Nosocomial infections and infection control

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Abstract

Hospital patients are susceptible to infection because of underlying diseases and medical interventions such as surgery, intubation or antibiotic use, and also their exposure to microorganisms from other patients, the hospital environment or hospital staff. An average of 5—10% of in-patients have a nosocomial infection, with highest rates in surgical and intensive care units. Most of these infections fall into one of five categories: line-associated infections and bacteraemia, surgical wound infection, nosocomial pneumonia, catheter-associated urinary tract infection, and gastrointestinal infection, including *Clostridium difficile* and norovirus. Many nosocomial infections are due to antibiotic-resistant organisms such as meticillin-resistant *Staphylococcus aureus* and multi-resistant Gram-negative organisms, which are selected by the antibiotic-rich hospital environment, but less resistant community pathogens may also cause hospital infection. Measures to prevent nosocomial infection are varied, and include aseptic handling of wounds, hand washing before and after every patient contact, and restrained antibiotic use. Recent public anxiety about nosocomial infection has led to increased political interest, with mandatory surveillance and publication of infection rates, financial incentives to reduce infections, and development of 'care bundles' — packages designed to ensure compliance with several different control measures.

Keywords catheter-related infections; cross-infection; hospital infection; meticillin-resistant *Staphylococcus aureus* (MRSA); microbial drug resistance; nosocomial infection; surgical wound infection

What's new?

- Multi-resistant Gram-negative organisms such as *Escherichia coli*, *Klebsiella* and *Pseudomonas*, are emerging as a significant problem, with fears of significant numbers of untreatable infections in the near future
- Antibiotic resistance is being increasingly seen as a global problem, with factors such as over-the-counter antibiotics in many countries, use of antibiotics in livestock, travel and health tourism all contributing to selection and spread of resistant organisms
- Antibiotic stewardship is increasingly emphasized, in order to limit any avoidable selection of such resistant organisms. Many hospitals employ a multidisciplinary approach to antibiotic stewardship, with microbiologists, pharmacists and infection control nurses all contributing
- Improved viral diagnostics means that the role of viral respiratory and gastrointestinal infection in hospital is increasingly recognized

Introduction

Nosocomial infections are those acquired in or associated with hospitals. They are also known as hospital-acquired or healthcare-associated infections. The usual definition of a hospital-acquired infection is one that was not present or incubating when the patient was admitted to a hospital or healthcare facility; where there is doubt, a cut-off period of 48 hours after admission is used. The terms hospital-acquired and healthcare-associated are often used interchangeably, but 'healthcare-associated' also has the wider meaning of any infection acquired as a result of healthcare in any setting. The related term 'iatrogenic' refers to infection or illness specifically associated with medical devices, procedures or therapies.

Any community infection can also occur in hospital, but there are many factors in the hospital environment that lead to a particular spectrum of infective problems. Nosocomial infections are common, and may be serious or fatal. Some are unavoidable, but doctors' duty of care to their patients extends to fundamental matters such as basic hygiene, which may prevent patients becoming infected, and avoidance of unnecessary antibiotics, to discourage development of resistance.

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Background

Despite the many recent advances in medical science, hospital-acquired infections still cause considerable illness and some mortality. It has been estimated that 5—10% of in-patients in British and Irish hospitals have a nosocomial infection; the prevalence is highest in surgical wards and intensive care units (ICUs), and lowest in medical units.[1] Apart from the significance of harm resulting from medical or nursing care, nosocomial infections cause a financial burden to hospitals, patients and society. In a study carried out in the 1990s, the cost in the UK, in terms of increased hospital stay and treatment, was estimated at up to £1000 million/year.[2] This figure does not include costs of litigation and compensation, nor does it include costs to the patient resulting from their infection.

Since 2000, nosocomial infections and antibiotic resistance have become the subjects of considerable media, public and political interest. Meticillin-resistant *Staphylococcus aureus* (MRSA) bacteraemia was chosen as the subject of the first national reduction programme in England and Wales in 2004, because it was relatively easy to measure (using straightforward laboratory diagnosis) and was believed to be a rough marker of general infection control standards. This was followed in 2007 by a national 30% reduction target for *Clostridium difficile* infections, with strict financial penalties for hospitals that did not meet their target. There was considerable success in reducing infection rates, though opinion is divided on whether an organism-specific approach leads to more generalized improvements in infection control, or, conversely, to skewing of resources and attention, and therefore neglect of other nosocomial

infections.[3,4] In the USA, the Centers for Medicare and Medicaid Services has reduced payments to hospitals for certain complications judged to be reasonably preventable — including several nosocomial infections.[5]

Predisposing factors in nosocomial infection

It is helpful to consider the causes of nosocomial infection under three headings: patient factors, medical/surgical interventions, and the hospital microbial environment, as follows.

Underlying patient factors

Many patients are intrinsically vulnerable to infection: they are at the extremes of age, debilitated, or have an underlying immunodeficiency (e.g. HIV). Neurological illness may lead to aspiration pneumonia; and immobility and dehydration may encourage urinary tract infection (UTI). Skin disease and bedsores allow organisms to enter subcutaneous tissue. In addition, and importantly, the normal flora of all patients includes potential pathogens such as *Escherichia coli* in the gut and *S. aureus* in the nose.

Medical and surgical interventions

Surgical incisions and intravascular devices provide means of entry for pathogens. Urinary catheterization often causes UTIs. Prosthetic joints and heart valves provide a protected niche for bacterial growth, and immunosuppressive therapy allows even low-virulence organisms to assume a dangerously pathogenic role.

Less obvious ways in which medical therapy can facilitate infection include anaesthesia and ventilation (which predispose to nosocomial pneumonia) and antibiotics (which alter normal flora, reducing resistance to colonization by hospital organisms). Inadequately disinfected endoscopes can transmit pathogens such as *Mycobacterium tuberculosis* and *Salmonella*, as well as hepatitis viruses.[6]

Hospital microbial environment

Patients may become infected with new organisms, from other patients, staff or the environment. Transient hand carriage by medical or nursing staff is thought to be the main route of spread, but occasionally other routes are involved (e.g. airborne route for respiratory pathogens). Overcrowding, understaffing and poor hygiene, particularly hand washing, increase the risk of cross-infection.

Antibiotic use in hospital has selected resistant organisms that readily colonize and infect patients (Table 1). Many (e.g. coagulase-negative staphylococci, enterococci) are of relatively low virulence, but can cause severe illness in compromised patients; some (e.g. MRSA) can be as virulent as their more sensitive counterparts. Multi-resistant Gram-negative organisms have increased in relative importance. Such organisms include members of the Enterobacteriaceae such as *E. coli* and *Klebsiella*, in addition to *Pseudomonas aeruginosa*. These bacteria often carry multiple resistance elements, including extended-spectrum beta-lactamases or carbapenemases that confer resistance to broad-spectrum cephalosporins and/or carbapenems such as meropenem; they may also be resistant to aminoglycosides such as gentamicin, and to ciprofloxacin. As a consequence, treatment of these infections can be extremely difficult, and there may be significant associated mortality. Global epidemics of such resistant strains of bacteria are increasingly recognized, and in some areas these organisms are not confined to hospitals but are also found in healthy individuals and in the environment. Factors contributing to spread include antibiotic over-use in both the hospital and the community, veterinary use of antibiotics allowing resistant organisms to enter the food chain, availability of over-the-counter antibiotics in some countries, and increased travel, migration and health tourism.[7] Antibiotic resistance is further discussed in the article on pages 642-648 of this issue.

Common syndromes and problems in nosocomial infection

Most nosocomial infections fall into a few common categories. Specialist units (e.g. burns, transplant, neurosurgery) see different infections, in addition to the problems described below. Infections in transplant patients are discussed in the article on pages 000—000 of this issue.

Line-associated infections and bacteraemia

In most settings, one-quarter to one-third of cases of nosocomial bacteraemia arise from an intravenous device, a similar proportion are from an unknown source, and the remainder have various sources, including the urinary tract, the gut and ventilator-associated pneumonia.[8]

Intravenous devices provide both a break in the skin, allowing entry of organisms, and a protected site for bacterial growth shielded by a biofilm of platelets, fibrin and bacterial slime. The risk is greater with increasing age of the line, central and multilumen lines, and poor insertion technique or line care, which can lead to infection of the insertion site or hub. Pre-existing skin disease and colonization with pathogens such as MRSA also increase the risk of infection. The heavy normal flora of the groin means that femoral lines generally become infected, despite careful insertion technique.

Almost 50% of nosocomial bacteraemia isolates are staphylococci (either coagulase-negative or *S. aureus*, including MRSA) and these are most likely to be line-associated. The remainder are mainly Gram-negative (*E. coli*, *Klebsiella*, *Enterobacter*, *Proteus* and *Pseudomonas*), with small numbers of enterococci and *Candida* (not bacteria, but generally included in reviews of 'bacteraemia'). Gram-negatives may be line-associated, but are more likely to have a urinary source, or to arise from the gut in patients with intra-abdominal pathology or neutropenia.

Presentation and diagnosis: line infections present with septicaemia or obvious infection of the exit site or tunnel, or are silent. Other sequelae (which may manifest only after line removal) include endocarditis and disseminated abscesses (e.g. spinal, ophthalmic). Blood cultures and culture of the line tip are the usual means of diagnosis.

Management: line infections (except some with coagulase-negative staphylococci) are almost never eradicated by antibiotics unless the line is also removed. Infected lines are sometimes left *in situ* when intravenous access is difficult, but this increases the risk of septicaemic complications.

Nosocomial chest infections

Pneumonia is responsible for about 25% of all nosocomial infections, but the diagnosis is often uncertain; in severely ill patients, there may be other explanations for fever, hypoxia and