-based products when taking care of patients with *C.difficile* infections. (3) Adherence to hand hygiene practices has been associated with decreased incidence of resistant organisms, including methicillin-resistant *S.aureus* (MRSA) and Vancomycin-Resistant *Enterococcus* (VRE). (4) In addition to hand hygiene, isolating patients that are colonized with resistant organisms and thorough environmental cleaning are essential to preventing avoidable transmission of nosocomial infections.

The Center for Medicare and Medicaid Services (CMS) will no longer reimburse additional payments for four HAIs which include catheter-related bloodstream infections (CrBSI), Ventilator-associated pneumonia (VAP), surgical site infections (SSI) and catheter-associated urinary tract infections (CA-UTI). This has provided motivation for the healthcare administrators to provide additional resources for guidelines and preventive measures.

VENTILATOR-ASSOCIATED PNEUMONIA (VAP)

Epidemiology

VAP contributes to a high morbidity and mortality in US hospitals. It is estimated that VAP affects 52,000 patients per year in the United States with the mortality rate ranging from 30-70%.(5,6) VAP is associated with increased hospital stays of 7 to 9 days per patient and increases costs to over $40,000 per patient (6).

Definition

Ventilator-associated pneumonia (VAP) is pneumonia in a patient who is mechanically ventilated. Definitions of VAP vary amongst organizations. The CDC and NHSN definitions are complex but they tend to follow clinical guidelines. In general, the signs and symptoms for VAP include fever, chills, malaise, purulent respiratory secretions, rhonchi, leukocytosis, an infiltrate on a chest X-ray and impaired oxygenation and ventilation. Blood cultures may be positive but have a low sensitivity (25%) because the organisms may originate from another source. The diagnosis of VAP is made from respiratory tract culture obtained from the upper or lower airways. A sterile culture from a lower tract (i.e. bronchoscopy, brochoalveolar lavage or protected brush specimen sample) is often preferred because tracheal colonization can

contaminate sputum cultures. (5,6)

Pathogenesis, Microbiology and Treatment

The majority of VAP cases are caused by aerobic gram-negative bacilli, specifically *Acinetobacter* species, *Pseudomonas aeruginosa, E. coli, Klebsiella* species and others. The remaining cause of VAP is *Staphylococcus aureus*. Empiric treatment is guided by local patterns of microbial susceptibility and risk factors for multi-drug resistant organisms. Risk factors for MDR (multiple drug resistant) organisms include antimicrobial therapy in preceding 90 days, current hospitalization of 5 days or more, high frequency of antibiotic resistance in the community or specific hospital location, or immunosuppressive disease and/or therapy. A regimen recommended by the America Thoracic Society (ATS) guidelines includes an anti-pseudomonal antibiotic (e.g. ceftazidime cefepime, ciprofloxacin, piperacillin-tazobactam, meropenem or imipenem) in combination with an antibiotic effective against MRSA (e.g. linezolid or vancomycin). (6) Once definitive cultures return, antibiotic therapy should be tailored to the narrowest possible spectrum. The optimal duration of VAP in adult patients is 8 days. Chastre et al, compared 8 days of therapy versus 15 days for VAP in a prospective, randomized, double-blind trial. (7) Excess mortality, length of ICU stay, and recurrent infections were not different between the groups, excluding patients with pseudomonal infections. Patients with pseudomonal infections receiving 8 days of therapy had higher recurrence rate compared to those patients receiving 15 days of therapy. Based on this trial, the standard of care is 8 days of antibiotics for VAP except for pseudomonal infections which requires 15 days.

The pathogenesis of VAP is a fine balance between host defenses and microbial colonization and invasion. (5,6) The microorganisms must persist and invade the lower respiratory tract in order to cause VAP. Healthcare devices or the environment including air, water and other fomites can serve as the source of the infections. The transfer of microorganisms between staff and patients can also serve as a source for infections. The entry of microorganisms into the lower respiratory tract can occur when a patient aspirates oropharyngeal pathogens or bacteria around the endotracheal cuff and they leak into the trachea. (6)

Prevention

Preventative measures are targeted towards the pathogenesis of VAP. First and foremost, intubation and mechanical ventilation should be avoided whenever possible and non-invasive ventilation should be used when clinically appropriate. (6,8) If patients are intubated, the duration of ventilation should be minimized. Assessments for readiness to wean ventilation should be performed daily. Many institutions have weaning protocols and guidelines that focus on minimizing sedation administration. These measures shorten exposure to the endotracheal tube and aspiration of contaminated secretions. Maintaining patients in a semirecumbent position (30-45° elevation of the head of the bed) reduces the risk of aspiration. In a multivariate analysis for risk factors for VAP, patients who maintained semirecumbency during the first 24 hours of mechanical ventilation reduced their risk for VAP by 67%. (8)

The progression of the oropharyngeal colonization to tracheobronchitis to pneumonia is a dynamic process. Oropharyngeal colonization is an independent risk factor for the development of VAP. Several strategies have been tested to reduce colonization such as the administration of prophylactic antibiotics, routine use of oral chlorhexidine, gastric acid suppression for stress ulcer prophylaxis, and selective decontamination of the digestive tract.

Acid suppressive therapy may increase colonization with potential pathogenic organisms. Several randomized trials have provided controversial results on the benefits of routine stress ulcer prophylaxis with either sucralafate or H2-antagonists to prevent VAP. (6,8) The American Thoracic Society recommends either sucralafate or H2-antagonists for those patients at risk for stress bleeding. (6) Routine oral care with chlorhexidine to reduce the oropharyngeal colonization is recommended by the Infectious Disease Society of America.(8) Routine systemic antibiotics and selective decontamination of the digestive tract strategies to prevent VAP are not recommended by the Infectious Disease Society of America (IDSA) or ATS guidelines. Lastly, the CDC recommends infection control strategies that include proper hand-hygiene to eliminate contamination from healthcare workers to patients. Institutions are recommended to monitor adherence to these national guideline in order to minimize the incidence of VAP.

CATHETER-ASSOCIATED URINARY TRACT INFECTIONS

Epidemiology

Urinary tract infections (UTI) are a common nosocomial infection. They are estimated to cause 449,334 infections each year in the United States. (5) A majority of the UTIs are caused by instrumentation, namely catheterization, of the urinary tract. Catheter-Associated Urinary Tract Infections (CA-UTI) are associated with increased morbidity, mortality and costs. (9) Attributed costs associated with CA-UTI add $800 per patient case, and overall contribute nationally to $450 million in hospital costs in the United States. (5)

Definition

An indwelling catheter is a drainage tube that is inserted into the urinary bladder through the urethra which is connected to a closed collection system. (10) This is also known as a Foley catheter. Alternative methods can be employed such as intermittent catheters, or external catheters or a surgically inserted suprapubic catheter. CA-UTIs that are reported to the National Healthcare Safety Network (NHSN) only refer to the indwelling catheters. UTIs can be classified into 3 categories: symptomatic, asymptomatic and others. Asymptomatic bacteriuria (ASB) is a condition in which a patient with or without an indwelling catheter has no signs or symptoms of infection (i.e. no fever, urinary urgency, dysuria, suprapubic tenderness or costovertebral angle pain), but they do have a positive urinary culture with no more than two uropathogens. Uropathogens include gram-negative bacilli, *Staphylococcus* spp, yeasts, beta-hemolytic *Streptococcus* spp, *Enterococcus* spp, *G.vaginalis, Aerococcus urinae* and *Corynebacterium* (urease positive). (9,10) Treatment of ASB has not shown to be beneficial and contributes to the presence of antimicrobial-resistant organisms and *C.difficile* infections. (10) Often ASB can be treated with removing the indwelling catheter without use of systemic antibiotics.

CA-UTI is defined by the CDC as a patient with an indwelling urinary catheter at the time of specimen collection and at least one sign or symptom without another recognized cause (fever, suprapubic tenderness, or costovertebral angle pain or tenderness and a positive urine culture (>105 colony-forming units/ml) with no more than 2 species of microorganisms. (9,10) A patient can have a CA-UTI after the Foley catheter has been removed; therefore, the CDC provides an alternate definition for those patients. Patients who had a Foley catheter removed within 48 hours prior to specimen collection and at least one of the following signs or symptoms without another recognized cause (fever, urgency, frequency, dysuria, suprapubic tenderness,

or costovertebral angle pain or tenderness and a positive urine culture (>105 colony-forming units/ml) with no more than 2 species of microorganisms).

Pathogenesis, Microbiology and Treatment

CA-UTIs are caused by microorganisms found in the meatal, rectal or vaginal areas. (9,10) They can also be caused by an exogenous source such as contaminated hands of healthcare providers or equipment. The bacteria can enter the urinary tract either by an extraluminal route by migrating along the outside of the catheter. The bacteria can also move along the internal lumen of the catheter from the contaminated collection bag. The pathogens that most frequently cause CA-UTIs include *E.coli, Candida* spp, *Enterococcus* spp, *Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Enterobacter* spp. The bacteria can form a biofilm (matrix of sessile microorganisms and host proteins) on the surface of the catheter and drainage system which universally occurs with prolonged duration of catheterization. The bacterial biofilm is resistant to antimicrobials and host defenses; they are impossible to eradicate unless the catheter is removed. (10) Therefore, the mainstay of treatment for CA-UTIs is catheter removal and appropriate targeted antimicrobial therapy. (5) Antimicrobial irrigation is not recommended.

Prevention

The key to preventing CA-UTI is judicious use of an indwelling catheter. It is estimated that 1 in 5 hospitalized patients have a catheter placed. (5) Indwelling catheters should only be used for select indications, such as: patients with acute urinary retention or bladder outlet obstruction, critically ill patients who require assessment of urinary output, patients who had selected surgical procedure (e.g. urology procedures, prolonged duration of surgery, etc), patients who require assistance with healing of open sacral or perineal wounds in incontinent patients, or patients who require prolonged immobilization. (10) The CDC guidelines emphasize that indwelling catheters should not be used as a substitute for nursing care, as a means of obtaining urine for culture or other diagnostic tests when a patient can voluntarily void, or for prolonged postoperative duration without appropriate duration. Patients with an indication for an indwelling catheter should have it removed as soon as possible, preferably within 24 hours if clinically appropriate. In addition, educational guidelines should emphasize sterile insertion technique, maintenance practices that keep the collection bag below the bladder to avoid reflux and preventing breaks in the collection system. A recent study conducted at the Minneapolis VA facility demonstrated that a multi-faceted approach including education, system redesign, rewards and feedback and involvement of a dedicated Foley catheter nurse significantly reduced inappropriate Foley catheter infection. (11) System-wide strategies to reduce CA-UTI have been recently reviewed by the Society of Healthcare Epidemiology and IDSA. (12) Strategies include development of guidelines for catheter use, insertion and maintenance, ensuring that only trained personnel insert urinary catheters and performing surveillance for CA-UTI.

SURGICAL SITE INFECTION

Epidemiology

Surgical site infections (SSIs) contribute to 17% of all HAIs, second to CA-UTIs. It is estimated that SSIs occur in 2-5% of patients undergoing inpatient clean (extra-abdominal) surgeries and up

to 20% of patients undergoing abdominal surgeries. (13, 14) Patients with SSIs have increased morbidity and mortality; they have up to 11 times higher risk of death. Surgical site infections cost an additional $3,000 to $29,000 per case depending on the procedure and pathogen. The costs attributed to SSIs are up to $10 billion annually in the United States. (5, 14)

Definition

Surgical site infections are classified by the infected site; they are superficial incisional (involving the skin or subcutaneous tissue), deep incisional (involving the fascia and/or muscular layers), or organ space. Surgical site infections often have positive bacterial cultures from the infected site (i.e. tissue or fluid) and often have purulent drainage. In general, the majority of SSIs are found within 48 hours of the surgical procedure. (13, 14)

Pathogenesis, Microbiology and Treatment

Many SSIs are a result of the invasion of microorganisms into the surgical site at the time of the operation. The pathogens may come from the patient's own flora, seeding from a distant focus of infection, or other exogenous sources, such as surgical personnel, the operating room environment and ventilation or surgical tools and equipment. (5, 11) The risk for SSI is a complex interplay between the microbial, patient, and surgical characteristics. Certain individual characteristics place patients at a higher risk for postoperative infections, such as advanced age, presence of diabetes mellitus, smoking status, nutritional status, body mass index, immunosuppression, and other co-morbid conditions (renal and hepatic failure). In addition, the characteristics of the surgery (i.e. the type of surgery, introduction of foreign material and amount of tissue damage) can affect the risk for SSIs. (13)

Staphylococcus aureus remains the most common microorganism isolated from SSIs from clean procedures. Other endogenous organisms may be involved in SSIs that may be present at the surgical site or resected organ (i.e. gastrointestinal, gynecological, respiratory tract). (5, 15)

Treatment

The mainstay for treatment is drainage of the infected wound, supplemented by wound care. (5). Systemic antimicrobial therapy should be administered and should be targeted to the isolated organism. Wound sponges with suction (vacuum-assisted closure (VAC)) have been used to assist with wound closure and maintenance.

Prevention

Many preventive measures have been reported to reduce the rate of complications associated with SSI. (5, 13) Many organizations (CMS and Surgical Infection Prevention Collaborative) joined together to improve adherence to the best practices for avoiding SSIs. Three performance measures for quality improvement strategies related to antimicrobial therapy have been instituted: delivery of intravenous antimicrobial prophylaxis within 1 hour before incision (2 hours before incision for Vancomycin and fluoroquinolones); the use of antimicrobial prophylactic agents consistent with published guidelines; and discontinuation of the use of the prophylactic agent within 24 hours after the surgery. Updated guidelines were published recently which detail the appropriate dosing and selection for specific procedures. (14) In addition to these pharmacological interventions, the Surgical Infection Prevention Collaborative recommended

three additional process measures to prevent SSIs. These include: proper hair removal (avoid razors for hair removal); controlling blood glucose level during immediate postoperative period; and maintenance of perioperative normothermia. (5, 13, 15).

CATHETER-RELATED BLOODSTREAM INFECTION (CrBSI)

Epidemiology

Intravenous catheter use in the nosocomial setting is common. It is estimated that central venous catheter use exceeds 15 million catheter-days each year in the United States. (5) Central line-associated bloodstream infections (CLABSI) are the majority of the infections in this group, with approximately 92,000 cases per year. The costs related to CLABSI are estimated to be $25,000 to $45,000 per case. As with other nosocomial infections, CLABSI are associated with increased length of hospital stay and costs, but they have not been associated with increased mortality. (5, 17)

Definitions

CrBSIs are defined when microbiologic and clinical symptoms suggest the catheter as the source of the infection. Some signs and symptoms of CrBSIs include: both local (e.g. erythema, induration, purulence and tenderness at catheter site) and systemic signs of infection (e.g. fever and leukocytosis). Some patients may only have the systemic signs and symptoms. Central-line associated bloodstream infections may be considered in a patient who has had surgery within 48 hours prior to the development of the BSI, and it is unrelated to another source of infection. (5, 17)

Pathogenesis, Microbiology and Treatment

CrBSIs are caused by translocation of skin flora along the surface of the catheter. Bacteria can also be introduced by direct contamination of the catheter or catheter hub by contact with hands or contaminated fluids or devices. (17) Less often, the catheters may become hematogenously seeded from another focus of infection or rarely contaminated infusate might lead to CrBSI. Often the bacteria develop a biofilm which may be impermeable to antibiotics and evades the immune system. The most common causative microorganisms remain to be coagulase-negative staphylococci, *Staphylococcus aureus*, enterococci and *Candida* spp. Gram-negative organisms also cause CLABSI. As with other nosocomial infections, antimicrobial resistance is a continued problem limiting our treatment options (17)

The mainstay of CrBSI treatment is the removal of the catheter, except for those caused by coagulase-negative *Staphylococcus*. CrBSI caused by fungi, *S.aureus* or gram-negative bacilli should be treated with systemic antimicrobials and removal of the catheter. Antibiotic therapy should be narrowed to the isolated organism. The duration of therapy can range from seven to ten days up to 4-8 weeks, if there is a complicated infection (i.e. infected thrombus, endocarditis, or osteomyelitis). (5)

Prevention

CrBSI can be reduced by improving education and training, appropriate staffing and the use of process checklists. The appropriate site selection (i.e. avoiding the femoral site), hand hygiene, aseptic technique and use of antiseptic skin preparations are essential. In addition, careful and appropriate catheter site care is essential to avoid CrBSI. (17).

C.difficile INFECTION

Clostridium difficile infection (CDI) remains a leading source of morbidity and mortality among hospitalized patients. Since its original description as the cause of pseudomembranous colitis (18,19), CDI has presented significant challenges in terms of the prevention, diagnosis, and treatment of this infection.

The reported incidence of *C. difficile* infection has risen dramatically since the 1990s. In the mid 1990s, the reported incidence of CDI in acute care hospitals in the United States was

30 to 40 cases per 100,000 population and rose to almost 50 cases per 100,000 in 2001, and up to 84 cases per 100,000 in 2005. In addition to the rise of endemic CDI, there have been multiple outbreaks in many medical centers, both nationally and internationally. Not only is the increase in the number of cases concerning, but the disease severity and mortality are alarming as well.(20)

Definition

Clostridium difficile is a spore-forming, obligate-anaerobic, gram-positive rod bacterium. It earned the name "difficile" because of the difficulty with which microbiologists originally cultivated this species.(21) This organism is usually a harmless commensal of the GI flora.

Some patients who harbor toxigenic strains of *C. difficile* in their GI tract will develop clinical illness, usually when they are treated with antimicrobials for other conditions. This illness may occur anywhere on a spectrum that spans from mild-moderate disease (watery diarrhea with or without abdominal pain or cramping) to severe disease (significant leukocytosis, hypovolemia, or fever), to severe disease with complications (toxic megacolon-induced ileus, intestinal perforation, bacteremia, or sepsis).

Pathogenesis, Microbiology and Treatment

Antimicrobial therapy plays an integral role in the pathogenesis of CDI by altering the normal flora of the colon and allowing toxigenic *C. difficile* to flourish. Almost all antimicrobials have been associated with CDI, but the drugs most commonly implicated include clindamycin, third-generation cephalosporins, penicillins, TMP/SMX, and fluoroquinolones. As little as one dose of an antibiotic can increase the risk of CDI, and this increased risk may continue for up to eight weeks after discontinuing the drug. (22)

Another risk factor is exposure to settings where the organism is present, such as hospital environment or long-term care settings. Due to spore-forming capabilities, it is resistant to commonly used disinfectants, such as alcohol. Hand washing with soap and water is the preferred method of prevention in the healthcare setting, but should be supplemented with environmental cleaning with disinfectants with known activity against *C.difficile*. Evidence suggests that antimicrobial stewardship programs that alter prescribing patterns of antimicrobials in a hospital setting can reduce the incidence of CDI. (23)

Diagnosing CDI in a timely fashion is necessary for the overall management of nosocomial CDI.

The laboratory tests for *C. difficile* either evaluate the presence of the toxin or the presence of the organism. (24) The optimal strategy to provide the most timely, cost-effective and accurate diagnosis is still controversial. The cytotoxicity assay (or tissue culture assay) is the gold standard for diagnosis of CDI, but due to its high cost and long turnaround time, few clinical laboratories use it. Most diagnostic tests that have been developed detect the toxins A and B produced by *C. difficile*. Molecular diagnostics are also an option for laboratories. There are commercially available real-time PCR assays (Cepheid Gene Xpert, BD-GeneOhn Cdiff assay and IVD RT-PCR) that detect for the gene encoding for toxin B. Lastly, there are laboratory tests that detect the presence of *C. difficile* for the diagnosis of CDI. Because these assays detect the organism rather than the toxin, patients colonized with *C. difficile* strains without the toxin may be thought to have CDI. Stool culture is the most sensitive test, but is not used in clinical

practice, but rather for epidemiological studies. Costs and convenience issues have moved many medical centers to replace cultures with less expensive and more rapid immunoassays. Treatment is necessary for all patients with clinical disease and whose fecal analysis confirms presence of *C.difficile*. The IDSA has treatment guidelines that include oral metronidazole for mild to moderate disease, whereas vancomycin is recommended for severe disease, as indicated by high white blood cell count (> 15,000 cell/mm3) or elevated Serum creatinine. (24) The treatment duration is 10 to 14 days. Fidaxomicin is a new macrocyclic antibiotic with activity against *C.difficile* which has been FDA-approved for use in patients with CDI.(25) Fidaxomicin is significantly more expensive than oral vancomycin and metronidazole, so this may be a limitation for some patients. The IDSA guidelines were published prior to the approval of fidaxomicin, so they do not address the use of this agent in clinical practice. Patients with severe disease with complications, such as hypotension, shock, toxic megacolon, or ileus may require more aggressive treatment with a combination of intravenous metronidazole and oral vancomycin and/or rectal vancomycin. In addition to the treatment directed toward *C.difficile*, it is imperative to discontinue the inciting antibiotic, when clinically appropriate.

Prevention

Preventive strategies focus on the reduction of the overuse of antimicrobials and efforts to prevent transmission from patient to patient. Since exposure to antibiotics is the primary risk factor, antibiotics should be avoided unless absolutely necessary. If antibiotics are prescribed, the narrowest spectrum should be selected with the shortest duration possible. To prevent transmission, proper hand washing and environmental cleaning are necessary. To minimize the spread of CDI, it is essential that these measures be promptly implemented when the diagnosis is suspected, rather than waiting for its confirmation.

SUMMARY

Nosocomial infections are common and are a tremendous burden to patients and the healthcare system. The social, economic and personal costs related to nosocomial infections are overwhelming for many institutions but many researchers have demonstrated various interventions that decrease infection rates. A multi-faceted approach that includes staff education, minimizing patient risk factors and easy to understand institutional guidelines are needed to prevent nosocomial infections. This is an active area of research with advancements to patient care published frequently.

ADDITIONAL RESOURCES:

Center for Disease Control and Prevention: www.cdc.gov/hai/
Infectious Disease Society of America: www.idsociety.org
National Healthcare Safety Network (NHSN): www.cdc.gov/nhsn

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LESSON EVALUATION
Please fill out this section as a means of evaluating this lesson. The information will aid us in improving future efforts. Either circle the appropriate evaluation answer, or rate the item from 1 to 7 (1 is the lowest rating; 7 is the highest).

1. Does the program meet the learning objectives?
Discuss impact of nosocomial infections YES NO
Interpret pathophysiology of HAIs YES NO
Relate preventable measures to reduce HAIs YES NO

2. Was the program independent & non-commercial YES NO

Low Relevance Very Relevant
3. Relevance of topic 1 2 3 4 5 6 7
4. What did you like most about this lesson?_____
5. What did you like least about this lesson?_____

Please Mark the Correct Answer(s)

1. **Ventilator associated pneumonia canbe prevented by:**
   A. Minimizing days on the ventilator
   B. Maintaining a prone position
   C. Routine systemic antibiotics
   D. Bowel decontamination

2. **Treatment of asymptomatic bacteriuria is associated with:**
   A. Selection of resistant bacteria.
   B. Improved clinical outcomes
   C. Reduced costs
   D. All of these

3. **Transmission of Healthcare-acquired colonization or infection can occur via the following pathway(s):**
   A. Susceptible host with indwelling device
   B. A healthcare provider with colonization of an infectious agent
   C. Environment with an infectious agent
   D. All of these

4. **Pathogenic organisms can be found in healthcare facilities on:**
   A. Healthcare providers
   B. Doorknobs, keyboards, medical equipment
   C. Patients
   D. All of these

5. **What are the key principals of infection control?**
   A. Hand hygiene
   B. Environmental cleaning
   C. Isolating patients colonized with resistant organisms
   D. All of these

6. **Healthcare associated infections are considered preventable & are considered medical errors.**
   A. True B. False

7. **Healthcare associated infections are associated with increased healthcare expenditures in the United States.**
   A. True B. False

8. **Surgical site infections can be prevented by:**
   A. Delivery of antimicrobial prophylaxis within 1 hour before surgical incision
   B. The use of appropriate antibiotic recommended by national guidelines
   C. Discontinuation of prophylactic antibiotics within 24 hours of the procedure
   D. All of these

9. **What are the preventable strategies for *C. difficile* infections?**
   A. Using antimicrobial wisely
   B. Using antimicrobial wisely
   C. Environmental cleaning
   D. All of these

10. **CrBSIs are defined as:**
    A. Clinical symptoms suggestive of infection
    B. Local symptoms related to the catheter (swelling, purulence, tenderness of catheter site)
    C. Placement of the catheter within 24 hours of signs/symptoms of infection
    D. A & C

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