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Full Length Research Paper

Surgical site infections: Assessing risk factors, outcomes and antimicrobial sensitivity patterns

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A prospective study was carried out on 1125 surgeries for the incidence of surgical site infections (SSIs). The etiologic agent was isolated, identified and the antibiotic susceptibility pattern was determined using standard methods. The risk associated with SSIs was assessed by multivariate regression logistic analysis. A case-control study was carried out for the outcome of SSIs. The outcomes measured were: length of intensive care unit (ICU) stay (in days), length of ward stay (in days), costs incurred (in rupees) by the patient, and mortality rate. The results indicated that 12% of patients undergoing surgery developed SSI. *Staphylococcus aureus* (33%) and *Enterococcus* spp. (33%) were the commonest etiologic agents. Patients with SSIs had a significantly extended ICU and ward stay ($p<0.001$), and incurred higher hospital costs ($p<0.001$) when compared to those who did not develop SSIs. The mortality rate was high in patients who developed SSIs. The risk factors associated with SSIs were age above 45 years ($p=0.012$), female ($p=0.070$), diabetic status ($p<0.001$) and surgeries such as gastrectomy, prostatectomy, hysterectomy, cholecystectomy and appendectomy. Surgical site wound infection, though preventable, still remains as high as 12%. Determining the antimicrobial patterns of the organisms causing SSIs will enable institutions to restrict the use of antimicrobials and take active measures in preventing the spread of drug resistance in a hospital.

Key words: Eitiology, risk factors, surgical site infections, SSI.

INTRODUCTION

Postoperative surgical site infections (SSIs) are a major source of illness to a surgery patient (Nichols, 1998). In the United States alone, these infections number approximately 500 000 per year, among an estimated 27 million surgical procedures (Centers for Disease Control and Prevention, 1994), and account for approximately one quarter of the estimated 2 million nosocomial infections in the United States each year (Haley et al., 1985). Infections result in longer hospitalization and higher costs. Studies have shown that the average hospital stays doubled and that the cost of hospitalization was correspondingly increased when postoperative surgical wound infection developed (Green and Wenzel, 1977). Complicated surgical procedures have a grave impact, increasing the duration of hospitalization as much as twenty-fold and the cost of hospitalization five-fold (Taylor et al., 1990). Increasing age of patients, gender and type of surgery are some of the factors that contribute to the development of an SSI. Intensive medical therapies and frequent use of antimicrobial drugs are capable of selection of resistant microbial flora (Nichols, 1984; Schaberg, 1994; Cruse and Foord, 1980). Nosocomial infections due to resistant organisms have been a problem with an increase in the incidence of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE) and *Pseudomonas aeruginosa* (Schaberg, 1994; Cruse and Foord, 1980; Cruse, 1992; Agarwal, 1972; Rao and Harsha, 1975; Kowli et al., 1985). Therefore, it is important for hospitals to improve the processes of care known to impact SSI rates.

The experience of the National Nosocomial Infection Study (NNIS) states there are several key components to programs that have been successful in preventing nosocomial infections (Anvikar et al., 1999; Culver et al., 1991). In reviewing the activities of the facilities participating in the NNIS program, the staff discovered three key components of a successful prevention effort, i.e. use of a multidisciplinary team to build consensus that a prob-

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lem existed, disseminate information about the infection and plan interventions that prevent nosocomial infections; educational sessions to introduce interventions; and data dissemination to show the impact of the interventions (Ferraz et al., 1992). Importance of sharing success stories and outlining epidemiologic approaches would help to understand and describe best practices (Culver et al., 1991). A review by Gastmeier (2004) on various studies pertaining to infection control policies has shown that numerous studies have focused on optimizing surveillance measures and investigating the use of reference data for reducing nosocomial infection rates. However, in the same review, Gastmeier speculates that the number of studies that reported the nosocomial disease burden was as few as seven studies in that year. Associating infection control and prevention efforts and prevalence rates will prove beneficial in endorsing or optimizing existing policies (Gastmeier, 2004). A hospital environment is bombarded with drug-resistant organism, which, in turn, adds to the disease burden of the patients prone to developing nosocomial infections. Periodical assessment of the antimicrobial susceptibility pattern of organisms causing nosocomial infections enables healthcare institutions to monitor irrational use of antimicrobials and to set guidelines on the use of antimicrobials. We carried out the present study in order to identify the aetiology of SSI, to compare the outcomes of SSI such as the rate of mortality, ICU stay, hospital stay and hospital expenses, and to assess the risk factors for SSIs.

MATERIALS AND METHODS

This study commenced from January 2005 up to June 2005, and 1125 surgeries were reviewed for the incidence of surgical site infections (SSIs). The etiologic agent and the antimicrobial susceptibility pattern were determined. Standard definitions were used to identify SSIs. The pus from the surgical wound site was cultured on Blood Agar and MacConkey Agar. The etiologic agents were identified using routine tests for identification. The Kirby Bauer Disc Diffusion method was used for the antimicrobial susceptibility patterns. An oxacillin disc (1 µg) was used for determination of methicillin resistance in *S. aureus* and a vancomycin disc (30 µg) was used to determine vancomycin resistance in *Enterococcus* spp. Both these were confirmed using MIC by the broth dilution method. Risk factors for patients developing SSI were derived using multivariate regression logistic analysis. A case control analysis of patients who developed SSI was done to assess the outcome of SSI. Patients who developed SSIs were the experiment group (n=50) and those who did not develop SSIs were the control group (n=25). They were matched for age (p>0.05), sex (p>0.05) and type of surgery (p>0.05). The outcomes were mortality rates, extended ICU stay and ward stay, and total hospital expenses incurred by the patients. The hospital expenses included the cost of ICU stay (if ICU stay was indicated), ward stay, medical bills and attendant travel expenses. This was done by following a format that was answered by the attendant and visual verification of the bills. Statistical analysis was done by Chi-square and Fisher exact tests. Comparison of cost was done by using the student t test (Two tailed, independent). The statistical software packages SPSS 11.0 and Systat 8.0 were used for the analysis of the data.

RESULTS

Out of the 1125 surgeries included in the study, 12% (n = 135) developed SSI. A single etiologic agent was identified and isolated in all the cases. The commonest etiologic agents were *S. aureus* and *Enterococcus faecalis*. In total, 33.3% (n=45) of the organisms isolated were *S. aureus* of which 14.0% (n=19) were methicillin-resistant *S. aureus* strains (MRSA), and 33.3% (n=45) of the organisms were *E. faecalis* of which 1.4% (n=2) were vancomycin-resistant *Enterococci* (VRE). *Pseudomonas aeruginosa* (24.4%; n=33), *Escherichia coli* (7.4%; n=10) and *Klebsiella* spp. (1.4%; n=2) were alos isolated. The antimicrobial susceptibility patterns of these organisms are depicted in Figure 1.

From Figure 1, it is evident that 91% of the *S. aureus* strains were resistant to penicillin, 42% to oxacillin, 24% to cloxacillin and 22% to clindamycin. Among the cephalosporins, all of the *S. aureus* strains were resistant to cefazolin, 91% to cefadroxyl, 22% to cefotaxime and cefaperazone. Also, 73% of the strains were resistant to cotrimoxazole. Ciprofloxacin resistance was seen in 51% of the strains and 11% of the strains were resistant to gentamicin and amikacin. All the *E. faecalis* strains were resistant to penicillin, 51% to cloxacillin and 49% to clindamycin, while 87% were resistant to cotrimoxazole and 22% were resistant to ciprofloxacin. Also, 9% of the strains were resistant to amikacin and 7% were resistant to gentamicin.

Among the gram-negative organisms, *P. aeruginosa* was resistant to cotrimoxazole (94%), followed by ciprofloxacin (58%), cefotaxime (54%), cefaperazone (24%), gentamicin (15%) and amikacin (9%). *E. coli* was resistant to cefazolin (70%) and cefadroxyl (70%), cefotaxime (30%) and cefaperazone (30%), cotrimoxazole (50%), ciprofloxacin (20%) and amikacin (10%), and gentamicin (10%). All of the strains of *Klebsiella* spp. were resistant to cefadroxyl and cotrimoxazole. Third generation cephalosporins, cefaperazone and cefotaxime were effective against all the strains. Likewise, gentamicin and amikacin were also effective against all the strains. 50% of the strains were resistant to ciprofloxacin.

Patients affected by SSIs (experiment group) had a longer ICU stay (p<0.001). The ICU stay in those who were affected by SSIs was on average of 8.7 days as compared with those who were not affected by SSIs who had an average ICU stay of 1.6 days. The average length of ward stay was also higher (17.2 days) compared to 5.5 (average) days in those patients who were not affected by SSIs (p<0.001). These patients were on multiple antibiotic regimens and had an increased financial burden as compared to those who were not affected. Hospital expenses were significantly higher (p<0.001).

Hospital expenses included medicine bills and ward stay bills. A cost comparison showed total expenses incurred by those affected by SSIs was Rs 29,000 (average) as compared to Rs 16,000 (average) by those who were not affected by SSI. The rate of mortality was also

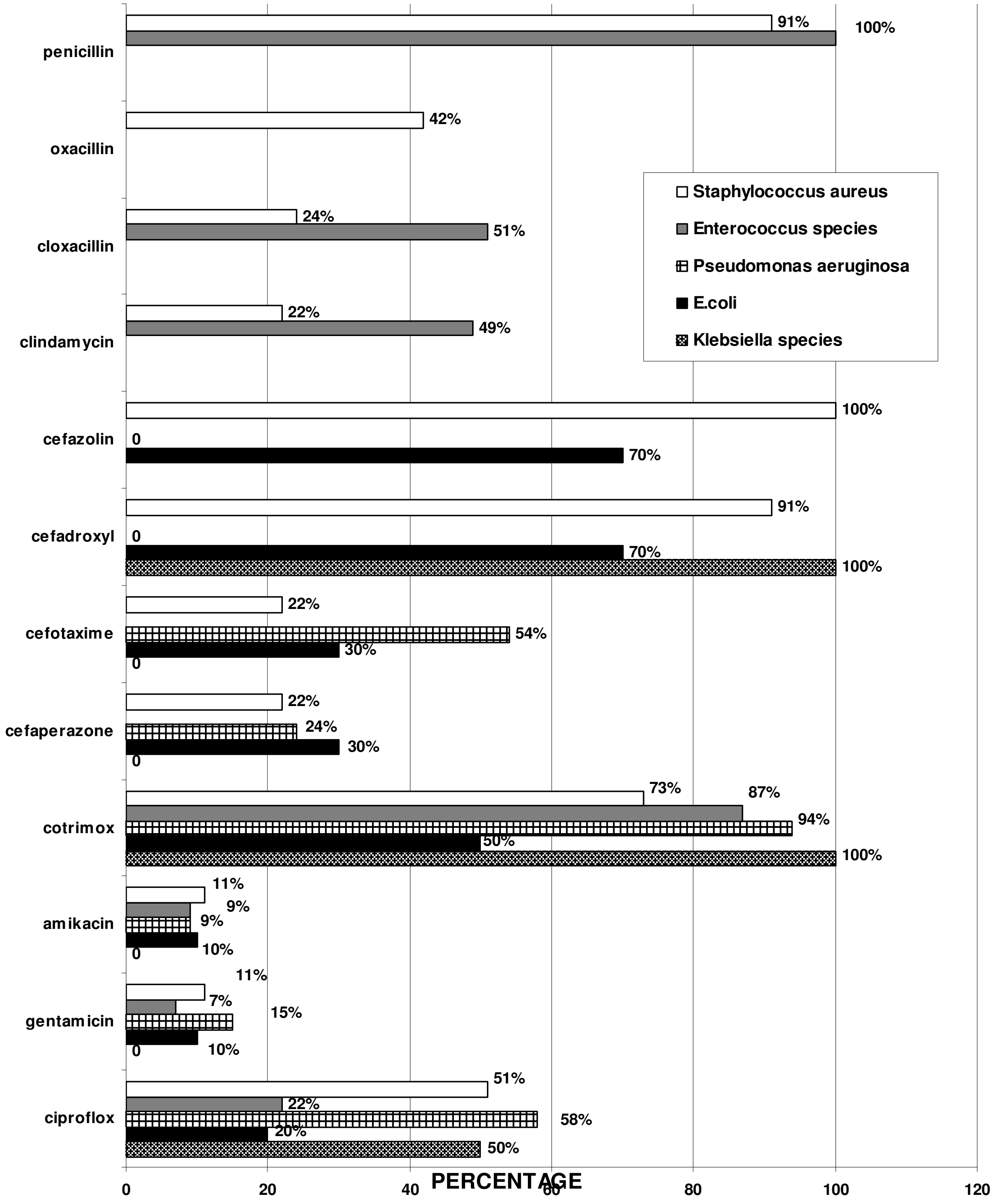

Figure 1. Percentage resistance patterns of organisms causing SSIs.

also higher in the experiment group with incidence of mortality being 12.8% compared to 3.8% in the control group.

Significant risk factors associated with SSI were age, gender, daily wage labourers, agriculture labourers and drivers were at risk and diabetics. Among the surgeries were gastrectomy, prostatectomy, hysterectomy and cholecystectomy. The risk factors and the statistical significance are presented in Table 1. The incidence of SSIs in these risk areas is shown in Table 2.

DISCUSSION

The prevalence rate of surgical site wound infection, though preventable, is high (National nosocomial infections surveillance, 1999). Studies by Agarwal (1972), Rao and

Table 1. Multivariate logistic regression analysis to find the significant risk factors associated with the incidence of SSIs in the hospital population.

Risk factors	Logist Co-efficient	P value	Adj.OR
Age >45 yrs	1.32	0.012*	3.74
Female	1.32	0.070+	3.75
Daily wage labourers agriculture labourers, drivers	1.48	<0.001**	4.39
Urban	-0.18	0.452	0.83
Diabetics	-1.36	<0.001**	0.26
Major surgery	-0.01	0.991	0.99
Gastrectomy	3.67	<0.001**	39.43
Prostatectomy	2.35	0.013*	10.51
Hysterectomy	2.25	0.015*	9.51
Cholecystectomy	2.54	0.037*	12.71
Appendectomy	1.67	0.065	5.31

+Suggestive significance $0.05<p<0.10$.
* Moderately significant $0.01<p \leq 0.05$.
** Strongly significant $p \leq 0.01$

Table 2. Incidence of SSI among the significant risk factors.

Risk factors	Total	Incidence of SSI	
		Number	Rate %
Age >45 years	551	102	18.5
Female	628	64	10.2
Daily wage labourers agriculture labourers, drivers	171	31	18.1
Appendectomy	266	9	3.4
Prostatectomy	191	29	15.2
Gastrectomy	33	12	36.4
Cholecystectomy	13	2	15.4
Hysterectomy	299	31	10.4

Harsha (1975), Kowli et al. (1995) and Anvikar (1999) have shown surgical site infection rates in India to be between 4 to 30% (Agarwal, 1972; Rao and Harsha, 1975; Kowli et al., 1985; Anvikar et al., 1999). Harbarth et al. (2008) have observed that methicillin-resistant *S. aureus* alone constituted 5.1% of surgical site infections (Harbarth et al., 2008). In our study the prevalence of SSIs was 12%; the common etiologic agents among gram-positive organisms being *S. aureus* and *Enterococcus* spp. Among the gram-negative organisms are *P. aeruginosa, E. coli* and *Klebsiella* spp. (Rao and Harsha, 1975). These results are consistent with literature reports indicating that S. *aureus* was the commonest isolate from postoperative wound infection (Nichols, 1998; Schaberg, 1994; Cruse and Foord, 1980). *E. faecalis* was seen in 33.3% of surgical site infections.

Among the gram-negative bacilli, *P. aeruginosa* (24.4%) was a predominant isolate, followed by *E. coli* (7.4%) and *Klebsiella* spp. (1.4%). A number of studies in the literature indicated a gradual increase in the emergence of antibiotic-resistant microorganisms in patients undergoing surgery (Green and Wenzel, 1977; Taylor et al., 1990; Cruse and Foord, 1980; Agarwal, 1972). We found 14% of the isolates were MRSA and 1.4% VRE. *S. aureus* in surgical site infection is mainly due to its predominant role in hospital cross-infection and emergence of virulent antibiotic-resistant strains. In the present study, 91% *S. aureus* strains and all the strains of *Enterococcus* spp. from the infected wound were resistant to penicillin. Ineffectiveness of penicillin against *S. aureus* has been reported by Green and Wenzel (1977), Taylor et al. (1990) and Nicols et al. (1997) (Green and Wenzel, 1977; Taylor et al., 1990; Berard and Gandon, 1964) Some studies have shown *P. aeruginosa* was 100% resistant to gentamicin, which was one of the antibiotics used for antimicrobial prophylaxis (Berard and Gandon, 1964; Cruse and Foord, 1980; Tripathy and Roy, 1984). In the present study, the percentage resistance of *P. aeruginosa* strains from surgical wounds was 15%. A prolonged preoperative stay with exposure to hospital environment and its ubiquitous diagnostic procedures, therapies and microflora have been shown to increase the rate of surgical site infection (Culver et al., 1991).

Kowli et al. (1985) found an infection rate of 17.4%

when preoperative stay was 0-7 days, and an infection rate of 71.4% with a preoperative stay of more than 21 days (Kowli et al., 1985). Anvikar et al. (1999) demonstrated that preoperative hospital stay predisposed an individual to 1.76% risk of acquiring an infection. With an increase in preoperative stay, the risk increased proportionally. A preoperative stay of one week increased the risk rate to 5% (Anvikar et al., 1999). Prolonged postoperative hospitalization, which is a major concern of most of the hospitals, has been evident in patients developing surgical site infection (Nichols, 1984).

In the present study, mean postoperative stay in patients who developed infection was almost three times as compared to patients who did not develop surgical site infection. When ICU stay was necessary, ICU stay was also significantly prolonged. The other outcome indicators such as costs incurred by a patient due to SSIs were significantly elevated. Mortality was 0.27 times more likely in those infected with SSIs. The risk factors associated with SSIs were age above 45 years, female sex, diabetic status and surgeries such as gastrectomy, prostatectomy, hysterectomy, cholecystectomy and appendectomy. Hospital infections are preventable (Kowli et al., 1985; Nicols et al., 1997; Nicols et al., 1972) and therefore it becomes a necessity for hospitals to recognise the growing threat of hospital infections and take immediate measures to control them.

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