Review article

Prevention of nosocomial infections – role of the health care personnel

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Abstract

Hospitalised patients are usually more susceptible for development of infections while the hospitals are turning out to be hideouts for various micro-organisms. Hence, incidence of nosocomial infections is on the rise worldwide, more so in the developing countries. This contributes to significant increase in healthcare costs and an unnecessary as well as unacceptable increase in morbidity and mortality. Patients in the intensive care unit are the most susceptible hosts for development of nosocomial infections due to poor protective airway reflexes, invasive monitors and procedures, lack of immunity as a result of their primary disease process, broad spectrum antibiotic therapy, poor nutrition, *etc.* Although development of newer antibiotics, proper antibiotic regimen and better detection modalities to control infection are desirable, there are several other means by which one can contain the spread of nosocomial infections. These include physical precautions and education to help contain the health care worker (HCW) from becoming a potential vector for transmission of infective organisms by instituting measures such as hand hygiene, use of personal protective equipment, cleaning and disinfection, appropriate disposal and disinfection of health care wastes among others. *'Hand and mind hygiene'* practice from the HCW can contain the nosocomial infections to a large extent.

Keywords: Hand hygiene, health care workers, micro-organisms, vectors.

"An ounce of prevention is better than pounds of cure"

Introduction

Hospitals are fast turning out to be the most suitable place for micro-organisms to come in contact with susceptible hosts. The most susceptible hosts are the patients in the intensive care units (ICU) as many of them are usually seriously ill to the extent of requiring support for one or more organ systems. In addition to reduced immunity due to serious illness, many factors unique to intensive care units render these patients more susceptible to infections. Many of these patients require procedures such as tracheal intubation and mechanical ventilation as well as invasive monitoring. These bypass the normal defence process of the body thereby increasing patients' susceptibility to acquire infections. Furthermore, the equipment used for these purposes are known to harbour micro-organisms for varying length of time. These patients often require sedation and analgesia for various reasons such as to alleviate pain, stress and boredom as well as to tolerate tracheal intubation and other devices. This may render the pharyngeal reflexes less protective against aspiration. Moreover, poor gag reflex is observed in many critically ill patients with altered sensorium. This leads to accumulation of secretions in the oral cavity which might act as

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nidus for infective organisms and these secretions may get aspirated to lungs. Many antibiotics that the patients receive during their ICU admission contribute to destruction of normal bacterial flora of the gastrointestinal system. All these factors render patients in ICU more vulnerable to acquire nosocomial infections.[1,2]

Intensive care is a team work comprising of several health care workers (HCW) including doctors, nurses, trainees and other support staff. Spread of infective organisms through HCW has been well documented in literature as far back as eighteenth century.[3-5] Despite their good intentions in caring for the patients, HCW continue to be vectors for transfer of infective organisms even today. Therefore, ICU has the highest incidence of nosocomial infections.[1,2] Such infections, unfortunately add not only to economic burden but also lead to functional disability, emotional stress and may even contribute to reduction in the quality of life in some cases. In addition, nosocomial infections have now become one of the leading causes of death, especially in the developing countries. Furthermore, continued spread of these infections may also contribute to the development of resistant strains. Therefore, developing countries must consider instituting appropriate measures to counter the spread of nosocomial infections if progress is to be made in improving the quality of patient care in hospitals and other healthcare facilities.The purpose of this article is to provide a clear and concise understanding of the source of infective agents in hospital, their routes of spread followed by the mechanisms that can be incorporated to prevent the spread.

Definitions

Nosocomial infections (hospital acquired infection, hospital associated infections or hospital infections): These are infections that did not exist in the patient nor were incubating at the time the patient was received at the hospital but developed during the course of the patient's stay at the hospital. Infections that occur > 48-72 h after admission and within 10 days following discharge are usually considered to be hospital acquired or associated infections. Such infections can be either endogenous or acquired by cross contamination. Endogenous nosocomial infections refer to presence of the infective agent at the time of hospital admission without any evidence of infection attributable to them and would develop into infection during the course of hospital stay as a result of suppressed immunity of the individual. Cross contamination refers to the patient coming in contact with new infective agents during the course of hospital stay that subsequently develops into an infection.[6]

Commensals: The term 'commensals' is derived from Latin meaning 'eating at the same table'. These are the organisms that are colonised in the host without causing any specific immune response or infection.

Commensalism: A host-microbial interaction that does not result in perceptible, ongoing, and/or persistent host damage.

Pathogens: The micro-organisms that invade the host body and have the ability or the potential to cause disease.

Colonisation: This refers to accumulation of the micro-organisms that do not belong to the normal flora of the host without inflicting any damage to the host. During the process of colonisation, the micro-organisms in or on a host's body would grow and multiply without invading the tissues or causing any cellular injury or symptoms.

Contamination: This refers to a state of having been actually or potentially in contact with micro-organisms that could be capable of producing disease or infection (pathogens).

Infection: Multiplication of an infectious agent in patient's tissues, resulting in subclinical or clinical illness.

Source and modes of spread of nosocomial infections

Several micro-organisms have been known to survive on almost any inanimate surfaces in the ICU for prolonged periods extending from days to

weeks to several months. Patient related sources where there is a high possibility of colonisation of the micro-organisms include clothing, bed, railings of the bed, monitors used for the patient including pulse oximeter, blood pressure cuff, temperature probe *etc.*[7-12] Even patient records that are kept by the bedside are known to harbour micro-organisms. Hospital water is regarded as another important source for acquiring nosocomial pathogens. Drugs (heparin solutions, propofol, inhalers, total parenteral nutrition, blood products, ultrasound gel *etc*), intravenous solutions (especially the hospital manufactured solutions), cleaning solutions and even foodstuffs can act as potential source for nosocomial pathogens. Airborne spread of the micro-organisms can occur *via* the droplets when the patient sneezes or during coughing episodes. These droplets can reach up to a radius of two metres around the patient. HCW related sources for contamination with micro-organisms include stethoscope, hands, nails, feet, footwear, clothing, pagers, mobile phones *etc.* Other sources for contamination with micro-organisms within the ICU include door knobs, wheel chairs, body warmers, infusion pumps, ventilators and other equipment within the vicinity of the patient. Studies have found computer accessories such as the mouse and the keyboard in ICU to be potential reservoirs for infective agents.[5,13-19]

The longer a micro-organism can survive on surfaces, that much higher would be the risk of vector mediated transfer of that particular micro-organism. Longer survival of micro-organisms is reported on plastic material, in the area contaminated by blood or its constituents, sputum and low temperatures (2-4°C), although they can survive on almost any object for a variable period of time.[13] Some of the micro-organisms that are well known to survive for more than a month include a) viruses: *adenovirus*, *astrovirus*, *rotavirus etc* b) bacteriae: *Acinetobacter*, spores of C*lostridium difficile*, *Escherichia coli*, *Enterococcus*, *Listeria* species, *Pseudomonas aeruginosa*, methicillin resistant *Staphylococcus aureus*, *Mycobacterium tuberculosis* and c) fungi: C*andida albicans* and *Torulopsis glabrata*. *Salmonella typhimurium*, a bacterium is known to survive for many years on dry inanimate surfaces.[13]

These micro-organisms responsible for nosocomial infections spread through surface contact, catheters, intravenous lines or surgical incisions and by airborne route. Surface contact is the most common route for spread of most of these infections. Hands are the most common body parts of a HCW that could possibly come in contact with any of these reservoirs of infective agents. When a HCW with contaminated hands touches any other surface or patient, these micro-organisms may easily get transferred thus contributing to development of nosocomial infections. Worse, this might also result in recontamination of cleaned or even sterilised surfaces. Furthermore, this may contribute to development and spread of drug-resistant strains.[5,13-15] Therefore, it is of no surprise that several studies have shown beneficial effects of hand hygiene. Hence, highest care must be taken by the HCW for hand hygiene during ICU hours. Use of protective disposable equipment such as gloves, gown, shoes, visors for eyes, cap and mask have also been shown to reduce the incidence of nosocomial infections in ICU.[5,14,20]However, despite all these evidences, studies have shown that only 40-50% compliance was achieved in hand hygiene by HCW.[13,14]

There can be several reasons for noncompliance of HCW with hand hygiene. These may include lack of proper education about beneficial effects of hand hygiene, lack of motivation due to staff shortage (need for too frequent hand hygiene), working during holidays, presence of dry cracked skin, irritation of skin due to repeated use of soap, requirement for frequent removal of hand ornaments, insufficient number of wash basins *etc.*[5,14,21,22]Therefore, educating the HCW *(mind hygiene)* regarding the importance of preventing themselves from being vectors for spread of nosocomial infections by strictly following the guidelines is very important. The following section provides some guidelines to follow for the HCW to minimise the chances of them being vectors for spread of nosocomial infections.

Measures and guidelines for preventing spread of nosocomial infections

ICU hand hygiene guidelines: Washing hands repeatedly between contacts is the best way to limit the HCW being a vector for transfer of infections. To achieve this successfully, the HCW should keep their nails trimmed as short as possible. It is desirable to not have jewellery in the hands during ICU work hours as it is very difficult to eradicate organisms from the grooves of jewellery by simple hand hygiene measures. In case anyone has any jewellery in the hand such as ring, bangles, wrist watch *etc*, these should be removed prior to sterilising the hand for any invasive procedures. Plain soap or soap solutions should be used for cleaning visibly contaminated hands and for routine hand wash. Addition of antiseptic agent such as 2% chlorhexidine or 1% triclosan to the soap or soap solution may further reduce bacterial load in the hands after hand wash. Hand lotions may be used about thrice a day amidst frequent hand washings throughout the working period. Alcohol based hand rub solutions that contain 70-90% alcohol are the most recommended hand hygiene solutions as they are superior to other measures such as washing hands with soap water only or with soap containing chlorhexidine or triclosan. This is because of the efficacy of alcohol based hand solutions in removal of both the transient as well as resident hand flora effectively even with as little as 15 seconds duration of hand washing.[23]However, the most important components of hand hygiene remain to be (i) good friction of fingers and hands under running water and (ii) hand hygiene measures after each contact with patient / patient related equipment and between patients. Surgical hand scrub should last for at least 2-6 minutes with all the hand jewellery removed and specific attention should be provided to clean the nail beds properly.[14] Dr Gunter Kampf proposed six golden rules to improve hand hygiene compliance. These essentially include use of alcohol based hand rub solutions that have good skin tolerance, ensuring that these are easily accessible to HCW (at bedside of each patient / wall dispensers), education of HCW regarding beneficial effects of good hand hygiene, setting oneself (senior staff) an example to emulate for other hospital personnel regarding hand hygiene, creating a hospital budget that would cover all expenses related to prevention of nosocomial infections and ensuring adequate staff to patient ratio.[24]

Guidelines for use of personal protective equipment (PPE) in ICU[5,14]: The PPE includes gloves, gown, cap and mask, goggles (eye protection) and shoes. These must be used wherever there is a risk of contact with blood, body fluid, excretions, secretions, skin contact and to prevent air borne droplet infections. The PPE must also be removed carefully immediately after use. Once used, they are assumed to be infected and should be discarded appropriately. Often, equipment meant for personal protection may cause cross-transfer of organisms to patients unless carefully used and discarded. Hand hygiene must be practiced immediately prior to donning and after removal of PPE.

Good hand hygiene measures coupled with use of gloves in appropriate instances has been shown to greatly reduce the incidence of cross-transfer of organisms. Gowns should ideally cover upper limbs till wrists, lower limbs till ankles, while they should also completely protect the front and back of the HCW. Always wear gown first, followed by gloves while gloves should be removed prior to the gown. Footwear that does not cover the feet completely (with holes on top or with open heels) may not provide adequate protection. Wearing surgical cap helps prevent transfer of organisms to HCW's hair. Similarly, wearing masks help prevent transfer of aerosol or droplet borne infective agents from patient and equipment to HCW, while also helping prevent transfer of organisms from mouth and nose of the HCW to patients. HCW should always protect self by wearing masks when they are within two metres radius from patients who are coughing or sneezing. Contact lenses and personal prescription glasses do not provide adequate eye protection. Visors, face shields and goggles can be used for eye protection. The eye protection equipment should be discarded after use without making hand contact with its front or side portions as they may be infected. Only sterile equipment and fluids should be used during invasive procedures.

Cleaning and disinfection measures: While cleaning has to be done for all surfaces and equipment, Spaulding's classification of instruments may help decide the quality of disinfection measures to be taken. Low level of disinfection is sufficient for equipment that comes in contact only with intact skin and not with mucous membrane. High level disinfection is necessary for that equipment which comes in contact with mucous membranes or non-intact skin without penetrating them. All equipment that have the ability to penetrate into the tissues require complete sterilisation.[5,14]

Other measures that can help to minimise the risk of nosocomial infections:

Role of nutrition: Several hospitalised patients suffer from malnutrition due to increased catabolism, stress, reduced intake or gastro-intestinal upset, infections *etc.* Therefore, providing adequate enteral and parenteral formulas that concentrate on 'immunonutrition' (antioxidant vitamins, trace minerals such as zinc, omega-3 fatty acids, glutamine) may help minimise the risk of nosocomial infections in sick patients.[25]

Role of probiotics: Probiotics are viable micro-organisms that colonise the host gastrointestinal tract by adhering to the intestinal mucosa that have the ability to provide beneficial health effects on various organ systems.[26] Use of broad spectrum antibiotics in critically ill patients often predispose them to the development of nosocomial infections. Therefore, probiotics may be useful in such patients according to some studies.[27]

Measures to prevent central venous catheter or haemodialysis catheter related infections: Use invasive lines only when necessary and remove them as early as feasible. Use appropriate sterile barrier precautions (gown, glove, cap, mask and drape sheet) during insertion, appropriate antiseptic techniques for site cleaning and ensure adequate care during maintenance. Use of chlorhexidine or silver sulfadiazine coated catheters may reduce incidence of infections. Use of new agents such as lysostaphin (an enzyme that effectively breaks up and destroys staphylococci in biofilms on catheters) in catheters and use of catheter lock solutions may also help minimise the infection risks.[28-30] Temporary haemodialysis catheters have a very high risk for development of nosocomial infections and should be used with caution and strict asepsis. Further, risk of transmission of hepatitis C virus (HCV) from patient to HCW or patient to patient through the dialysis machine or its tubings can be minimised by appropriate barrier precautions, safe disposal and disinfection of equipment.[31]

The issue of antimicrobial resistance

Antimicrobial resistance is on the rise and is a significant issue worldwide. Antimicrobial resistance develops when a microbe acquires a gene that allows it to nullify the antimicrobial activity of the antibiotic. Use of an antibiotic to which the microorganism is resistant will lead to increased suffering, economic burden due to prolonged hospital stay, additional investigations, increased morbidity and mortality.[5] Most commonly identified microorganism in most parts of the world is methicillin resistant *Staphylococcus aureus* (MRSA). Hospitals happen to be the most suitable place for an infectious agent to come in contact with a susceptible host. The risk factors for colonisation of antimicrobial resistant micro-organisms include advanced age, presence of critical illness, longer duration of hospital stay, admission to intensive care units that provide proximity to susceptible equipment or carriers/ infected individuals, use of broad spectrum antibiotics and invasive monitoring or mechanical ventilation.[32] This part of the article attempts to understand the problems associated with MRSA and discuss strategies to prevent it.

The hospital or institution should implement a programme of active surveillance cultures (anterior nares, throat swab, axillae, rectum, groins, perineum and any open wounds) and contact precautions to control the spread *via* direct or indirect contact. This should be done at the time of hospital admission and periodically for patients at high risk for carriage of MRSA who are likely to have lengthy hospital stay. Every colonised patient should be identified and should be cared for in isolation to minimise the spread to other patients. Use of appropriate hand

hygiene measures and personal protective equipment should be strictly enforced. Misuse of antibiotics by avoiding inappropriate or excessive antibiotic prophylaxis and therapy as well as appropriate dosing and duration should be ensured. Unnecessary use of fluoroquinolones especially in institutions that are endemic to MRSA must be checked. Decolonisation therapy for both patients and HCWs to prevent spread of MRSA while avoiding its widespread or prolonged use to minimise the evolution and spread of antimicrobial resistant strains should be considered.[5]

Summary

Nosocomial infections are on the rise world over. These are unacceptable as the patients who visit hospital for treatment of a particular ailment end up suffering from additional problems. This not only increases patient suffering, morbidity and mortality but also is a burden on health care expenditure. Just as the hospitals should be providing relief from ailments for the patients, the sole intention of HCW is to facilitate rapid diagnosis and recovery of patients. Unfortunately, HCWs themselves are becoming potential vectors for transmission of nosocomial infections. Therefore, urgent measures need to be instituted in every hospital to prevent or minimise the incidence of nosocomial infections. Not only should appropriate antibiotic policies be instituted, but also one should focus on the nonpharmacological aspects that contribute to reduction in such infections. These must include implementation and education of HCWs regarding the beneficial effects of strict adherence to hand hygiene measures, use of personal protective equipment, appropriate cleaning and disinfection policies, health care waste disposal policies and measures to minimise development of antibiotic resistance. *'Hand and mind hygiene'* practice by the HCW can help contain the spread of nosocomial infections to a large extent.

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