



Prevalence of Surgical Site Nosocomial Infection in A Tertiary Health Care Institution in Nigeria

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Abstract - Study on prevalence of surgical site nosocomial infection in a tertiary health care institution in Nigeria was carried out. Patients admitted and slated for operation were selected and monitored from theater before and after the operation and further followed to the wards for monitoring of the healing processes of the surgical wounds. Bacterial load of the air and floor in the theater was determined by settling plate and floor swabbing before and during the operation. Wound swabs were taken immediately after operation and subsequently while the patients are recuperating in the surgical wards. The swabs were inoculated on Nutrient, Chocolate and MacConkey agar, incubated at 37°C. The following bacterial species were isolated: *Staphylococcus aureus* (18%), *Staphylococcus epidermidis* (16%), *Streptococcus pyogenes* (6%), *Streptococcus spp.* (1%), *Bacillus subtilis* (3%), *Bacillus cereus* (5%), *Bacillus megaterium* (5%), *Proteus mirabilis* (6%), *Citrobacter freundii* (2%), *Pseudomonas aeruginosa* (11%), *Klebsiella pneumoniae* (7%), *Klebsiella spp.* (2%), *Pseudomonas spp.* (3%), *Bacillus spp.* (1%), *Escherichia coli* (7%), *Serratia marcescens* (5%), and *Serratia spp.* (2%). Infection rate on surgical sites are as follows: Appendisectomy (46.9%), Exploratory laparotomy (45.7%), Simple mastectomy (38.9%), Thyroidectomy (36.8%) and other type of surgery (30.0%). Out of 299 patients operated 124 were infected, this represent 41.5% prevalence rate. It can be concluded that the hospital has high prevalence rate of surgical site nosocomial infection.

Keywords - Nosocomial Infection, Surgical Wound Infections

1. Introduction

Surgical site nosocomial infection is the most common infections in surgical patients, accounting for about 24% of the total number of nosocomial infections. Although the practice of surgery had spread rapidly following the introduction of ether at Massachusetts General Hospital in 1846, even relatively minor procedures could be complicated by severe systemic infection and death, while for major procedures this was the expected outcome. Increasing knowledge regarding the relationship between bacteria and infection advanced at the end of the Century by such legendary figures as Pasteur, Lister, and Koch, led to a series of discoveries and the development of techniques that paved the way for modern surgery. Lister recognized the role of bacteria in surgical wound

infections and in 1867 introduced the practice of spraying antiseptics into wounds to combat bacteria. Subsequently, in 1881, Koch verified the superiority of heat over antiseptics for killing bacteria and preventing access of bacteria to wounds (Wangensteen and Wangenstein, 1978).

The role of the surgeon's hands in introducing bacteria into wound was slow to be recognized despite the work of Semmelweis in 1847. In 1882, when Ernst Bergmann arrived at the Ziegelstrasse Clinic in Berlin and was asked what was new in surgery, he replied, "Today we wash our hands before operation" (Dellinger and Ehrenkraus, 1998).

In the 20th Century, the standardization of aseptic practices in the operating room has greatly improved the safety of clean operative procedures, but operations involving anatomic structures with a dense endogenous flora that cannot be eliminated before operation, such as the colon and rectum,

continue to carry a very high risk of infections (Dellinger and Ehrenkranz, 1998). National Research Council (NRC) documented the rate of surgical wound infection following 15,613 operations carried out for 27 months starting from 1959 to 1962 in 16 operating rooms of five university hospitals (Howard *et al.*, 1964). The study was designed to investigate whether the reduction of airborne bacteria in the operating room, accomplished with ultraviolet light irradiation, could achieve a reduction in surgical wound infections. The result of the study found that ultraviolet light produced a significant reduction in airborne bacteria, but this reduction had no effect on wound infections except in the class of refined clean wounds, which are wound with the lowest probability for contamination by endogenous bacteria. The infection rate in all other classes of wounds: other clean, clean contaminated, contaminated, and dirty wounds were unaffected by ultraviolet irradiation. This study (Howard *et al.*, 1964) was one of the earliest and one of the most convincing studies to document the importance of endogenous bacteria as primary etiological agent of surgical wound infections.

This report also introduced a system for classifying wounds according to the risk of endogenous contamination (and thus of postoperative wound infection), and provided a basis for comparing wound infection statistics. Although more sensitive and specific wound classification system employing additional risk factors for wound infection have been developed since then (Haley *et al.*, 1985; Culver *et al.*, 1991), they all continue to incorporate element of this original scheme. This report was also the largest and most carefully conducted study in its day to examine a host of other factors related to the patient and the environment that influence the risk of postoperative wound infections.

Although antibiotics were introduced near the end of the Second World War, their use did not appear to result in a lower infection rate despite early optimism. The effective use of antibiotics for prevention of postoperative infection was made possible by the pioneering studies of John Burke, who used an animal model to demonstrate the critical importance of the timing of prophylactic antibiotic administration (Burke, 1961). Results of his study showed that appropriate antibiotics given before bacterial contamination, could cause a significant reduction in the risk of infection, while the same antibiotic, given after bacterial contamination, was much less effective. The information was translated into trials demonstrating clinically and statistically significant effect in human patients undergoing scheduled operative procedures, first by Bernard and Cole (1964) and then by Polk and Lopez-Mayor (1969) in the 1960s. Work on prophylactic antibiotics since that time has focused on defining those procedures and circumstances most likely to benefit from the use of prophylactic antibiotics and on examining the relative efficacy of different drugs and different routes and regimens of administration. In the 1970s, reports of surveillance by surgical groups of large numbers of incisions validated the relationship between wound class and differing risk of infection as well as the beneficial effect of reporting wound infection data to the

operating surgeons (Cruse and Foord, 1980).

Surgical wound infections are caused by bacteria, and in the absence of bacteria they do not occur (Dellinger and Ehrenkranz, 1998). However, surgeons have known for years that many other factors also influence the risk of infections. Burk demonstrated in 1963 that all (50 of 50) clean surgical incisions contain bacteria at the end of an operation, but only a small number (4% in that report) become infected (Burke, 1963). An animal study of the relationship between bacteria inoculums and infection risk showed an increasing risk of infection with increasing numbers of bacteria. It was further predicted that reductions in the incidence of postoperative infection could be achieved by techniques that reduce the number of bacteria that gain access to surgical wounds and by focusing on methods to increase the efficacy of host defenses in resisting those bacteria that gain access to the wound.

This work was carried out to determine prevalence of surgical site nosocomial infections in a university teaching hospital in Nigeria with a view to determine prevalence rate of each site of surgical nosocomial infections and making necessary recommendation to improve the situation.

2. Materials and Methods

2.1. Sampling Hospital

The hospital used is a University Teaching hospital (Tertiary health care institution) with bed size of about 500 and five different surgical wards.

2.2. Bacteriological Study of Theatre Air

The bacterial load of the air in the operation theater of University of Ilorin Teaching Hospital was studied using settling plate method. Plates containing Nutrient agar (NA), MacConkey agar, and Chocolate agar were exposed and placed in different areas of the theater at the start of each surgical operation and left exposed until the operation procedure was completed. Thereafter, they were covered and taken to the laboratory for incubation. The duration for each operation was recorded. The Nutrient and MacConkey agar plates were incubated at 37°C in an ambient incubator while plates containing Chocolate agar were incubated in a carbon dioxide incubator containing 10% CO₂ for 24 hrs. Colonies that developed after 24hr of incubation in the plates were enumerated and recorded. Based on the number of colonies per plate, the number of exposed plates and the duration of the surgical operation, the number of colonies in the air per hour was determined and recorded number of colonies forming unit per cubic meter of air (cfu/m³). Colonies showing different morphological characteristics were isolated, purified into pure cultures, coded, sub-cultured onto nutrient agar slant and kept in refrigerator for subsequent characterization.

2.3. Bacteriological Study of Theatre Floor

While the operation was in progress, the bacteria load of the theater floor was studied using swabbing method. The floor of

Out of 64 patients operated for appendicectomy, 30 (46.9%) were infected. For exploratory laparotomy, 48 (45.7%) out of 105 patients operated developed infections. Infections due to

herniorrhaphy, simple mastectomy, Thyroidectomy and other unclassified operations were 33.3%, 38.9%, 36.8% and 30.0% respectively (Table 2).

Table 2. Prevalence of Surgical Site Nosocomial infections in 2005 (Feb-Dec)

Type of Operation	No infected	No of Operations	Infection Rate
Appendicectomy	30	64	46.9
Exploratory Laparotomy	48	105	45.7
Herniorrhaphy	9	27	33.3
Simple Mastectomy	7	18	38.9
Thyroidectomy	14	38	36.8
Others (Unclassified)	16	47	30.0
Total	124	299	41.5

Average bacterial counts from various surgical sites are presented in Table 3 above. Higher counts were observed in appendicectomy in the surgical ward (2.3×10^5 cfu/ml) than

all other classified surgical operations. Bacterial counts before and after closure of surgical wound ranged between 3.0 to 2.8×10^1 CFU/ml.

Table 3. Average bacterial counts from surgical wound surfaces before and after closure in the theater and surgical wards.

Type of operations	Average bacterial counts CFU/ml		
	Before closure in theater	After closure in theater	Surgical wards
Appendicectomy	1.6×10^1	2.8×10^1	2.3×10^5
Exploratory Laparotomy	-	1.3×10^1	1.8×10^5
Herniorrhaphy	3.0	1.8×10^1	1.2×10^5
Simple mastectomy	-	-	1.3×10^5
Thyroidectomy	-	1.9×10^1	2.8×10^5
Others (not classify)	6.0	1.4×10^1	3.4×10^5

S. aureus, *S. epidermidis*, *Ps. aeruginosa* and *E. coli* were the most prevalent surgical site pathogens isolated. Prevalent

rate were respectively, 26%, 18%, 17% and 14% (Table 4).

Table 4. Prevalent Pathogens in the Surgical Site at the University Teaching Hospital in 2004 (Jan-March) and 2005 (Feb-Dec)

Isolated Pathogens	Prevalence Number	Percentage
<i>S. aureus</i>	36	26
<i>St. epidermidis</i>	26	18
<i>Enterobacter spp.</i>	6	4
<i>E. coli</i>	20	14
<i>K. pneumoniae</i>	10	7
<i>Pr. mirabilis</i>	10	7
<i>Ps. aeruginosa</i>	24	17
<i>Bacillus spp.</i>	3	2
<i>Strept. Pyogens</i>	4	3
<i>Proteus vulgaris</i>	3	2
Total	162	100

Table 5. Age Distribution of Patients with Nosocomial Infections in Surgical sites of the University Teaching Hospital in 2006 and 2007

Age Group of Patients	No of Patients operated	No Infected	% Infection
0 - 10	2	0	0
11 - 20	37	18	49
21 - 30	66	40	61
31 - 40	62	27	52
41 - 50	50	23	46
51 - 60	31	18	58
61 - 70	16	11	69
71 and above	23	12	52

Impact of the Age distribution on prevalence of surgical site nosocomial infection showed that Age range of 61-70

years had the highest prevalence (69.0%), followed by 21-30 years (61%) (Table 5).

4. Discussion

The results of the prevalence of surgical wound nosocomial infections carried out at a tertiary health care institution in Nigeria revealed as follow; Bacterial load levels in both the theatre and surgical wards were below the prescribed infectious dose of 106 cfu/ml of wound fluid swabs (Levine et al., 1976; Raahave et al., 1986; Breidenbach and Trager, 1995; Pruitt et al., 1998). Very low bacterial count in both air and floor of theatre and surgical wards in the tertiary health care institution studied is an indication that level of hygiene in this hospital was good.

A total of one hundred and sixty two (162) comprised of seventeen bacterial species were isolated in the hospital environment in 2004 - 2005. *S. aureus* and *S. epidermidis* were the most predominant endemic bacteria species in the hospital environment. These predominance and presence of these two organisms which are likely to have originated from human sources (patients, hospital personnels or visitors to the wards) should be a source of concern to hospital administrators and medical personnel. *S. aureus* especially methicillin resistant ones (MRSA) is currently a major threat to the successful management of infections in hospitals all over the world.

Ps. aeruginosa another comparatively frequent isolated nosocomial pathogen is a known causative agent of surgical wound and urinary tract infections, its presence in the hospital environment also give cause for alarm because of its antibiotic resistant nature. *Kl. pneumoniae*, *E. coli*, *Pr. mirabilis*, *Strept. Pyogenes*, *Ser. marcescens* isolated in the hospitals have also been incriminated in surgical site infection. In this work, some of the isolated bacterial species, such as *B. cereus*, *Ps. aeruginosa*, *S. epidermidis*, *S. aureus*, and *Pr. mirabilis* which were found in the theater and surgical wards were also present in the patients' wounds, implying that these environmental organisms are already colonizing the wound from the theatre. The organisms probably got into the patients wound through either the air or by direct inoculation during dressing, or other devices used on patients or the medical personnel.

Between Feb-May 2005, *S. epidermidis* *S. aureus* that have been hitherto isolated from wounds of patient from the theater were no longer detected in the patients wounds but between July-December, 2005, the distribution pattern of isolates in the theatre and surgical wards changed again. In the theatre *S. epidermidis*, *S. aureus* and *Klebsiella* spp were found in air, floor and the patient wound, *Enterobacter* spp and *Bacillus* spp were also isolated from the floor and the patients wound.

The reason for this new distribution pattern of isolates may not be unconnected with the fact that during this time large numbers of medical students undergoing training were in the theater on posting to observe all operation procedures. Many of them came with their overall, while some used theatre overall. In the surgical ward, *S. epidermidis*, *Kleb-*

siella spp, *Ps. aeruginosa* and *S. aureus* were detected in air, floor and wound of the patients. These observed bacterial distribution have high tendency to cause serious wound infections in the patient, if the right dose of these organism are available.

Comparative analysis of nosocomial infection rate in surgical sites in Feb-April 2004 and Feb-Dec 2005 showed 41.5% prevalence rate. The percentage increase in prevalence of nosocomial infection was highest in the case of appendectomy. This was despite a decreased level of air and floor microbial burden in the theater and surgical ward of the hospital. This low microbial levels in the theater and surgical wards, would according to Bendy, et al., 1964, and the report of some other researchers (Raahave et al., 1976; Pruitt et al., 1986; Breidenbach and Trager, 1995; Levine et al., 1998), be too low to be responsible for contamination and infection of surgical site and wounds. However, Whyte et al. (1991) and Garibaldi (1991) have reported that very low microbial levels in the environments could cause wound contamination and eventual infection, in certain surgical cases.

Whyte et al. (1991) showed that during cholecystectomy, low number of species of bacterial culture from bile can be predictive of wound contamination and later wound infection. Garibaldi (1991) found that 30 or more colony forming units (cfu) of bacteria cultured from a wound are predictive of wound infection and is regardless of wound class, he further demonstrated in a prospective study of 190 colorectal surgery patients that a concentration of 5cfu/ml or higher number of bacteria in the peritoneal fluid is predictive of wound infection.

It means therefore that, the observed infections of surgical site and wound could have resulted from the relatively low microbial burden of the theater and surgical wards

The pathogens isolated from the surgical sites (*S. aureus*, *S. epidermidis*, *Ps. aeruginosa* and *E. coli*) have severally been implicated as major causative agents of nosocomial infection of surgical sites and wounds (CDC, 1999; Shittu, et al., 2002; Oguntibeju and Nwobu 2004). A number of these isolates (*S. aureus* and *S. epidermidis*) are indicative of contamination from personnel and therefore unsatisfactory hygienic practices.

Classification of prevalence of nosocomial infection of surgical sites according to age of patients showed that patients of age at the two extreme ends (geriatric and paediatric) were more susceptible to nosocomial infection, which is in consonance with the reports of Rosineide and Paulo, (2003). This could be due to low immunity levels in these two categories of patients - under-developed organs and immune system in the very young and aging, debilitated organ system with resultant weakened immune system in the old.

5. Conclusion

Prevalence of surgical site nosocomial infections carried out in a tertiary institution in Nigeria showed that the prevalence

theater which has already been demarcated (one meter square) was sub divided into 16 sub-squares, and one of these squares was randomly chosen and swabbed using sterile cotton swab moistened with sterile normal saline. The swab was then put into test tube containing 9ml sterile normal saline and mixed properly as to discharge its contents. One milliliter (1ml) each of this mixture was then used to flood plates of Nutrient agar, MacConkey agar and Chocolate agar. Plates of nutrient agar and MacConkey agar were incubated at 37°C for 24 hrs while the plates of Chocolate agar was incubated under 10% CO₂ for 24 hrs (Bond and Schukster, 2004 and Favero *et al.*, 1984).

The colonies that developed after 24 hrs of incubation, were counted, streaked onto nutrient agar slants and stored at 7°C in refrigerator for further processing.

2.4. Bacteriological Study of Operated Surgical Sites

Surgical operations in the theater were followed and the time taken to complete each surgical operation cycle (i.e. time between incision of the operation site and closure of sutured sites) was recorded. Immediately after completion of an operation and closure of the operated site, it was swabbed using sterile swab stick. The swab was then inoculated into 9ml sterile peptone water from which 1ml each was inoculated on Nutrient agar, MacConkey agar and Chocolate agar plates. The plates were taken to the Microbiology Laboratory of the Hospital, incubated aerobically (for Nutrient and MacConkey agar plates) or under 10% CO₂ (in case of Chocolate agar plates) at 37°C for 24 hours. The colonies that developed after incubation were sub-cultured onto nutrient agar slant and stored in refrigerator for further characterization.

2.5. Bacteriological Study of Patient's Environment in the Wards

The microbial loads of the air environment in the Wards to which the patients were transferred to after the surgical operations were also evaluated using the plate settling method as described above. The microbial levels of the floor of the Wards where the operated patients were kept were also determined using cotton swabs as already described. Resulting colonies were computed and sub-cultured onto nutrient agar slants, kept in refrigerator at 7°C for further characterization.

2.6. Detection of Surgical Site Nosocomial Infections (SSI)

The operated patients in the ward were visited on daily bases, and the sites of operations were inspected for signs of infection. Patient's folders were also checked on daily bases for information that might indicate signs of infection in the surgical sites. The classification of an operations site as positive for surgical site infection (SSI) is based on the definition of WHO/CDC (2002) which states that "SSI is an infection that occurred within 30 days after operative procedure". The patient is deemed to have developed SSI when at least one of the followings is noticed in the patient.

- Purulent drainage from the superficial incision.
- Organism is isolated from an aseptically obtained culture of fluid or tissue from superficial incision.

- At least one of the following signs or symptoms of infection occurs: pain, tenderness, or heat and superficial incision deliberately opened by surgeon unless incision is culture negative.

Where there was occurrence of any of the above signs or symptoms on a patient, the consultant attention was drawn and decision on the status of the sign made. Such sites were then swabbed using sterile cotton swab stick, inoculated in 9 ml sterile peptone water broths, inoculated on Nutrient agar, MacConkey and Chocolate agar and appropriately incubated as described above.

2.7. Characterization of Bacteria Isolates

All the isolated bacteria already sub-cultured onto Nutrient agar slants were characterized based on their cultural, morphological and biochemical reactions as described by Cowan and Steel, 1974 and Monica, 1991.

3. Result

S. epidermidis, *Klebsiella* spp. and *S. aureus* were isolated in the air, floor and wound of patients in both the theater and surgical ward. In surgical ward *Ps. aeruginosa* was isolated in the air, floor and the patients' wounds. *Streptococcus* was also isolated from the wound, though it was not isolated from the air and floor of the ward (Table 1).

Table 1. Distribution of Bacterial Species during Operations in the Theater and Monitoring of Patients in the Surgical Wards (July-Dec, 2005)

Isolates	Air	Theatre Floor	Wound	Air	Ward Floor	Wound
<i>S. epidermidis</i>	+	+	+	+	+	+
<i>Klebsiella</i> sp.	+	+	+	+	+	+
<i>Bacillus subtilis</i>	-	+	-	-	-	-
<i>Enterobacter</i> sp.	-	+	+	-	-	-
<i>Serratia marcescens</i>	-	+	-	-	+	-
<i>Pseudomonas</i> sp.	+	+	+	-	-	+
<i>E. Coli</i>	-	+	-	+	-	-
<i>Ps. aeruginosa</i>	+	+	-	+	+	+
<i>Serratia</i> sp.	+	-	-	-	-	-
<i>Bacillus cereus</i>	+	-	-	+	+	-
<i>Bacillus megaterium</i>	+	-	-	+	-	-
<i>Citrobacter freundii</i>	-	+	-	-	+	-
<i>Proteus mirabilis</i>	+	+	-	+	+	-
<i>Bacillus</i> sp.	-	+	-	-	+	-
<i>Streptococcus</i> spp.	+	-	+	-	-	+
<i>Staph. aureus</i>	+	+	+	+	+	-

rate was high. A prevalence rate of 41.5% is alarming and requires urgent attention to prevent epidemic of the infections in the hospital. That the *Staphylococcus aureus* and *Staphylococcus epidermidis* are the most frequently isolated organisms among the organisms causing infections underscored the need to pay urgent attention to the control of the infections in the hospital. *Staphylococcus* species, particularly *Staphylococcus aureus* are have been regarded as super burge organisms, they are resistant to commonly prescribed and even newly developed antibiotics. It can be concluded that, rate of surgical site nosocomial infections in Nigeria hospitals as revealed in this work is totally unacceptable as patients must have been paid, over stayed in hospital and even died of infections that were not present when they were admitted into the health institution and as such need for functional infection control committee is urgently require.

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