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An Overview Of Surgical Site Infections: An Insight Into The Prevalence, Etiology And Predisposing Factors

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Abstract: Background: Surgical site infection is one of the major predictive factors for morbidity and mortality. The advancement in the asepsis and antibiotic protocols may have reduced its incidences in the developed countries, but it still remains a condition needing close attention by the treating surgeon in avoiding an undesirable catastrophe.

Methods: A cross-sectional prospective study was conducted on all the patients who underwent major surgical procedures during the period between Jan 2010 and Dec 2010. Pre-operative factors, intra-operative and post operative variables were collected. Culture specimens from the infected surgical wounds were tested for type of growth and susceptibility testing was done using disc diffusion technique.

Results: A total of 638 patients underwent major surgical procedures during the above mentioned study period. Surgical site infection was detected in 91 (14%) patients. Out of these patients, 83 (91%) and 8(9%) had superficial and deep surgical site infection respectively. Staphylococcus aureus was the predominant organism in 31cases (28.5%); of which 8 (25%) were Methicillin Resistant Staphylococcus aureus. This was followed by Escherichia coli (17.8%), Pseudomonas (16%) and Klebsiella (14.2%). Among the Escherichia coli and Klebsiella pneumoniae isolates, 30% and 37.5% were Extended Spectrum Beta Lactamases producers respectively. Presence of co-morbid illness, use of iodine alone on skin during preparation of parts, duration of surgery ≥ 3 hours and cigarette smoking were significant factors for prediction of surgical site infection.

Conclusion: Surgical site infection is common among patients admitted in surgical wards, with co-morbid illness, use of drain, iodine alone in skin preparation, prolonged duration of the operation and cigarette smoking. Prevention strategies focused on factors associated with SSI are necessary in order to reduce the rate of SSI in our setting.

Key words - Surgical Site, Infections, Antibiotics

I. INTRODUCTION

Surgical site infections (SSIs) accounts for 20% to 25% of all Hospital acquired infections in majority of the studies worldwide [1]. Despite improvements in standard operating room practices, strict instrument sterilization methods and the best efforts at infection prevention strategies, surgical site infections remain a major cause of hospital-acquired infections. On a Global scale, the incidence ranges from 2.5% to 41.9% [3-9] and is increasing globally even in hospitals with most modern facilities and standard protocols of preoperative preparation and antibiotic prophylaxis. In developing countries where resources are limited, even basic life-saving operations, such as appendectomies and cesarean

sections, are associated with high infection rates and mortality [4, 10]. In the United States alone, 2% to 5% of the 16 million patients undergoing surgical procedures every year have postoperative surgical site infections [10]. Thus SSIs have been responsible for higher morbidity and mortality rates following any surgical procedure. They have a high impact on the cost and hospital resource utilization and hence prevail to be a major problem worldwide [2]. Number of studies carried out in India show an overall infection rate of 4.04 to 30% for clean surgeries and 10.06 to 45% for clean-contaminated surgeries.[5], [7], [10]
This particular study was conducted to estimate the prevalence pattern and predictors of surgical site infections.

II. Methodology

A cross-sectional prospective study was conducted among patients undergoing major surgery at M.S.Ramaiah Medical College and Hospitals from Jan 2010 to Dec 2010. Patients in the post operative surgical wards and surgical ICUs were studied. A total of 638 cases of all age groups and gender undergoing major surgical procedures with visible incision (laparotomy, excisional biopsy, appendicectomy, thyroidectomy, herniotomy, mastectomy, amputations, cholecystectomy, splenectomy etc) were studied.

III. Data collection & Laboratory procedures

Predictor variables such as patient characteristics, preoperative data, intra-operative data and postoperative data were collected. Details recorded included; type and duration of operation, wound class, antimicrobial prophylaxis, use of drain and total hospital stay. Each patient was followed up from the admission time until time of the discharge and 30 days postoperatively.
Superficial surgical site infection was diagnosed if any one of the following criteria was fulfilled: purulent drainage from the superficial incision, organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision, at least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat, and superficial incision is deliberately opened by surgeon, and is culture-positive or not cultured.

Deep surgical site infection was diagnosed if any one of the following criteria was fulfilled; purulent drainage from the deep incision but not from the organ/space component of the surgical site, a deep incision spontaneously dehisces or is deliberately opened by a surgeon and is culture-positive or not cultured and the patient has at least one of the following signs or symptoms: fever (> 38°C), or localized pain or tenderness. A culture-negative finding does not meet this criterion, an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathological or radiological examination, diagnosis of a deep incisional SSI by a surgeon or attending physician.

Pus or pus swabs were obtained from surgical incision and transported immediately to the laboratory. Pus samples collected were processed for aerobic bacterial culture on blood agar and MacConkey agar and incubated aerobically at 37^{o}C for 18-24 hrs. Culture plates were examined and the organisms were identified by colony morphology, gram stain and standard biochemical tests. Antibiotic susceptibility test was performed on Mueller Hinton agar (MHA) by Kirby Bauer disc diffusion technique using H1 media antibiotic discs. Methicillin Resistant Staphylococcus aureus (MRSA) were detected using Cefoxitin Discs (30ugms), on MHA plates which were incubated at 35^{o}C for 24 hrs. ESBL (Extended Spectrum Beta Lactamases) were confirmed by performing combined disc test using Ceftazidime and ceftazidime + clavulinic acid.

IV. Results & Discussion

638 patients in all underwent major surgery during the study period. SSI was detected in 91 patients, giving an overall infection rate of 14% (Table I), out of which 83 (91%) were superficial SSIs and 8(9%) were deep SSIs. Due to various reasons such as peritonitis, intestinal obstruction, intestinal perforation laparotomy was the leading procedure performed in 61 patients. The time taken for SSIs to develop ranged from 3-10 days with a mean of 4.6 days. The mean age of patients with SSIs amongst the 91 patients was 41years. There were

74 (81.3%) males and 17(18.7%) females (Table II).

Table I - Bacterial isolate form the SSI

Organisms	Number	Percentage
Staphylococcus aureus	31	28.5
E.Coli	20	17.8
Pseudomonas spp	18	16
Klebsiella spp	16	14.2
Proteus spp	9	8
Acinetobacter	6	5.3
Enterococcus spp	7	6.25
Providencia spp	4	3.5
Enterobacter spp	1	0.89

Table II – antibiotic susceptibility pattern of bacteria isolated from surgical wounds: gram negative bacilli (% sensitivity)

Antibiotic	E. coli	Klebsiella	Proteus	Acinetobacter	Providentia
Ampicillin	30	IR	IR	16.6	IR
Ceftazidime	50	56.25	77.7	33.3	100
Ceftriaxone	45	31	66.6	33.3	75
Ciprofloxacin	30	43.7	66.6	16.6	75
Gentamicin	70	87.5	55.5	66.6	75
Imepenem	100	93.7	77.7	33.3	100
Meropenem	100	87.5	77.7	100	100
Piperacillin +Tazobactum	-	93.7	100	100	100
Amikacin	90	93.75	66.6	66.6	100

IR- Intrinsically Resistant

A - Predictors of SSI Pre-morbid illness

64 (70.3%) of the 91 patients had pre-morbid illness namely diabetes Mellitus 34 (37.3%), hypertension 37 (40.6%), COPD 25 (27.4%), corticosteroid therapy 13(14.2%), obesity 11 (12%) and Bronchial asthma 11(12%) as in table - 4. The SSI rates for patients with pre-morbidity and without were 70.2% and 38.4% respectively.

B - History of cigarette smoking

In this study 35(38.4%) of the 91 patients had a history of cigarette smoking.

C - Antimicrobial prophylaxis

All 91 cases with SSIs received preoperative antimicrobial prophylaxis. 54(59.3%) received ceftriaxone and metronidazole; ceftriaxone alone in 14 (15.3%) and cefazolin in 23(25.2%). The timing of the antimicrobial prophylaxis ranged from 10 minutes before the incision to 30minutes post incision.

D - American Society of Anesthesiologists (ASA) classification, skin preparation, use of drain

The SSI rates for ASA classification I and III were 5.2% and 88.9% respectively. In 80 (87.9%) patients iodine was used for skin preparation. The SSI rates for iodine alone and Iodine + Spirit were 87.9% and 12.1% respectively. In this study, the use of drain was recorded in 52 patients (57.1%). SSI rates among patients who used drain and those who did not use drain were 57.1% and 42.9% respectively.

E - Duration of Surgery

The duration of operation ranged from 30 minutes to 6 hours with a mean of 1.5hrs. The SSI rate in patient with duration of operation < 3 hours was 15% and in those which had duration of operation ≥ 3 hours, it was 65%.

F - Post-operative antibiotic prophylaxis

Except for three patients all the others who underwent excisional biopsy, were treated with antibiotics after the surgical operation, varying from 48 hrs to 7 days.

G - Surgical wound classification

Among the 91 patients, 72 (79.1%) had clean surgeries, 12 (13.1%) had clean-contaminated surgeries, 5 (5.4%) had contaminated surgeries and 2(2.1%) cases had dirty surgery. SSI was seen in all types of surgeries in the following order- clean surgeries(7.6%), clean contaminated(21%), contaminated(27.4%), and dirty(43.9%).

H - Bacterial infection and susceptibility pattern

All 91 patients diagnosed to have SSI had specimens collected for microbiological investigation grew single or multiple organisms after 18-24hrs of incubation. 21 out of 91 cultured specimens (23%) had mixed growth. Common bacteria isolated were: Staphylococcus aureus 31 (28.5%), Escherichia coli 20 (17.8%), Pseudomonas spp 18(16%) and Klebsiella pneumoniae 16 (14.2%), while the least isolated bacteria was enterobacter spp (0.89%) (Table 1). 6(30%) and 6 (37.5%) of Escherichia coli and Klebsiella pneumoniae were found to be ESBL producer respectively i.e. resistant to first, second, third and fourth generation cephalosporins. Most of these ESBL producing isolates were isolated from the patients with laparotomy and dirty wounds. MRSA was detected in 8(25%) of all Staphylococcus aureus isolates and all of them were from the relaparotomy wounds.

In this study, most of our patients were in the age group 19-65 and showed a male preponderance. Similar demographic observation was reported by another study in India [17]. The rate of SSI was significantly higher in male patients. This could be explained by multiple risk factors in male such as cigarette smoking as described in many studies [19]. Cigarette smoking has been reported to have an impact on wound healing through impairment of tissue oxygenation and local hypoxia via vasoconstriction [20]. Previous studies have shown that patients with pre-morbid illnesses, such as diabetes mellitus are at high risk of developing SSI due to their low immunity [18]. This was confirmed in this study.

However in the present study, all patients with surgical site infection had received antibiotic prophylaxis for various surgeries. Many studies do not show a significant association between the preoperative antibiotics and SSI. But we still believe that antibiotic prophylaxis is most effective in preventing surgical site infections when administered 30 to 60 minutes before the start of surgery. The lack of significance could partly be explained by a non existing antibiotic policy regarding different procedures for these patients. The findings of this study necessitate the introduction of evidence based antibiotic prophylaxis in developing countries.

In this study it was observed that, the rate of SSI was significantly associated with ASA classification. Similar observations have been made by other studies wherein the chance of SSI in ASA grade III [23-25] was higher. The study also observed that the use of povidone alone was found to be associated with higher SSI rates. Povidone iodine has a shorter activity than chlorhexidine and is inactivated by blood and serum protein [27, 28]. Additionally the use of surgical drain has been reported to be associated with an increased risk of SSI, which was confirmed in this study [24, 27, and 28]. In agreement with other studies [29], the present study found that an operation of more than 3 hours duration leads to 4 times higher risk for SSI. Increasing the length of procedure theoretically increases the susceptibility of the wound by increasing bacterial exposure and the extent of tissue trauma (more extensive surgical procedure) and by decreasing the tissue level of the prophylactic antibiotic.

Surgical wound classification has long been established as an important predictor for the postoperative surgical site infections [12, 30, and 31]. In our study, as in previous studies, the risk of SSI was statistically higher in contaminated and dirty wounds than in clean wounds. Staphylococcus aureus was the predominant isolate from the postoperative wound infections which was consistent with reports from other studies [5, 32]. It has been found that in clean surgical procedures, Staphylococcus aureus from the exogenous environment or the patient's skin flora is the usual pathogen. In other categories of surgical procedures, including clean-contaminated, contaminated and dirty, the polymicrobial flora closely resembling the normal endogenous microflora of the affected site is the most frequently isolated pathogens [32].

Staphylococcus aureus was the most common isolate in patients who underwent mastectomy and appendicectomy. Escherichia coli and Klebsiella pneumoniae were the most common gram-negative bacteria and were predominantly isolated from laparotomy and intestinal anastomosis. Similar findings have been reported in other studies [32, 33]. The study also found that higher number of the pathogens was resistant to the commonly prescribed antibiotics such as ciprofloxacin, ampicillin, penicillin, gentamicin, erythromycin, and ceftriaxone. Other studies from Nigeria and Kenya reported a similar antimicrobial susceptibility pattern [34]. These findings reflected the widespread and indiscriminate use of antibiotics, coupled with poor patient compliance and self treatment without prescription among African patients. The majority of gram negative isolates were sensitive to amikacin, imepenem and meropenem while gram positive were sensitive to vancomycin and linezolid. This could be explained by the fact that these antibiotics are relatively rare in the surgical wards and are more expensive and hence rarely misused.

Table III – antibiotic susceptibility pattern of bacteria isolated from surgical wounds: gram positive cocci (% sensitivity)

Antibiotics	S.aureus	Enterococcus
Ciprofloxacin	50	71.4
Erythromycin	71.87	-
Gentamicin	65.6	71.4
Linezolid	100	100
Penicillin	0	0
Vancomycin	100	100
Cefoxitin	75	-

Table IV – comorbid conditions in 64 patients with SSI

Diabetes mellitus	34	37.3%
Hypertension	37	40.6
Smoking	35	38.45
COPD	25	27.4
Corticosteroid therapy	13	14.2
Obesity	11	12
Bronchial asthma	11	12

V. Conclusion

Surgical site infections are a major problem in the surgical wards and their incidence is higher than the incidence reported in developed countries. Multi-resistant Staphylococcus aureus followed by Escherichia coli and Klebsiella pneumoniae are common bacteria causing SSIs. Pre-morbidity, use of drain, use of iodine alone in skin preparation, duration of operation of more or equal 3 hours and cigarette smoking were significantly associated with SSI. A better surveillance system for SSI with feedback of appropriate data to surgeons is highly recommended to reduce the SSI rate in developing countries.

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