NOSOCOMIAL INFECTIONS – AN OVERVIEW

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There is no hospital however small, airy or well ventilated, where the epidemic ulcer is not to be found at times, and thus no operation dared to be performed. Every cure stands still, every wound becomes a sore and every sore is apt to run into gangrene. But in great hospitals specially, it prevails at all times and is a real gangrene. It has been named the Hospital Gangrene and such were the ravages at Hotel Dieu of Paris the great storehouse of corruption and disease that the surgeons did not dare call it by its true name.

JOHN BELL (1801) on: Hospital Infections

DEFINITION

The term nosocomial infection or hospital-acquired infection is applied to any clinical infection that was neither present nor was in its incubation period when the patient entered the hospital. Nosocomial infections may also make their appearance after discharge from the hospital, if the patient was in the incubation period at the time of discharge.

PREAMBLE

Patients are no doubt better treated in hospitals than anywhere else; however congregating a large number of sick under a single roof could easily facilitate the transmission of infectious disease from one patient to another. One must remember that infections in hospitals have existed since the very inception of hospitals themselves. To say that nosocomial infections are of great importance in hospitalized patients is to state the obvious. Nosocomial infections, even in this modern era of antibiotics, continue to remain an important and formidable consequence of hospitalization. It has been estimated that about

3.5% of patients leave the hospital after having acquired infections, depending on the case, hospital size and multiple other factors.

HISTORICAL MILESTONES

- One of the earliest records of hospital infections are perhaps those found in an egyptian papyrus written around 3000 B.C. Needless to say, mere absence of documentation of bacterial infection does not exclude its prevalence prior to this time. Nearer home, in the Indian context a similar account of hospital infection is available in the ancient Ayurvedic literature (ca. 600 B.C.) Again the famous Hindu physician Charaka and surgeon Sushuruta (Ca. 400 B.C.) have also emphasized the need for prevention of infection in clinical practice. Else where in the world too there is ample evidence that hospital infection were prevalent and documented in ancient times viz: the records of Herodatus on the conditions that prevailed in Greek and Roman hospitals in the period 1000 to 600 B.C., and the Hipprocrates' treatise (ca 400 BC) testifying the existence of infection.

- For several subsequent centuries that followed it was generally believed that the disease was caused by the "contagion" and spread by wind and various other types of air currents.

- It soon became recognized that certain medicaments were capable of either preventing or checking the progress of infection. **Place in 1721** used the term "**Antiseptics"** to describe these substances and, nearly 30 years later, **Pringle in 1750** conducted extensive trials with antiseptics while working with the British army in Flanders.

- In **1856 Louis Pasteur** conclusively demonstrated that bacteria were responsible for fermentation of wine, which could be prevented by gentle heating whereby the microorganisms were destroyed. The existence of such microorganisms in the atmosphere were proved by him in 1864. In his celebrated lecture to **Acadimie de Medicine on April 30th, 1873.** Louis Pasteur is quoted as having said:

"**If I had the honour of being a surgeon, not only would I use absolutely clean instruments, but after cleaning my hands with the greatest care would only use sponges previously raised to a heat of 1300-1500 Fahrenheit. I would still have to fear germs suspended in the air, and surrounding the bed of the patient".**

- The now well-known work of **Semmelweiss (1861)** on puerperal sepsis was largely disregarded at the time. He observed that puerperal sepsis was associated with medical staff and students who attended patients and also performed autopsies. Semmelweiss deduced that "morbid matter" present on their hands derived form cadavers or other patients was responsible for spread of the disease. A drastic reduction in infection rates was achieved by the introduction of hand-washing practices with chlorinated lime.

- At about the same time, **Florence Nightingale** in a much quoted remark in her book **Notes on Hospitals.**

"It may seem a strange principle to enunciate as the very requirement in a Hospital that it should do the sick no harm…. The actual mortality in hospitals, especially in those of large crowded cities, is very much higher that any calculation founded on the mortality of the same class of diseases among patients treated out of hospital…"

- Although Florence Nightingale was sceptical of the germ theory of disease, she established important principles of nursing, hospital design and hygiene. In **1869 Simpson** provided further evidence by the survey of the sequelae of amputation, which established that sepsis, gangrene and pyaemia were very much common in large urban hospitals than in rural practice.

- At about this time **Lister** introduced his "antiseptic theory", following the extensive use of carbolic acid to pack wounds, especially of compound fractures, sterilize instruments and sutures, decontaminate his hands and as an air spray. He observed

that these practices could greatly reduce the incidence of suppuration and gangrene, which quite commonly occurred otherwise.

- In **1883 Gustao Neubar** introduced the use of masks and gowns in surgery, and **Halsted in 1890** introduced the use of rubber gloves in surgery. Steam sterilization was discovered by **von Bergman in 1896** and all these measures further increased the safety of surgery and contributed greatly in bringing down rates of infection by use of aseptic and antiseptic techniques.

- During the period, when many fundamental discoveries in bacteriology were being made, other principles of hospital infection control were also simultaneously established. **Flugge (1897, 1899)** showed the importance of droplet and aerial spread in tuberculosis. By **1894, Hutinel** and others had established basic isolation systems for diphtheria and other infectious diseases in childrens' and fever hospitals.

- With the turn of the century attention began to get focused largely on aseptic techniques in surgery and theses superceded the use of antiseptics. More and more attention was given to the operation theatre and air ventilation.

THE ERA OF ANTIBIOTICS

- The introduction of penicillin, which heralded the antibiotic era, banished from hospitals the terrible cases of chronic sepsis, mainly caused by Staphylococcus aureus. Nevertheless, the era of antibiotics ushered in for the first time a period in which staphylococcal rather than streptococcal infections dominated the scene. Penicillin- resistant, and later multiply-resistant, S.aureus caused serious wound, burn and other sepsis. With this, interest in air-borne and dust-borne spread as well as transmission on the hands of attendants was revived. Also, the introduction of certain "broad-spectrum" antibiotics seemed to keep check on S.aureus infections and the importance of multiply-resistant S.aureus appeared to fade. Interest shifted in the 1950s, 1960s and 1970s to gram-negative bacilli; antibiotic-resistant enterobacteria, such as Escherichia coli, Klebsiella spp. and later on to Serratia spp., which caused

large outbreaks. Infection by Pseudomonas aeruginosa came into prominence with the increasing number of patients being rendered susceptible either by illness itself or by treatment. The infecting bacteria appeared to be favoured by the antibiotics in current use in the hospitals.

- More recently, of late, the extensive use of indwelling medical devices and possibly as a result of the introduction of new antibiotics coupled with their indiscriminate use, the gram-positive cocci have once again emerged as the predominant causes of infection. Methicillin-resistant Staphylococcus. aureus (MRSA), Vancomycin-resistant Enterococcus spp.(VRE) and MRSA with reduced susceptibility to Vancomycin have posed serious problems.

SOURCES OF HOSPITAL INFECTIONS

For an infection to occur in the hospital the prerequisites are:

(a) A susceptible host.
(b) A microbe capable of producing an infection.
(c) An environment that is congenial for the multiplication of the microbe.

It is the delicate interplay of these 3 components that ultimately culminates in the occurrence of an infection.

Also, various combinations of four main factors influence the nature and frequency of infections. These are:

(i) Low resistance of the patients
(ii) Contact with infectious persons
(iii) Contaminated environmental sites
(iv) Drug resistance of endemic organisms

The source of the infecting organism may be **exogenous -** from another patient or a member of the hospital staff, or from the inanimate environment in the hospital; or it may be **endogenous** – from the patients own flora which at the time of infection may include organisms brought into the hospital at admission and certain others acquired subsequently. In either case, the infecting organisms may spontaneously invade the tissues of the patient or may be introduced into them by surgical procedures, instrumental manipulation or nursing procedures.

The inanimate environment of the hospital that acts as an important source comprises of :

(a) Contaminated air, water, food and medicaments
(b) Used equipments and instruments
(c) Soiled linen
(d) Hospital waste (Bio medical waste)

A patient comes to the hospital because he is unwell he has an underlying disease for which he may be under investigation including various types of instrumentation or he may be receiving antibiotics. Also if he has an underlying malignancy he may have under gone surgery and may be receiving chemotherapy and/or radiotherapy. All this in turn decreases his host defence mechanisms and his vitality, making him increasingly susceptible to infection. Antibiotic therapy may cause a change in the flora, while instrumentation may lead to direct implantation of organisms. In most instances these could lead to an infection arising from an exogenous or an endogenous source and occasionally the infection could be an autoinfection.

MICROBIAL CAUSES

A large number of microorganisms are responsible for hospital infection. Infact any microbe may have the capacity/ability to cause an infection in the hospitalized patient. The causative microorganisms may be broadly classified into the following these categories:

1. Those "**conventional**" pathogens that could cause disease in healthy persons in the absence of any specific immunity to them.

2. Those "**conditional**" pathogens that could cause disease (other than simple localized infections) only in persons with lowered resistance to infection or when implanted directly into tissue or normally sterile area.

3. Those "**opportunistic**" pathogens that could cause generalized disease, but only those patients who have a greatly diminished resistance to infection.

Of course, one has to bear in mind that these distinctions are by no means clear cut and the grading accorded to each of these individual pathogens could be challenged.

A detailed list has been compiled and is available in the WHO manual edited by M.T. Parker.

Infections by Staphylococcus aureus, Group B Streptococci, Enterobacteriaceae and Pseudomonas aeruginosa could either be acquired from other persons (exogenous source) or by self infections (endogenous/autoinfection) whereas most infections by Group A Streptococci are from other persons. Again while most infections caused by Enterococci and other non-haemolytic streptococci, anaerobic cocci, histotoxic clostridia, Bacteroides and Acinetobacter species are self infections, infections with Clostridium tetani, Pseudomonas cepacia, Flavobacterium meningosepticum are nearly always and infections by Pseudomonas aeruginosa and members of the Klebsiella-Enterobacter - Serratia group are often, acquired form "independent" environmental sources (exogenous). Patients and hospital personnel may acquire infection by HIV and Hepatitis B, C, D viruses through contact with blood positive for these viruses form patients and blood donors.

TYPES OF HOSPITAL-ACQUIRED INFECTIONS

The most common types of nosocomial infections that could occur in a hospital set up are: -

1. Surgical wound and other soft tissue infections.
2. Urinary tract infections
3. Respiratory infections
4. Gastroenteritis
5. Meningitis

Of these, surgical infections special importance for the surgeon and is dealt with in brief in the following paragraphs.

SURGICAL WOUND INFECTIONS

In a prevalence survey (Emmerson et al 1996) surgical wound infection accounted for 12.3% of all hospital-acquired infections. In the USA incidence study, surgical wound infection accounted for 24% of all nosocomial infections. In some surveys the definition of wound infection was based on a simple, easily observable character such as presence of pus in the wound. However, a more complex and comprehensive definition, making use of several other signs of inflammation (e.g. erythema) has been used with an elaborte scoring system. Needless to say the recorded incidence of infection will also depend on the length of postoperative stay and the degree of follow-up after discharge from hospital.

Factors most consistently associated with an increased incidence of postoperative infections are: -

1. Over 60 years, of age
2. Preoperative stay in hospital
3. Long duration of the surgical procedure
4. Pre-existing infection at the site of the wound

Other equally important conditions that play an important role are underlying diseases such as :-

1. Diabetes
2. Immunosuppression
3. Irradiation
4. Malnutrition
5. Steroid therapy

In preoperative preparation, shaving of hair from the site, rather than treatment with depilatories or clipping of the hair has been associated with a much higher frequency of infection. In some studies, certain factors of significance such as male sex, emergency operations and the use of surgical drains have come to light. It is generally agreed that **good surgical technique** is most important.

Staphylococcus aureus remains the dominant species in surgical wound infection, followed by the enterobacteria. Bacteroides spp. along with other gut bacteria, very often in mixed growth is found typically in wounds after a colonized viscus has been entered. Although S. aureus may occur in all types of wound, it is the typical cause of the less frequent wound infection in “clean” surgery. Most commonly, infection of surgical wounds occurs at the time of surgery. Again, in the great majority of cases, the origin of the bacteria appears to be the patient’s own body flora (endogenous infection). Much less often it is from a member of the surgical team. However, in any instances the origin is obscure. The usual and common routes are direct spread from the incised organs and intraoperative contamination of instruments and of surgeons’ gloves and clothing. Contamination from various types of apparatus has occasionally been described. Although the air-borne route is important in the implantation of prostheses, it occurs only in rare episodes in general surgery.

In addition to these endemic infection, which are caused by a variety of organisms, outbreaks of epidemic infections occur from time to time due to the presence of a particular strain of a virulent organism carried by some member of the staff of present in materials that should be sterile. Although these hazards can be reduced by observing aseptic methods, the common development of sepsis after clean operation shows the limitations of aseptic

methods and brings home the need for meticulous standards. Occasionally an " epidemic" increase in the incidence of postoperative wound sepsis may also be caused by some failure in aseptic technique or sterilization. These outbreaks are associated with an increased incidence of infection caused by a wide range of bacteria, and not by one epidemic strain.

The mode of spread of infections is hospital occurs mainly by the following 2 methods:-

1. Aerial
2. Contact

"Aerial" transmission could be from the nose/mouth of the person or from inanimate sources like the air-conditioning plants, respiratory apparatus etc. a variety of infections including measles, small pox, tuberculosis, sepsis by Staphylococcus aureus and Streptococcus pyogenes, meningococcal infections, respiratory diseases associated with Streptococcus pneumoniae, Streptococcus pyogenes. From inanimate sources aerial spread could result in respiratory infections by Enterobacteria, Pseudomonas aeruginosa and Legionella.

"'Contact" could be either from other patients, doctors, nurses and other staff or from independent environmental sources. While any of these could lead to respiratory infection, sepsis or diarrhoea, direct contact into tissue or wounds or mucous membranes by infected needles, surgical instruments or by blood and/or blood products could result in serious infections like hepatitis or AIDS.

CONTROL OF NOSOCOMIAL INFECTIONS

The CDC (1985) on the efficacy of nosocomial infection control (SENIC) showed beyond doubt that increase in surveillance activities is able to directly bring down the rates of nosocomial infections. It is only too well known that nosocomial infections are most prevalent in certain high risk areas such as the intensive care renal dialysis and organ transplant units, burns ward, cancer ward, operation theatres, post-operation theatres, post-operative ward nursery and the geriatric ward. Therefore, all methods aimed at containing hospital infections should be primarily focused in these "high risk areas". Some of the

problems that are likely to hamper an infection control programme in a developing country which has limited resources include:

1. The lack of quality control of sterilization and disinfection procedures.

2. The quality of water and food made available in the hospital.

3. The hospital environment itself.

4. The lack of trained staff.

5. The lack of knowledge of hospital infection control principles and practices among the staff.

6. The general misuse of antibiotics both in the community and in the hospital,

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