

# 8 Nosocomial Infection–Prevention and Management

**Abstract:** Nosocomial infections (NI) are among the most difficult problems confronting clinicians who deal with severely ill patients. They are becoming more alarming in 21st century as antibiotic resistance spreads. By prolonging the hospital stay of patients, NI adds significantly to the economic burden. The incidence of NI is estimated at 5-10% in tertiary care hospitals reaching up to 28% in ICU.<sup>1</sup> Ninety percent of the nosocomial infections are caused by bacteria, whereas mycobacterial, viral, fungal or protozoal agents are less commonly involved. NI is very much preventable. The prevention of NI can be done by risk stratification of patients based on type of patient and type of procedure being performed and by prevention of transmission of infection by direct contact or indirectly through airborne route or common vehicle transmission. This can be achieved by education of the hospital personnel, development of strategy for hand washing and gloving; introduction of modern approaches of automation and organization of hospital disinfection services. A multidisciplinary “Infection control committee” in a hospital with an aim to review and approve activities of surveillance to identify areas of intervention in order to prevent NI’s and ensuring adequate staff training in infection control and safety has important role in controlling NI in any hospital. The key point in management includes high index of suspicion, appropriate source control and institution of effective antimicrobial therapy based on local sensitivity pattern.

**Key words:** NI = Nosocomial Infection, HCAI = Health care-associated infection.

## INTRODUCTION

The term nosocomial infection is synonymous with hospital acquired infections. An infection is considered nosocomial if it develops in a patient who has been hospitalized for 48 to 72 hours and was not incubating the infection at the time of admission. Currently, in the United States, nosocomial infections affect more than 1.6 million patients annually leading to an overall annual cost of about \$ 4.5 billion. The CDC (Centers for Disease Control and Prevention) estimates that nosocomial infections contribute to 0.7 to 10.1% of deaths and cause 0.1 to 4.4% of all deaths occurring in hospitals. Ten to thirty percent of patients admitted to hospitals and nursing homes in India acquire nosocomial infection as against five percent in the West, according to members of Hospital Infection Society (HIS), India. This alarming situation is attributed to hospitals reluctance to invest in infection control, lack of awareness and improper waste management. In a study, conducted in intensive care units of seven Indian cities shows that the central venous catheter-related bloodstream infection (CVC-BSI) rate was 7.92 per 1000 catheter-days; the ventilator-associated pneumonia (VAP) rate was 10.46 per 1000 ventilator-days; and the catheter-associated urinary tract infection (CAUTI) rate was 1.41 per 1000 catheter-days.<sup>2</sup>

The distribution of pathogens for NI and their resistance pattern has been changing constantly and for effective management of NI constant surveillance of the organism responsible for hospital acquired infection and local sensitivity pattern is important. Moreover, hospitals provide a breeding ground for drug-resistant bacteria which can be transmitted due to poor infection control practices in the hospital.

## PREVENTION OF NOSOCOMIAL INFECTIONS

Patient is exposed to variety of microorganism during hospitalization. The infection may be caused by micro organism acquired from another person in hospital (cross-infection usually by hand) or may be caused by patients own flora (endogenous). Some organism may be acquired from an inanimate object or substance recently contaminated from other human source. The patient susceptibility is also important in causation of NI. Important patient factors include: age (extremes of age), immune status, and underlying disease (diabetes mellitus, leukemia, HIV, neoplasia), diagnostic and therapeutic interventions.<sup>3</sup> Prevention of nosocomial infections is the responsibility of all individuals and services providing health care. Everyone must work cooperatively to reduce the risk of infection for patients and staff. Infection control programs are effectively provided they are comprehensive and include surveillance and prevention activities, as well as staff training. An "Infection Control Committee" provides a forum for multidisciplinary input and cooperation, and information sharing. This committee should include wide representation from relevant disciplines, e.g. management, physicians, other health care workers, clinical microbiology, pharmacy, central supply, maintenance, housekeeping, training services. The committee must have a reporting relationship directly to either administration or the medical staff to promote program visibility and effectiveness. It has the following tasks:<sup>4</sup>

- To review and approve a yearly program of activity for surveillance and prevention
- To review epidemiological surveillance data and identify areas for intervention
- To assess and promote improved practice at all levels of the health facility
- To ensure appropriate staff training in infection control and safety.

### **Infection Control Professionals (Infection Control Team)**

Health care establishments must have access to specialists in infection control, epidemiology, and infectious disease including infection control physicians and infection control practitioners (usually nurses). In some countries, these professionals are specialized teams working for a hospital or a group of health care establishments; they may be administratively part of another unit, (e.g. microbiology laboratory, medical or nursing administration, public health services). The optimal structure will vary with the type, needs, and resources of the facility. The reporting structure must, however, ensure the infection control team has appropriate authority to manage an effective infection control program. The infection control team or individual is responsible for the day-to-day functions of infection control, as well as preparing the yearly work plan for review by the infection control committee and administration. These individuals have a scientific and technical support role: e.g. surveillance and research, developing and assessing policies and practical supervision, evaluation of material and products, control of sterilization and disinfection, implementation of training programs.

Prevention plays a major role in the control of NI. Hospital infection control committees are increasingly organized in modern hospitals to advice regarding the control and prevention of NI. Many preventive measures have been recommended. These include isolation policies, administrative measures and hospital epidemiology surveillance. These measures are applied to reduce morbidity, length of hospital stay, mortality and hospital costs.<sup>1</sup>

Among the published guidelines three main approaches are as follows:

1. Elimination of Endogenous nosocomial pathogens to reduce oropharyngeal, intestinal and skin colonization.
2. Use of methods to prevent cross contamination and to control various sources of nosocomial pathogens that can be transmitted from patient to patient or from personnel to patient i.e. hand washing, proper disinfection and care of catheters, respiratory equipments, humidifiers, endotracheal tube and dialysis systems.
3. Use of antibiotic prophylaxis in post-operative and high risk patients (burn patients, patients in ICUs etc.). Aerosolized polymyxin-B and/or endotracheal aminoglycosides can be given to

prevent *Pseudomonas* and/or *Acinetobacter* pneumonia which have the highest mortality rates.

Some basic practical points that need to be emphasized include.

## **Hand Washing**

Hand washing is the single most important preventive strategy and remains the cornerstone of infection control. The normal microbial flora of the skin helps to prevent colonization of hospital-acquired microorganisms. Skin flora is composed of resident and transient micro-organisms. In general, resident microorganisms tend not to be highly virulent but can cause infections in patients who are immuno-compromised or who have implanted foreign devices.

Routine hand washing before and after contact with a patient; before and after performing invasive procedures; before and after touching wounds; and after contact with inanimate sources, such as urine-measuring devices that are potentially contaminated with microorganisms, could prevent many nosocomial infections. A brief, vigorous rubbing together of all surfaces of lathered hands, followed by rinsing under a stream of water, is adequate hand washing. Microorganisms can either be removed mechanically, by washing hands with soap or detergents and rinsing; or chemically, by washing hands with antimicrobial products that can inhibit the growth or kill the microorganisms. In high-risk health care settings (such as an ICU), effective hand washing with antimicrobial agents (containing chlorhexidine), compared with washing with soap and water, was shown to reduce nosocomial infections. Transient microorganisms, in contrast to resident flora, are easily removed by mechanical means. Antimicrobial soaps, should be used in nurseries, neonatal units, ICUs, and when dealing with patients with immunodeficiencies or who are at risk of developing infections with resistant organisms. Unfortunately, hand washing often is not performed as frequently as recommended. Factors that predict hand washing compliance are profession, hospital ward, time of day, patient/nurse ratio, and type of care provider. Factors leading to poor hand washing compliance include lack of education, poor hygienic habits, perceived lack of importance, lack of time, dry skin, skin irritation or dermatitis, absence of suitable cleansing agent, and inadequate hand washing facilities.

## **Isolation**

The CDC has recently proposed two levels of Isolation Guidelines for Hospitalized Patients: Standard and Transmission-Based Precautions.<sup>5,6</sup> This new system replaces the previous disease-specific systems and has integrated universal precautions and body substance isolation. Standard Precautions states that blood; all patients' body fluids (except sweat), secretions, and excretions; mucous membranes; and non intact skin be treated as potentially infectious. The components of Standard Precautions include: hand washing, wearing gloves, wearing mask, eye protection, face shield and gowns when appropriate, cleaning patient-care equipment, enforcing environmental control, cleaning linen, enforcing occupational health and blood borne pathogen protocols and cohorting patients. Transmission-Based Precautions are used for infected or colonized patients (confirmed or suspected) with transmittable microorganisms. These precautions should be used in conjunction with Standard Precautions. However, in resource limited situation the patients can be stratified based on risk of acquiring NI (Table 1) and appropriate antiseptic measures could be followed based on the risk categorization (Table 2).

Empiric isolation is crucial and based on clinical presentation and symptoms at the time of admission, before a definitive diagnosis is made. Depending on different clinical scenarios, empirical isolation using airborne precautions (eg. cough, fever, maculopapular rash, vesicular rash, tuberculosis), droplet precautions (eg. meningitis, influenza, and pertussis) and contact precautions (eg. acute infectious diarrhea, history of previous colonization with multi drug resistant organisms such as MRSA and VRE) should be implemented, pending definite diagnosis.

## **Cleaning, Disinfecting, and Sterilizing Patient Care Equipment**

1. *Cleaning*: All objects to be disinfected or sterilized should first be thoroughly cleaned to remove all organic matter (blood and tissue) and other residue.
2. *Indications for sterilization and high-level disinfection*: Critical medical devices or patient care equipment that enters normally sterile tissue or the vascular, system or through which blood flows should be subjected to a sterilization procedure before each use. Laparoscopes, arthroscopes, and other scopes that enter normally sterile tissue should also be subjected to a sterilization procedure before each use; if this is not feasible, they should receive at least high-level disinfection. Equipment that touches mucous membranes, e.g., endoscopes, anesthesia breathing circuits, and respiratory therapy equipment, should receive high-level disinfection.

## **Antimicrobial Control**

It is estimated that 23 to 40% of hospitalized patients receive systemic antimicrobial agents at any given time, and about 40 to 50% of their use is inappropriate. The following principles are of use in formulating a policy for antibiotic use-

- Review antimicrobial agents and select a basic formulary.
- Establish prophylactic, empirical, and therapeutic guidelines (antibiotic policy).
- Restrict the use of agents that have special limited indications, cause excessive toxicity, or are costly.
- Release restricted agents for use in predetermined circumstances or after approval.
- Ensure that the antibiotics on the formulary are the same as those being used for susceptibility testing by the microbiology laboratory.
- Monitor patterns of antibiotic susceptibility and trends in antibiotic use, providing regular feedback to the medical staff.
- Audit the use of specific antibiotics (antibiotic audit).
- Conduct ongoing educational programs
- Regulate in-hospital promotional efforts of pharmaceutical companies.

## **Percutaneous Injury-risk and Management**

One of the major risks to a health care workers health and career is the development of an occupational blood-borne infection. Three viruses are the most important causes of occupational blood-borne infection: hepatitis B virus (HBV), hepatitis C virus (HCV) and the human immunodeficiency virus (HIV). The most efficient mode of blood-borne pathogen transmission to health care workers is percutaneous or sharps" injury because of large volume of blood (or infectious dose) may be inoculated in a single exposure.<sup>5,6</sup>

## **MANAGEMENT OF NI**

Treatment of nosocomial infections is three-fold. First, a high index of suspicion must be present. Second, appropriate source control is paramount, such as the removal of infected lines or an infected abscess. Third, antimicrobial therapy that covers the likely infecting organisms and local resistance patterns should be commenced promptly. Early and regular microbiological consultation helps to ensure an optimal clinical outcome, controls the emergence of resistance and reduces costs. The most appropriate empiric treatment is best achieved on the basis of resistance surveillance. The choice of empiric antibiotic therapy for the treatment of any NI before microbiology is available requires.

- i. Surveillance data on a regular basis of predominant organisms in the hospital/ICU.
- ii. Surveillance of the current resistance patterns of these organisms.

- iii. Identification of outbreaks of NI involving one or more prevalent organisms.<sup>7</sup>

### **Principles of Empiric Therapy**

The conventional empiric therapy has to be broad enough to ensure coverage of most of the suspected pathogens. Combination therapy with antipseudomonal penicillin (piperacillin) plus an aminoglycoside or an antipseudomonal cephalosporin (Ceftazidime) plus an aminoglycoside have been for long the initial regimen recommended officially. However, in situations suggestive of gram positive organisms such as MRSA (in institutions where this organism is endemic) the addition of a glycopeptide forms part of empiric therapy. Rifampicin, fusidic acid Streptogramins (Quinupristin- Daltopristin) also covers most gram positive organisms. During outbreaks of NI with high probability of cross contamination of a previously identified endemic multi resistant organism such as *Pseudomonas aeruginosa*, carbapenems (e.g., imipenem or meropenem) in combination with either an aminoglycoside (amikacin) or a fluroquinolone (Ciprofloxacin) should be recommended. Any empirical therapy should be reassessed 2 or 3 days after its initiation. Treatment should be readjusted on the basis of report of antibiotic sensitivity tests available on day 2 or 3, and clinical response of the patient. Potential choice of more suitable combination therapy or switch to less expensive/toxic antibiotics when the clinical status of patient suggests doing so is recommended. For identification of NI the surveillance criteria is quite handy (Table 3).

### **Specific Empiric Situations**

1. When anaerobic bacteria are suspected for instance in surgical abdominal polymicrobial infection or in aspiration pneumonia, the addition of Clindamycin or Metronidazole is recommended. Imipenem is a useful alternative for mixed aerobic anaerobic infections.
2. If Legionellosis is suspected (atypical pneumonia), erythromycin and rifampicin either alone or in combination are the antibiotics of choice.<sup>5</sup>
3. In patients of neutropenia with neutrophil count  $500/m^3$  or below and fever  $38.3^{\circ}C$ .

### **Initial Antibiotic Therapy**

- i. Ceftazidime plus vancomycin. Vancomycin is given only if suspected causative agent is MRSA, penicillin resistant pneumococci or other gram positive resistant organisms.
- ii. If Vancomycin is not required then monotherapy with Ceftazidime, Imipenem, Cefepime or Meropenem is given.
- iii. If a combination is needed standard combination should be Ceftazidime plus antipseudomonal penicillin (like Piperacillin).<sup>7,8</sup>

### **Therapeutic Strategies of Documented NI**

The identification of the etiological agents involved in a given outbreak of NI should rely on an efficient clinical microbiology laboratory and good epidemiology practices within the hospital wards. Moreover the choice of single agent or a combination based on clinical consideration should also refer to the known patterns of susceptibility/resistance.<sup>9</sup> The patient's condition, severity of underlying disease, the presence of various devices (Catheters, ventilatory equipment, prosthesis etc.) are important factors which may interfere with the choice of a single agent or of a combination of antibiotics guided by the clinical condition of the patient. The site of NI and pharmacokinetic consideration are other factors leading to an appropriate choice of antibiotics: adequate delivery of drug(s) in infected tissues depends on dosage and route of administration, and on local factors at the infection site, such as potential inactivation of aminoglycoside at low pH, high protein binding with limited amount of free drug, poor penetration (eg. CSF) and

variable penetration of drugs into cells (macrophages) to reach and kill intracellular organisms (*Legionella pneumophila*).

## **SPECIFIC NOSOCOMIAL INFECTIONS**

### **Urinary Tract Infection**

A Gram's stain of the urine may help decide the nature of the infection well before culture results are available. The choice of antibiotics for Gram-negative infections is usually ceftazidime or cefoperazone, combined with an aminoglycoside. In presence of renal failure, fluoroquinolone may be used in place of aminoglycoside. In gram-positive infections, amoxicillin-clavulanic acid is generally used till such time a culture report is available. If infection with resistant staphylococci is suspected, the drug of choice is vancomycin, which covers both resistant staphylococci as well as enterococci. Gentamicin may be added for mixed Staphylococci and gram-negative infections. Suspected candida infection of the upper urinary tract or suspected disseminated candidiasis requires the use of intravenous amphotericin B or intravenous fluconazole. Candidiasis confined to the bladder should be treated with oral fluconazole and/or irrigation of the bladder with amphotericin B.

### **Nosocomial Pneumonia<sup>10</sup>**

One percent of all patients admitted to an acute care institution develop pneumonia or bronchitis and incidence is higher in ICU patient. Nosocomial pneumonia carries a grave prognosis. Empirical therapy is invariably started after a suitable sample of lower respiratory secretions (either a sputum sample or tracheal aspirate through a tracheostomy) is sent for examination. It is wise to start therapy promptly without waiting for laboratory results. The choice of antibiotics is dependent on the microbiological profile prevailing in a particular hospital ICU and the antibiotic sensitivity to these organisms. *Klebsiella*, *P.aeruginosa* and the Enterobacter species are the common nosocomial organisms in most ICUs. Empiric therapy can be started with a third generation cephalosporin like ceftazidime (1g IV 6 hourly), together with an aminoglycoside like Gentamicin (80 mg i.m. 12 hourly). To this metronidazole (500 mg IV 8 hourly) may be added to cover anaerobes. If sputum samples or tracheal aspirates chiefly show gram-positive cocci, and if staphylococci are grown on culture, cloxacillin may be substituted for ceftazidime; in patients with methicillin resistant staphylococci, vancomycin (500 mg IV 6 hourly) is used. If the patient continues to fare poorly and if the pneumonia persists or increases over a period of 4-5 days, a combination of imipenem(500 mg IV 6 hourly) and vancomycin can be used. Culture sensitivity reports need to be ignored if the patient improves on the empiric antibiotic therapy started initially. Nosocomial pneumonias are often polymicrobial, and anaerobes particularly *B.fragilis* is frequently associated causative agent. Though penicillin or clindamycin is effective against most anaerobes, equally good results are obtained with metronidazole. Imipenem covers most anaerobes besides covering gram-positive and gram-negative organisms. Antimicrobial regime may be continued for 2-3 weeks in the hope of achieving a bacteriological cure.

### **Nosocomial Bloodstream Infection<sup>11</sup>**

It accounts 14.2% of all nosocomial infections. It includes sepsis and intravascular device-related infections, which is more common in ICUs (2 to 7 times more often than in the ward).<sup>10,11</sup> Higher risk in those admitted to a surgical ICU than any other ICU. Nosocomial BSI can be divided into primary BSI (caused by an unrecognized focus of infection) and secondary BSI (develop following a documented infection with the same organism at another anatomic site). Catheter-related sepsis is characterized by fever, tachycardia, leucocytosis and occasional tachypnea; if unrecognized and untreated increasingly severe sepsis results. It is important to rule out any other cause of sepsis in the patient before diagnosing catheter-related sepsis. Frank pus at the

entry site of the catheter in the presence of fever, chills and tachycardia usually points to catheter-related sepsis. Other than varying grades of bacterial sepsis, the two major complications are septic thrombophlebitis and disseminated fungal infection. Coagulase-negative Staphylococcus is the most common pathogen (31%). Others are *S. aureus* (16%), *Enterococcus* (9%), *Candida* species (8%), *Klebsiella pneumoniae* (5%), *Enterobacter* species (4%), others (27%). Short-term catheters are best removed and antibiotics are given for a period of 5-10 days depending on the clinical response. Empiric therapy generally includes a third generation cephalosporin (ceftazidime or cefoperazone) with an aminoglycoside. If features of sepsis persist, methicillin or vancomycin is added. If catheter sepsis is proven on culture reports, or is strongly suspected, and if the patient's symptoms worsen in spite of using a broad-spectrum antibiotic cover, a decision to start amphotericin B should be taken. Septic thrombophlebitis particularly of central veins requires the use of intravenous heparin in addition to an appropriate combination of antibiotics.

### **Surgical Site Infection (SSI)**

Third most frequent nosocomial infection. SSIs are divided into incisional SSIs and organ-space SSIs. Only 33 to 67% of infected wounds are cultured, among those, 15 to 20% of SSI are caused by *Staphylococcus aureus*, *Enterococcus* (15%) and remainder are caused by gram-negative organisms and yeast. Amikacin shows resistance in about 50% of cases. Cefoperazone-Sulbactam combination is resistant in 30% of cases. Imipenem resistance is seen in 10%. Appropriate use and timing of perioperative antibiotic prophylaxis is the single most important intervention. If the perioperative antibiotic is administered after the incision, the risk of an SSI increases six fold above the risk when it is administered 2 hours or less before the incision. Reporting of surgeon-specific SSI rates is also important in reducing nosocomial SSIs.

### **Skin and Soft Tissue Infections (SSTI)**

Among hospital acquired SSTI one selected situation particularly difficult to treat and control is that of burn wounds. Topical wound care using various agents like 0.5% AgNO<sub>3</sub> solution, 10.0% mafenide acetate cream and silver sulfadiazine, local antibiotics and prophylactic systemic antibiotic therapy constitute the best approach to prevent burn wound infection. Systemic antibiotics therapy although controversial, is recommended for prevention of infection immediately after burn injury when host defenses are reduced.

### **Other Nosocomial Infections**

Eye infections account for 0.5% of all nosocomial infections and primarily occur in specialized hospitals. CNS infection as nosocomial infection occurred in 0.56 per 10,000 hospital discharges. Other sites of infection should be considered when there is no obvious focus of sepsis. These include sinusitis, acute acalculous cholecystitis, acute pyelonephritis, bacterial endocarditis and, more rarely, necrotizing fasciitis or meningitis. Appropriate examination, cultures, or radiological investigation may be required.

## **CONCLUSION**

Improvement in hospital epidemiology surveillance, infection control practices and applications of guidelines for prevention of NI should result in decreasing incidence of morbidity and mortality. However, NI still remains a major threat in high risk patients.

## **REFERENCES**

1. Jain Atul, Singh K. Recent Advances in the Management of Nosocomial Infections, Review article. JK Science, 2007;9:1.

2. Mehta A, Rosenthal VD, et al. Device-associated nosocomial infection rates in intensive care units of seven Indian cities. *Journal of Hospital Infection* (2007) 67, 168-174. [www. sciencedirect.com](http://www.sciencedirect.com)
3. Emori TG, et al. An overview of nosocomial infections, including the role of the microbiology laboratory. *Clin Microbio Rev* 1993;6:428-42.
4. National Nosocomial Infections Surveillance (NNIS) System, Centers of Disease Control and Prevention. National Nosocomial Infections (NNIS) report, data summary from October 1986 - April 1996. *Am J Infect Control* 1996;24:380-88.
5. Centers for Disease Control and Prevention. Public health service guidelines for the management of health care workers exposure to HIV and recommendation for post exposure prophylaxis. *MMWR* 1998;47(RR-7):1-28.
6. Centers for Disease Control and Prevention. Recommendations for preventing transmission of HIV/HBV to patients during exposure- prone invasive procedures. *MMWR* 1991;40:1.
7. Glauser M, Boogaerts M, Cordonnier C, et al. Empiric therapy of bacterial infections in severe neutropenia. *Clin Microb Infect* 1997;3 (A Suppl.):S77-86.
8. Hughes WT, Armstrong D, Bodey GP, et al. Guidelines for the use of antimicrobial agents in neutropenic patients with unexplained fever. *Clin Infect Dis* 1997;25:551-73.

9. Kessler RE, Fung-Tong J. Susceptibility of bacterial isolates to  $\beta$ -lactam antibiotics from US clinical trials over a 5-year period. *Am J Med* 1996;100(6A):13S-9S.





## Multiple Choice Questions

1. **Which of the following are important patient factors in causation of nosocomial infections?**
  - A. Extreme of age
  - B. Diabetes mellitus
  - C. HIV infection
  - D. Neoplasias
  - E. All of the above
2. **Which is the single most important preventive etiology for infection control?**
  - A. Isolation
  - B. Bleaching
  - C. Fumigation
  - D. Hand washing
3. **Which of the following is an important cause of occupational blood-borne infection?**
  - A. HCV
  - B. HIV
  - C. HBV
  - D. Influenza
4. **Which of the following are common organisms implicated in surgical site infection?**
  - A. *Staph aureus*
  - B. *Enterococcus*
  - C. Gram-negative bacteria
  - D. All of the above
5. **Which is the commonest organism implicated in nosocomial bloodstream infection?**
  - A. *Candida*
  - B. *Staph. aureus*
  - C. Coagulase-negative *Staphylococcus*
  - D. *Klebsiella pneumoniae*

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1. E 2. D 3. D 4. D 5. C