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Risk Factors Associated With Post-Operative Infections Among Orthopaedic Patients With Clean Wounds In OAUTHC, Ile Ife, Nigeria

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Abstract: *The development of post-operative infection depends on contamination of the operative site at the end of a surgical procedure which specifically relates to the pathogenicity and inoculum of microorganisms present, balanced against the host's immune response. This work is aimed at determining the risk factors and major pathogens involved in post-operative infection among orthopaedic patients with clean wounds managed at Obafemi Awolowo University Teaching Hospital, Ile-Ife, Nigeria. Samples were collected at pre incision (before skin preparation), incision and post incision (after the closure of the site) from Orthopaedic patients with clean wounds on admission for surgical operation at the Obafemi Awolowo University Teaching Hospital Complex, Ile – Ife. A well-structured questionnaire indicating patient demographics such as age, gender, diagnosis, duration of operation and other relevant information was used to collate data. Settle plates containing freshly prepared Blood agar, EMB agar, Tryptone soy agar (supplemented with Nystatin) and Mannitol salt agar were exposed and placed in strategic locations in the operating room and in the ward. A total of 75 consecutive orthopaedic surgery patients with clean wounds on admission were considered for this study. They were of both sexes with wound classifications as follows: Open reduction and internal fixation (ORIF) (62.7%), Excisional biopsy (6.7%), Hip hemiarthroplasty (4%), Soft tissue release, Limb lengthening, Corrective osteotomy and Bone grafting as 2.7%, Amputation, Darrach's procedure, Total hip replacement and Patelectomy as 1.3% while other surgical procedures was 10.7%. Their age ranged from a year old (1 yr) infant to an eighty year old (80 yr) woman. The mean age of participants was 35.82 ± 0.48 (standard error of mean) for male and 43.65 ± 0.47 for female, with most of the subjects within the age range of twenty one and forty. Three (4%) out of the seventy – five subjects used in the study had post – operative surgical site infection with two (66.67 %) of them being male and one (33.33 %) female. Their occupation includes civil servants 17 (22.67%) as the highest followed by students 14 (18.67%), traders 12 (16 %), retirees 6 (8%), artisans 6 (8%), infants 3 (4%), farmers 3 (4%) and housewife 2 (2.67 %). Others include timber contractor, cocoa produce seller and self-employed making a total of 12 (16 %). The three infected subjects had their occupation as trader, civil servant and cocoa produce seller. Their source of injury were occupational hazard 2 (2.67 %), school accident 2 (2.67 %), home accident 4 (5.33 %), congenital deformities 8 (10.67 %) and road traffic accident 48 (64 %). Other source of injury includes removal of growth tumour, ganglion excision and hemiarthroplasty making a total of 11 (14.67 %). Altogether, 162 bacterial isolates were recovered; one hundred and fifty six (156) from the operative site comprising of 68 from pre incision, 36 at incision and 52 from post incision sites while the last six (6) were from the three (3) patients with post-operative infection. The predominant isolates from both operative site and wound sepsis were Staphylococcus aureus, and Corynebacterium pseudodiphtheriticum. Two hundred and ninety one (291) bacterial isolates were recovered from the settle media plates exposed at four strategic locations in the operating room. The predominant isolates were Bacillus subtilis, Corynebacterium jeikeium, Staphylococcus aureus and Corynebacterium pseudodiphtheriticum. Fifty (50) bacterial isolates were recovered from the ward environment; mainly B. subtilis,C.pseudodiphtheriticum and S. aureus. The incidence of post-operative infection in clean orthopaedic wound in this study was 4 % with Staphylococcus aureus as the commonest pathogen. Factors such as duration of surgery, surgical procedure and number of persons in the operating room were identified as risk factors for SSIs in this setting. It is recommended that installation of video conferencing device would be useful in reducing the number of persons in the operating room as this has been considered a major risk factor in post-operative infection in this study.*

Keywords: *Post-operative infections, risk factors, Staphylococcus aureus, Corynebacterium pseudodiphtheriticum, Corynebacterium jeikeium, Bacillus subtilis*

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I. Introduction

Post-operative wound infections are major global problem in the field of surgery leading to many complications, and thereby increase the morbidity and mortality rate (Anguzu and Olila, 2007; Raza *et al.,* 2013). The infection rate vary from one hospital to the other (Isibor *et al.,* 2008) and could be affected by many factors such as the state of carrier, infection sources and conduct in the operation room (Bratzler, 2012).According to World Health Organization (WHO), the risk of Surgical Site Infection (SSI) in developing countries is higher than in equivalent surgical procedures carried out in high-income countries. This is especially so in sub-Saharan Africa (Allegranzi *et al*, 2011; Bagheri *et al*., 2011). Surgical Site Infection rate in Tanzania is 26%, 58.5% in Uganda and 44.1% in Ethiopia (Anguzu and Olila, 2007). Reports from Nigeria put the incidence rate range from 4% to 15 % (Lawal *et al.,* 1990; Ako – Nai *et al.,* 1991; Ako – Nai *et al.,* 1992).

These infections in clean operations may be caused by endogenous (e.g., bacteria on the patient's skin) or exogenous sources (e.g., personnel, the environment or materials used for surgery). Studies on the pathogenesis of post - operative infections have shown that the groundwork for infection is laid intra – operatively by bacterial contamination of surgical wounds (Ako-Nai *et al*., 1992; Pryor*et al*., 2004). Intra - operative bacterial colonization of surgical wounds is therefore a prime factor in the development of subsequent wound infection. Bacterial pathogens that are able to survive in the hospital environment for long period and resist disinfection are particularly more important for nosocomial infections (Kramer *et al*., 2006). A systematic review of nosocomial pathogens indicated that most Gram-positive bacteria such as Enterococcus species including Vancomycin resistant Enterococci, *Staphylococcus aureus* including methicillin resistance *S. aureus* (MRSA) and *Streptococcus pyogenes* survive for months on dry surfaces. Many Gram negative bacteria, such as *Acinetobacter* species, *Escherichia coli*, *Klebsiella* species, *Pseudomonas aeruginosa*, and *Serratia marcescens* can survive on inanimate surfaces even for months (Kramer *et al*., 2006). The study is aimed at identifying some of these factors and major pathogens involved in post-operative wound infections in this setting.

Inclusion criteria

The major criterion for inclusion into the study was patients undergoing clean, elective Orthopaedic surgical operation. The study was made up of both male and female who were inpatients on admission at the Obafemi Awolowo University Teaching Hospital Complex, Ile – Ife. The subjects were from all age brackets.

Ethical Approval

This study was reviewed and approved by the Ethical Committee of the Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria (Protocol Number IPHOAU/12/507). Informed consent was obtained from each participant and parental consent from parents of subjects below the age of 13 years.

Collection of Samples

Samples were collected at pre incision (before skin preparation), at incision and post incision(after the closure of the site) from Orthopaedic patients with clean wounds on admission for surgical operation at the Obafemi Awolowo University Teaching Hospital Complex, Ile – Ife. A well-structured questionnaire indicating patient demographics such as age, gender, diagnosis, duration of operation and other relevant information was used to collate data. All patients had peri operative antibiotic prophylaxis which consists of i.v cefuroxime, 1.5g at induction of anaesthesia followed by 750mg i.v 12 hourly x 2 doses as stated by the unit policy.

Description of the Operating Suite and Orthopaedic Ward

The operating suite is located on the second floor of the hospital building designated as phase two. The operating suite is free from the general traffic and air movement in the rest of the hospital. The suite consists of four operating rooms, equipped with two split air conditioning systems with the back opening into free space where the systems can easily be ventilated from outside. The theatre has two double corridors into which swing exit doors from the operating rooms open. Each operating room has a separate scrub room and anaesthesia was administered to the patients on the operating table.

The Orthopaedic ward consists of thirty – four beds shared by both sexes. There are four separate rooms on the west side of the unit each of which can occupy two patients. Each room contains facilities for standing fans. One hundred and four windows are located throughout the ward facilitating cross ventilation. The nurses' station is located in the middle of the unit and there is only one entrance to the unit. The unit has three toilets located at the far end of the ward and used primarily by patients who are mobile while non-mobile patients constrained to their beds will be supplied with bed pans and assisted by ward maids.

Assessment of Orthopaedic Ward and Theatre

Settle plates containing freshly prepared Blood agar, EMB agar, Tryptone soy agar (supplemented with Nystatin) and Mannitol salt agar were exposed and placed in strategic locations in the operating room and in the ward.

Methods of Collection of Sample

Samples were collected from the site of the surgery before skin preparation, during surgery and after wound closure from each subject using sterile cotton – tipped applicators. Samples were also collected from the surgical site at the emergence of infection with sterile cotton tipped applicator. Each applicator was introduced into freshly prepared thioglycolate fluid medium in MacCartney bottles and incubated at 37°C for 48h. Those thioglycolate fluid medium in which growth was noted was thereafter inoculated onto freshly prepared selective and differential media (Mannitol Salt Agar, Eosin Methylene Blue Agar, Tryptone Soy Agar and Blood Agar. The plates were incubated at 37°C for 18–24 h or more until growth is observed.

Characterisation and Identification of Isolates

Isolates were streaked out on MacConkey agar, Eosin Methylene Blue agar, Mannitol Salt agar and Nutrient agar plates for pure isolated colonies. The presence of growth and colour, average colony size, surface, elevation and opacity of colonies produced by each isolate on the media were noted. Young growing cultures of each isolate (18 - 24 h old) were used in preparing smears on clean, grease free microscope slide. The slide was covered for 30 seconds with crystal violet. This was poured off and rinsed with tap water. Gram's iodine solution was applied on the slide for 30 seconds and rinsed. The stain was then decolourised with ethanol and the slide was immediately rinsed with tap water and counter stained with aqueous safranin for about 60 seconds. The slide was rinsed again and allowed to dry. Characteristics of the bacteria were observed under oil immersion microscope at X100 objective.Each bacterial isolate was characterized using the conventional methods for bacterial identification (Cowan and Steel, 1985; Cheesbrough, 2004).

Data Analysis

The results obtained in this study were presented with descriptive statistics, such as mean ± standard error of mean (SEM); proportion (i.e. post-operative infection [POI] rate) was with 95% confidence interval (95% CI).

II. Results

Seventy five participants were recruited for the study. Forty – four (58.7%) of them were males while 31 (41.3%) females. Their age ranged from a year old (1 yr) infant to an eighty year old (80 yr) woman. The mean age of participants was 35.82 ± 0.48 (standard error of mean) for male and 43.65 ± 0.47 for female, with most of the subjects within the age range of twenty one and forty. The overall sex distribution is shown in table 1. The majority of the subjects were between the age group of twenty one to forty. Three (4%) out of the seventy – five subjects had post – operative surgical site infection with two (66.67 %) of them being male and one (33.33 %) female (Table 2). Their occupation includes civil servants 17 (22.67%) as the highest followed by students 14 (18.67%), traders 12 (16 %), retirees 6 (8%), artisans 6 (8%), infants 3 (4%), farmers 3 (4%) and housewife 2 (2.67 %). Others include timber contractor, cocoa produce seller, self-employed making a total of 12 (16 %) (Table 3). The three infected subjects had their occupation as trader, civil servant and cocoa produce seller. Their source of injury include occupational hazard 2 (2.67 %), school accident 2 (2.67 %), home accident 4 (5.33 %), congenital deformities 8 (10.67 %) and road traffic accident 48 (64 %). Other source of injury includes removal of growth tumour, ganglion excision and hemiarthroplasty making a total of 11 (14.67 %) (Table 4).

The incidence of post – operative surgical site infection in relation to surgical procedure and duration of surgery is shown in table 5. All the patients that were involved in the study had different surgical procedure at different operation time and none of the procedure had post-operative infection except the open reduction and internal fixation which had the highest number of patients involved. The incidence of post - operative surgical site infection in relation to pre – operative and post – operative stay is as shown in table 6. The duration of pre-operative stay ranged from a day to forty seven weeks with the mean time in weeks ranging from 0.14 to 16.33, while the duration of post-operative stay in mean per week ranged from 0.14 to 2.71. The medical personnel in the theatre include the physicians (surgeons, resident doctors and house officers), nurses (scrub, circulating and peri operative nursing (PON) student), medical students and other medical personnel (anaesthetists and researchers). The total number of medical personnel altogether was one thousand and ninety one (1,091) with the number of people that were not directly involved in the procedure having the highest percentage. In the overall, ORIF procedure had the highest number of medical personnel which included a very high number of personnel that were not involved directly with the surgical procedure (Table 7).

Altogether, five hundred and three (503) bacterial species were recovered and duly identified following the basic bacteriological procedure (Cowan and Steel (1985); Cheesbrough, 2004). One hundred and fifty six (156) of the bacterial species were from the patient (pre incision= 68; incision= 36; post incision=52); two hundred and ninety one (291) from the operating room air; fifty (50) from the ward environment while the remaining six were from the infected site. The dynamics of the bacterial species classified based on Gram reaction from different sources is as shown in tables 8 and 9 while the dynamics of bacterial species from different sources of patients without post-operative infections and patients with post-operative infection is as shown in tables 10, 11 and 12 respectively.

Table 1: The overall sex distribution of participants

Age (years)	Total no of individuals	(%)
1 – 78 (Male)	44	58.67
3 – 80 (Female)	31	41.33

Table 2: The incidence of post-operative infection in relation to the overall age and sex distribution

Age group(yrs)	Male (%)	Incidence of infection (%)	Female (%)	Incidence of infection (%)
≤ 20	8 (18.18)	0	4 (12.9)	0
21 – 40	22 (50)	2 (66.67)	10 (32.25)	0
41 – 60	9 (20.45)	0	9 (29.03)	0
61 – 80	5 (11.36)	0	8 (25.8)	1 (33.33)
Total	**44 (100)**	**2 (66.67)**	**31 (100)**	**1**

Table 3: Incidence of Post-Operative Infection in Relation to their Occupation

Occupation	No of patients	Incidence of infection (%)
Housewife	2	0
Infants	3	0
Farmers	3	0
Artisans	6	0
Retirees	6	0
Traders	12	1 (33.33)
Students	14	0
Civil servants	17	1 (33.33)
Others	12	1 (33.33)
Total	75	3 (100)

Table 4: Incidence of Post-Operative Infection in Relation to their Source of Injury

Source of injury	No. of patients	Incidence of infection
Occupational hazard	2	0
School accident	2	0
Home accident	4	1 (33.33 %)
Congenital deformities	8	0
Others (e.g removal of growth tumour)	11	0
Road traffic accident	48	2 (66.67 %)
Total	75	3

Table 5: Incidence of Post-Operative Surgical Site Infection in Relation to the Surgical Procedure and Duration of Surgery

Surgical procedure	No.of patients	(%) Total	Duration of surgery(mean time in minutes)	Incidence of infection (%)
Open reduction and internal fixation	47	62.7	129.40	3(6.4)
Excisional biopsy	5	6.7	47.8	0
Hip hemiarthroplasty	3	4	151.67	0
Soft tissue release	2	2.7	122.5	0
Limb lengthening	2	2.7	137.5	0
Corrective osteotomy	2	2.7	70	0
Bone grafting	2	2.7	86	0
Amputation	1	1.3	70	0
Darrach's procedure	1	1.3	65	0
Total hip replacement	1	1.3	174	0
Patelectomy	1	1.3	133	0

Other musculoskeletal	8	10.7	114.9	0
Total	75	100	1301.77	3 (4)

Table 6: Incidence of Post - Operative Surgical Site Infection in Relation to Pre – Operative and Post – Operative Stay

Surgical procedure	No. of patients	Pre – operative stay (mean time in weeks)	Post – operative stay (mean time in weeks)	Incidence of infection (%)	P value
Open reduction and internal fixation	47	5.66	2.05	3 (6.4)	0.013
Excisional biopsy	5	1.39	1.14	0	
Hip hemiarthroplasty	3	16.33	2.21	0	
Bone grafting	2	4	2.14	0	
Corrective osteotomy	2	0.29	0.29	0	
Limb lengthening	2	1.14	2.71	0	
Soft tissue release	2	1.29	0.71	0	
Amputation	1	0.14	ND	0	
Total hip replacement	1	0.43	0.43	0	
Darrach's procedure	1	1.71	0.14	0	
Patelectomy	1	2.29	1.86	0	
Other musculoskeletal	8	6.86	1.61	0	
Total	75	40.71	15.29	3 (4)	

Table 7: Incidence of Post - Operative Surgical Site Infection in Relation to the Number of Medical Personnel in the Operating Room

Surgical procedure	**Total (%)**	**Number of medical personnel**					**P value**
		Physicians	**Nurses**	**Medical student**	**Others**	***Incidence of infection (%)***	
Hip hemiarthroplasty	41 (3.76)	13	9	0	19	0	
Open reduction and internal fixation	713 (65.35)	224	111	78	300	3	0.001
Amputation	13 (1.91)	7	2	0	4	0	
Total hip replacement	16 (1.47)	7	3	0	6	0	
Darrach's procedure	8 (0.73)	4	2	0	2	0	
Soft tissue release	32 (2.93)	11	7	7	7	0	
Patelectomy	17 (1.56)	4	3	0	10	0	
Limb lengthening	23 (2.11)	8	5	0	10	0	
Corrective osteotomy	30 (2.75)	11	7	0	12	0	
Excisional biopsy	60 (5.50)	23	14	4	19	0	

Table 8: Dynamics of Gram positive Bacteria from Different Sources

Bacterial isolates	Total no. cultured	Pre-incision	Incision	Post-incision	Infected wound	Operating room air	Ward air
Staphylococcus aureus	81	17	6	8	2	42	6
Corynebacterium pseudodiphtheriticum	76	10	9	6	2	38	11
Bacillus subtilis	69	4	3	2	0	46	14
Corynebacterium jeikeium	61	8	0	6	0	43	4
Corynebacterium xerosis	49	6	3	6	2	29	3
Corynebacterium pseudotuberculosis	30	6	3	10	0	10	1
Staphylococcus schleiferi	22	0	0	0	0	16	6
Arcanobacterium haemolyticum	18	5	0	3	0	9	1
Bacillus cereus	12	0	1	0	0	8	3
Staphylococcus sciuri	10	2	2	1	0	5	0
Staphylococcus capitis	10	0	0	1	0	9	0
Corynebacterium ulcerans	9	3	0	1	0	4	1
Micrococcus luteus	3	0	1	1	0	1	0

Corynebacterium diphtheriae	2	2	0	0	0	0	0
Staphylococcus cohnii	2	0	0	1	0	1	0
Staphylococcus epidermidis	2	0	0	0	0	2	0
Staphylococcus simulans	2	0	0	0	0	2	0
Staphylococcus saprophyticus	1	0	0	0	0	1	0
Staphylococcus hominis	1	0	0	0	0	1	0
Staphylococcus haemolyticus	1	0	0	0	0	1	0
Micrococcus varians	1	1	0	0	0	0	0
Total	**462**	**64**	**28**	**46**	**6**	**268**	**50**

Table 9: Dynamics of Gram negative Bacteria from Different Sources

Bacterial isolates	Total no. cultured	Pre-incision	Incision	Post-incision	Infected wound	Operating room air	Ward air
Pseudomonas aeruginosa	17	2	6	3	0	6	0
Enterobacter aerogenes	15	0	0	1	0	14	0
Escherichia coli	5	1	1	2	0	1	0
Proteus vulgaris	4	1	1	0	0	2	0
Total	**41**	**4**	**8**	**6**	**0**	**23**	**0**

Table 10: Dynamics of Gram positive Bacteria from Different Sources of patients without post-operative infection

Bacterial isolates	Total no. cultured	Pre-incision	Incision	Post-incision	Operating room air	Ward air
Staphylococcus aureus	79	17	6	8	42	6
Corynebacterium pseudodiphtheriticum	73	10	8	6	38	11
Bacillus subtilis	69	4	3	2	46	14
Corynebacterium jeikeium	60	8	0	5	43	4
Corynebacterium xerosis	45	5	3	5	29	3
Corynebacterium pseudotuberculosis	26	6	3	9	7	1
Staphylococcus schleiferi	22	0	0	0	16	6
Arcanobacterium haemolyticum	16	5	0	2	8	1
Bacillus cereus	12	0	1	0	8	3
Staphylococcus sciuri	10	2	2	1	5	0
Staphylococcus capitis	10	0	0	1	9	0
Corynebacterium ulcerans	9	3	0	1	4	1
Micrococcus luteus	3	0	1	1	1	0
Corynebacterium diphtheria	2	2	0	0	0	0
Staphylococcus cohnii	2	0	0	1	1	0
Staphylococcus epidermidis	2	0	0	0	2	0
Staphylococcus simulans	2	0	0	0	2	0
Staphylococcus saprophyticus	1	0	0	0	1	0
Staphylococcus hominis	1	0	0	0	1	0
Staphylococcus haemolyticus	1	0	0	0	1	0
Micrococcus varians	1	1	0	0	0	0
Total	**445**	**63**	**27**	**41**	**264**	**50**

Table 11: Dynamics of Gram negative Bacteria from Different Sources of patients without post-operative infection

Bacterial isolates	Total no. cultured	Pre-incision	Incision	Post-incision	Operating room air	Ward air
Pseudomonas Aeruginosa	16	2	5	3	6	0
Enterobacter aerogenes	15	0	0	1	14	0
Escherichia coli	5	1	1	2	1	0
Proteus vulgaris	4	1	1	0	2	0
Total	**40**	**4**	**7**	**6**	**23**	**0**

Table 12: Dynamics of Bacteria isolates from Different Sources of patients with post-operative infection

Bacterial isolates	Total no. cultured	Pre-incision	Incision	Post-incision	Infected wound	Operating room air	Ward air
			Gram positive isolates				
Corynebacterium xerosis	4	1	0	1	2	0	0
Corynebacterium pseudotuberculosis	4	0	0	1	0	3	0
Corynebacterium							

pseudodiphtheriticum	3	0	1	0	2	0	0
Arcanobacterium haemolyticum	2	0	0	1	0	1	0
Staphylococcus aureus	2	0	0	0	2	0	0
Corynebacterium jeikeium	1	0	0	1	0	0	0
Micrococcus varians	1	1	0	0	0	0	0
			Gram negative isolates				
Pseudomonas aeruginosa	1	0	1	0	0	0	0
Total	**18**	**2**	**2**	**4**	**6**	**4**	**0**

III. Discussion

Seventy five patients used in this study were made up forty four males and thirty one females.Three out of the seventy five patients which include two males and one female developed post-operative infection giving a surgical site infection (SSI) rate of 4%. This SSI rate was similar to a previous study conducted in one of the Nigerian hospitals (Enweani, 1991). The three infected cases occurred in patients with superficial incisional infections which were corroborated by several studies that described superficial incisional infection as the most common surgical site infection (Nichols, 2004; Oliveira and Carvalho, 2007; Ercole *et al*., 2011). The SSI rate among the male patients was 4.5% while that of female was 3.2%. This is in line with a study conducted in India where males had higher SSI rate than females (Anusha *et al*., 2010; Anand *et al*., 2013). Similar values were also reported in a Tanzanian study (Mawalla *et al*., 2011). Though males tended to have higher SSIs, there was no significant difference in SSI rate when compared with the females (p=0.08). This was consistent with a number of other studies (Ntsama *et al*., 2013; Nwankwo *et al*., 2013).

The mean age of the patients with post-operative infection was 44 ± 13.32 years with the maximum age of 70 years while those without post-operative infection was 38.85 ± 2.23 with maximum age of 80 years. The statistical analysis that compared average ages of these two groups showed that there was no significant difference between them (p=0.65). This study which had no significant relationship between gender and post-operative infection was consistent with other studies (Ntsama *et al*., 2013; Nwankwo *et al*., 2013). Maksimovic *et al*., 2008 also reported no significant differences in age or gender between their case patients and matched controls.

The mean length of preoperative stay among patients with post-operative infection was 8.3 days with a maximum of 15 days while the mean length of preoperative stay among patients without post-operative infection was 38.2 days with a maximum of 620 days. This study revealed no association of this factor with post-operative infection in contrast to a previous study conducted in this setting (Akinyoola *et al*., 2008). Reducing the length of hospital stay before surgery seems to be an important preventive measure, because hospitalization periods have been reported to enhance skin colonization by hospital microbiota. In a similar fashion, the mean length of post-operative stay among patients with post-operative infection was 43 days with a maximum of 100days while the mean length of postoperative stay among patients without post-operative infection was 12.5 days with a maximum of 48 days. This also did not reveal any association with post-operative infection, though another study confirmed the length of post-operative hospital stay as a significant factor for post-operative infection (Ako – Nai *et al*., 1992). The mean surgery length for the three patients with post-operative infection was 181.7 minutes with a maximum duration of 240 minutes while the mean surgery length for the remaining patients without post-operative infection was 115.5 minutes with a maximum duration of 375 minutes. Surgery length of more than 120 minutes has been considered a risk factor for infection (Nichols, 2004; Ridgeway *et al*., 2005; Khan *et al*., 2006); as it increases tissue exposure time, team fatigue, and enhances technical errors (Mangram *et al*., 1999). Ercole *et al*. (2011) reported that patient's clinical condition, pre- and post-operative hospitalization time and type of surgical procedure are associated risk factors to SSIs. Aerial contamination in the operating room averaged 169.1 to 189.5 colonies per plate on blood agar and tryptone soy agar while the aerial contamination in the ward averaged 168.9 to 215.3 colonies per plate on tryptone soy agar and blood agar. This is suggesting a high degree of contamination despite the fact that only aerobes were considered. The degree of contamination of both the operating room and the ward air in this study did not however reflect in the incidence of post-operative infection.

The data analyzed in this study suggests that majority of the surgical procedures were elective, without any association between this variable and the development of infection. Other authors support this finding, defining that emergency surgeries do not seem to constitute a risk factor for SSI (Maksimovic *et al*., 2008; Ercole *et al*., 2011). Open reduction and internal fixation (ORIF) of fractures with implants and prosthetic devices has become the predominant modality of treatment of fractures in most trauma centres (Schatzker, 1996). This is not only because of the better understanding of the biomechanics of implantable materials but more importantly because of the better functional outcome in these patients. Despite this, it was reported to be associated with post-operative infection. It is interesting to know that 6.4 % of the patients who underwent ORIF in this study developed post-operative infection, and incidentally, it is also significant that this constitutes all of the post-operative infection recorded in this study since none of the patients who had the other procedures developed any infection. A similar finding of some authors reported the range of 0.8 to 13%for both deep and superficial infections (Schatzker, 1996; Onche, 2000). It is suspected that this observation could be as a result of the interference of ORIF with the blood supply to the bones and implants which are foreign bodies that could provide surfaces for bacterial adhesion (Classen *et al*., 1992; Onche, 2000).

The total number of medical personnel for all the procedures in this study was 1,091 which include the physicians, nurses, medical student and other members of the medical team that were not directly involved in the procedure. The average number of medical personnel in the theatre during the procedures for the three patients with post-operative infection was 20.3 with a maximum of 30 persons. This averagely includes 5.3 physicians, 7.3 medical students, 2.7 nurses and 5 for other members of the medical team. Similarly, the average number of medical personnel in the operating room for the remaining patients without post-operative infection was 14.3 with a maximum of 30. This averagely includes 4.8 physicians, 1.0 medical student, 2.6 nurses and 6 for other members of the medical team. This factor has been confirmed as a significant risk factor for SSIs (p=0.001) in this study. In this hospital setting, many clinical students, house officers and residents tended to attend orthopaedic operations and the operation rooms were not designed as a teaching setting. Reduction of number of persons in the operating room may reduce the incidence of SSIs (Scherrer, 2003).

The bacteria isolates recovered from the infected site were mainly*Staphylococcus aureus,Corynebacterium pseudodiphtheriticum* and *Corynebacterium xerosis*. It has been reported that in clean surgical procedures, *S. aureus* from the exogenous environment or the patient's skin flora is the common pathogen in the cause of surgical site infection (Andhoga *et al*., 2002; Aishby*et al*., 2010). *Corynebacterium jeikeium* has been confirmed as the most common coryneform from orthopaedics and other surgical site infections (Rizvi *et al*., 2011). *Corynebacteriumsp* that were originally referred to as commensals or saprophytes in human, animal or the environment have now been associated with human or animal infections (Bernard and Funke, 2012). The isolation of *Corynebacteriumsp* from the surgical site before infection is suggesting the presence of these non-diphtheroid corynebacteria in the mucosa and normal skin flora of humans and animals as reported by some authors (Yassin *et al.*, 2003; Collins *et al*., 2004).

IV. Conclusion and Recommendation

The rate of SSI in clean Orthopaedic operations in this study is 4% which could still be reduced as some authors believed that SSI rate in this class of wound should be less than 2% (Culver *et al*., 1991). This could be achieved by instituting a standard infection control protocol which includes limiting the number of medical personnel in the operating room during surgical procedures and strict adherence to the antibiotic administration policy.

Since most of the persons in the operating room that make up the high number are students, it is hereby suggested that installation of video conferencing device would go a long way in reducing the number of persons in the operating room thus reducing the risk of surgical site infection .

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