Assessment of predictor variables and clinical consequences associated with surgical site infection in tertiary care setting, Karachi, Pakistan

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Abstract: Among the well-known Health care-associated infections (HAIs), surgical site infections (SSIs) contribute to considerable high mortality and morbidity rate, substantial prolongation in hospitalization period and extra expenses in terms of treatment cost. This study was aimed to evaluate the predictive variables associated with surgical site infections, and their clinical consequences. This was a prospective, cross sectional study conducted in the surgical department of tertiary care setting in Karachi, Pakistan. Each patient was followed up from the time of admission until time of the discharge postoperatively for 30 days. A total of 554 surgical procedures were performed and 81 SSIs were identified. The predictor variable/risk factors significantly associated with the presence of SSI were age, gender, BMI, ASA score, co-morbid condition, surgical wound class, emergency surgeries, duration of surgery, type of anesthesia, prosthetic implant, pre operative length of stay and pre operative blood transfusion. Outcomes of such studies may be utilized in the design of a multi factorial practice to get better patient's safety and clinical outcomes.

Keywords: Surgical site infections, mortality, surgical wound class, length of hospitalization, readmission, clinical consequences.

INTRODUCTION

Hospital acquired infections (SSIs) are not only associated with morbidity and mortality, but they also impose a substantial economic burden across the globe. Risk of these infections is further amplified when patient is exposed to invasive procedure (Bibi *et al.,* 2011). SSI is considered to be the third most commonly reported Nosocomial Infection. SSI is responsible for longer hospitalization and higher cost in patients, which results in social and economic loss to the patients and family (Shahane *et al.,* 2012). The risk factors/predictors responsible for SSIs are considered to be highly diverse in nature. The occurrence of SSIs depends on a number of factors including patient health status (pre-morbid conditions such as diabetes and hypertension), length of hospital stay and patient level of education, the type of surgical intervention performed, sterilization procedures and use of any pre-operative antibiotics and the quality of the facility of postoperative surgical care. For this purpose, it is important to have accurate data on SSIs in order to optimize patient health outcome and to prioritize healthcare funding (Rawabdeh *et al.,* 2016). The prevalence and incidence rate of surgical wound infections vary usually between hospitals, surgeons, patient, procedures, patients and geographical locations (Moses, 2016).

Reliable estimates of the global burden of SSI are hindered by an insufficiency of data with an adequate outlining of endemic infections at national and regional levels, predominantly in resource-limited settings. The potential determinants of a high burden of health-care associated infection in developing countries include inadequate environmental hygenic conditions, poor infrastructure, insufficient equipment, understaffing or untrained staff, overcrowding, the scarceness of knowledge and application of basic infection-control measures, prolonged and inappropriate use of invasive devices and antibiotics, and lack of local and national guidelines and policies (Rahman and Arshad 2015). In the light of above facts the present study was designed to find out the prevalence of SSIs in tertiary care hospital settings and to evaluate the risk factors/predictors for such infections following various surgical procedures along with their clinical outcomes.

Methodology

This was a prospective cross sectional study among patients undergone specific surgery and carried out

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between May 2016 and April 2017 in tertiary care settings of Karachi, Pakistan. The actual sample size is 238 cases that was calculated by using the standard formula for calculating sample size on the basis of prevalence.

$$N = \frac{(Z)2 \times P\,(1 - P)}{d^2}$$

Prevalence is taken at 19.2% reported by CDC (NNIS, 1999).The bound of error is taken at 5% with 95% confidence interval. The sample size was inflated to581to exclude non-response and poorly filled questionnaires.

$$N = \frac{(1.96)2x\,(0.192) \times (1 - 0.192)}{(0.05)^2}$$

Sample size was obtained using the standard formula for calculating sample size on the basis of prevalence. The study population included adult surgical cases admitted in surgical ward either as elective procedure or as emergency. Informed consents of all respondents and ethical approval of the study was obtained prior to the participation. The confidentiality of patients was highly maintained during research. Infections over the incision sites after complete resolution were excluded. Patients having age groups above 20 years undergone major surgical intervention with visible incision (cesarean section, laparotomy, appendectomy, cholecystectomy, hernia repair, thyroidectomy, laminectomy, hemorrhoidectomy, wound debridement, incision and drainage), were serially recruited until the sample size was obtained. The patients were assessed preoperatively, and post operatively to find out the predictor variables of infections. Standardized data collection form was used to record information included; age, gender, BMI, ASA score, co morbid conditions, type of surgery, category of operation, wound class, duration of operation, preoperative hospital stay, pre operative blood transfusion. Each patient was followed up from the time of admission until the time of the discharge and during follow up visits. According to WHO guidelines, surgical site infection (SSI) was identified with redness, inflammation, pain, local heat, 38^{o}C or above temperature and septic/infected discharge from the incision site during 30 days after surgical procedure (Schwartz, 1999).

Assurance of quality and data analysis

Study tool was elucidated in detail before application. In order to defend the exactness (accuracy) of outcomes, all questionnaires were under direction of the consultants, reviewed and checked carefully before they were collected. Data were entered and analyzed using Statistical Package for Social Sciences (SPSS version 22) software. To determine the significance associations between the predictor and outcome variables to all categorical variables, Chi- square test was performed. *p* value less than 0.05 was considered statistically significant.

RESULTS

Study population and demographic characteristics

During the study period, 554 patients underwent various surgical procedures in the general surgery department of tertiary care setting. Different procedures as seen in Table 1 were incorporated. Postoperative infection occurred in 81 cases giving an overall incidence of 14.6% infection. The category, (surgical procedure) with the highest SSI percentage was incision and drainage followed by wound debridement, laparotomy, appendectomy, cholecystectomy, hernia repair, abdominal hysterectomy and cesarean section. The least counted procedures were thyroidectomy, laminectomy and hemorrhoidectomy in which none got infected. The infection rate with different surgeries reported in table 1. While, surgical site infection reported internationally for various surgeries were presented in Table 2.There were 221(39.89%) males and 333 (60.10%) females (table 2). The SSI rate between male and female was 51.8% and 48.1% respectively (p-value = 0.017).

Predictors of SSI

The following patient variables were associated with the risk of SSI in the crude analyses: age, gender, BMI, elevated ASA score, and pre morbid illness. Out of 554, the age range of 31-40 comprised of the highest number of study respondents (34.6%). Higher infection rate was observed in male than female (table 3).

Pre operative and operative variables were also assessed (tables 4 & 5). Infections were least frequent (6.6%) in clean procedures and were highest among dirty cases 54.5% (table 4). Type of anesthesia, wound class, preoperative stay, pre operative transfusion, duration of operation, category of operation, prosthetic implantation were also found to be a significant risk factor associated with surgical site Infection.

Clinical consequences

Readmission, rate of infection, average length of hospitalization and mortality rate were also observed and found to be highly significant; these outcomes were compared with the international bench mark (table 5).

DISCUSSION

SSIs are increasingly becoming an institutional marker of quality assurance. These infections, representing a global threat, are associated with greater complications. In the surgical population, morbidity and mortality increased due to surgical infection and contributes to an already mounting healthcare cost (Hedrick *et al.*, 2006). The total number of patients included in the study was 554 (221 males and 333 females). The mean age of patients was found to be 40.31±13.66 (range 20-85). The overall incidence of surgical site infection reported was 14.6%. In

Table 1: Infection Rate in Different Surgical Procedures

Type of Surgery	No of cases	No. infected (%)	*P-value*
Lower Segment cesarean section (Lscs)	119	6 (5.0%)	*P*= 0 .000
Laparotomy	88	30 (34%)	
Cholecystectomy	116	12 (7.4%)	
Hernia repair	66	6 (9%)	
Appendectomy	60	12 (20%)	
Wound debridement	7	3 (42.8)	
Incision and drainage	15	9 (60%)	
Abdominal hysterectomy	39	3 (7.9%)	
Laminectomy	14	0	
Hemorrhoidectomy	20	0	
Thyroidectomy	10	0	
Total	554	81 (14.6%)	

Table 2: Frequency of SSI Reported in Various Literature and Databases

Author, year	Country/City	Type of surgery	No of patient	Infection rate
Jido andGarba, 2012	Nigeria.	Lscs	640	9.1%
Razavi *et al*., 2004	Iran	Laprotomy	142	17.7%
Sachin *et al*., 2012	India	Cholecystectomy	35	7.1%
Elbur *et al*., 2012	Sudan	Hernia repair	75	6%
Harahsheh *et al*., 2002	Jordan	Appendectomy	481	15%
Nwankwo *et al*., 2012	Nigeria	Debridement	100	76%
N/A	-	Incision and drainage	-	-
Young *et al*., 2013	Denver	Abdominal hysterctomy	192	10.7%
Friedman *et al*., 2007	Durham	Laminectomy	6,365	1.0%
N/A	-	Haemorrhoidectomy	-	-
Dionigi *et al*., 2014	Italy	Thyroidectomy	241	2%

Table 3: Patient Characteristics/Variables Associated with Surgical Site Infection

Risk factors	SSI Yes N; (%)	Non SSI No N; (%)	N;(%)	Odd Ratio (OR)	*p* value 95% CI
1.Age					
21-30	3(2.6)	113(97.4)	116(100)	0.181(0.056 - 0.585)	0.0043
31-40	37(19.3%)	155(80.7%)	192(100)	1.632(1.064 -2.504)	0.0247
41-50	14(12.1%)	102(87.9%)	116(100)	0.938(0.512 -1.719)	0.8379
51-60	12(12.8%)	82(87.2%)	94(100)	1.000(0.523 - 1.915)	0.9978
61-70	6(31.6%)	13(68.4%)	19(100)	3.156(1.167 - 8.538)	0.0236
70+	9(52.9%)	8(47.1%)	17(100)	7.694(2.886 - 20.512)	< 0.0001
2.Gender					
Male	42(19%)	179(80.9%)	221(100)	1.604(1.066 - 2.415)	0.0234
Female	39(11.7%)	294(88.28)	333(100)	0.907(0.603 - 1.363)	0.6397
3.Bodymass index (BMI)(kg/m^2)					
Normal	21(7.5)	257(92.4)	278(100)	0.558(0.338 -0.923)	0.0232
Overweight	30(16.8)	148(83.14)	178(100)	1.386(0.878 - 2.188)	0.1607
Obese	30(30.6)	68(69.3)	98(100)	3.017(1.850 -4.919)	< 0.0001
4.ASA Score					
I	15(6.60)	212(93.39)	227(100)	0.483(0.272 - 0.858)	0.0131
II	51(17.22)	245(82.7)	296(100)	1.423(0.972 - 2.084)	0.0694
III	9(39.1)	14(60.8)	23(100)	4.396(1.843 - 10.487)	0.0008
IV	6(75)	2(25)	8(100)	20.518(4.071 - 103.395)	0.0003
5.Co-morbid conditions					
Diabetes mellitus	33(31.4)	72(73.8)	105(100)	3.134(1.952 - 5.032)	< 0.0001
Hypertension	33(35.1)	61(72.5)	94(100)	3.700(2.281 - 6.000)	< 0.0001
Obesity	30(30.6)	68(76.2)	98(100)	3.017(1.850 - 4.919)	< 0.0001
Anemia	20(26.6)	55(73.3)	75(100)	2.487(1.417 - 4.364)	0.0015
Miscellaneous	15(31.9)	35(77.3)	47(100)	2.931(1.532 - 5.605)	0.0011

the present study, various risk factors were evaluated to establish their association or influence on Infection rate. Type of surgical procedure is directly associated with the risk of occurrence of surgical infection. It is based on

impending bacterial contagion of the tissues at the time of surgery and the level of bacterial burden (Malik *et al.,* 2013).

The present study showed the significant association of type of surgery with infection rate, parallel study documented by other investigator (Mawalla *et al.,* 2011).

Category of operation (elective or emergency) plays a significant role in determining infection rates. Surgical procedures operated in emergency condition are more likely to get infected due to breech in sterilization protocol, inadequate preparation, co-existing infection and compromise immunological status of patient (Sutariyaand Chavada, 2016). In this study, infection rate in emergency procedures was almost 2.5 times higher in contrast to elective surgical procedures.

Age was found to be a significant factor associated with surgical Site infection. It can be due to multiple factors like, mal-absorption, malnutrition, low healing rate, increased catabolic processes and low immunity (Nasser *et al.,* 2013).

This study coincides with the study conducted by Mawalla *et al*., in 2011 found higher infection rate in male than female (Mawalla *et al.,* 2011). This could be illustrated by several risk factors in male such as cigarette smoking and HIV. The literature reported that SSI increases with obesity, one reason being a reduce in blood circulation in fat tissues which is concordant with our study (Labib*et al.,* 2012). The study shows that with the duration of procedure above 2 hours, the risk of SSI increases (6).

In this study a higher incidence of postoperative wound infection was observed when duration of operation was prolonged may be due to longer exposure of tissues to theater environment, hypothermia and requirement of blood transfusion all of them are potential risk factors for SSI Significant association between anemic patients and SSI was strongly observed in the present study. In accordance with our study, previous studies have shown that patients suffering from pre-morbid diseases, such as diabetes mellitus and hypertension are at high risk of developing SSI (Saeedinia *et al.,* 2015; Tang *et al.,* 2001).

The infection rate was found to be directly associated with increasing ASA score, similarly, same result mentioned in a study conducted by Afifi and Bghagho, in 2009 which was found to be in good agreement with the present study (Afifi and Baghagho, 2009).

The overall rate of surgical site infection during one year of the study was 14.6% (81 out of 554). Independent patient risk factor for surgical site infection that were identified by multivariate analysis were different age group including, 21-30 (OR =0.181, 95% C.I =0.056 - 0.585), 31-40(OR=1.632, 95%C.I =1.064 -2.504), 41-50(OR=0.938, 95%C.I =0.512 -1.719), 51-60 (OR=1.000,95% CI =0.523 - 1.915), 61-70 (OR=3.156, 95% CI=1.167 - 8.538), 70+ (OR=7.694, 95%CI=2.886 - 20.512), gender i.e. male (OR=1.604, 95% CI =1.066 - 2.415), female (OR=0.907, 95% CI=0.603 - 1.363), normal weight (OR=0.558, 95% CI =0.338 -0.923), over weight (OR=1.386, 95% CI =0.878 - 2.188), obese (OR=3.017, 95% CI=1.850 -4.919),ASA score I(OR=0.483, 95% CI=0.272 - 0.858), II(OR=1.423, 95% CI=0.972 - 2.084), III (OR=4.396, 95% CI=1.843 - 10.487), IV(OR=20.518,95% CI=4.071 - 103.395),Co-morbid conditions including, diabetes (OR=3.134, 95% CI=1.952 - 5.032), hypertension (OR=3.700, 95% CI=2.281 - 6.000), anemia (OR=2.487, 95% CI=1.417 - 4.364), miscellaneous diseases (OR=2.931, 95% CI=1.532 - 5.605)

Preoperative and surgical variables identified by multivariate analysis include category of operation i.e. elective (OR=0.936,95% CI=0.660 - 1.328), emergency (OR=0.468, 95% CI0.224 - 0.977), wound class including; clean (OR=0.456,95% CI=0.193-1.076), clean contaminated (OR=0.490, 95% CI=0.304-0.788), contaminated (OR=2.492, 95% CI=1.614 - 3.849), dirty wounds (OR=3.730,95% CI=1.778-7.827), type of anesthesia; local (OR=2.931, 95% CI=0.743-11.564), general (OR=0.310=95% CI=0.132 - 0.727), spinal (OR=1.079, 95% CI=0.761-1.529), duration of operation; >1 hour (OR=1.746, 95% CI=0.888 - 3.431), between 1 to 2 hours (OR=0.580, 95% CI=0.367 - 0.917) <2 hours (OR=2.659, 95% CI=1.737 - 4.072), prosthetic implantation (OR=0.621, 95% CI=0.261 - 1.480), pre operative length of stay including >1 day (OR=0.977, 95%CI=0.449 - 2.124),1 day (OR=0.875, 95% CI=0.588 - 1.302, 2 days (OR=1.832=95% CI=0.989 - 3.390), 3 days (OR=3.799, 95%CI=1.694 - 8.51), <3 days (OR=2.735, 95% CI=1.031 - 7.253) and pre operative blood transfusion (OR=6.034, 95% CI=3.504 - 10.392)

Type of the anesthesia also had significant association with the SSI as it was more observed with general anesthesia than regional anesthesia this may be due to the fact that general anesthesia patients are unable to provide a robust defense against pathogens because of their weak or depressed immune systems (Fan *et al.,* 2014). Similar finding was observed by Johnson *et al.,* in 2006 (Johnson *et al.,* 2006).

The highest rate of SSI was found in dirty cases (54.5%) followed by contaminated (36.5%), clean contaminated (7.1%) and clean procedure (6.6%) there was a significant correlation was observed between the rate of wound infection and the contamination of the wound. Similar incidence was reported in various studies (Mahesh *et al.,* 2010; Elbur *et al.,* 2012).

In the present study, readmission rate after SSI was 18.5% which was found in good agreement with the previous studies reported as shown in table 5. In the current study, two patient expired due to organ/space infection contribute 2.4% mortality rate in infected patients which was found in good agreement with the study conducted by Boltz *et al;* in 2011 reported 2.1% mortality rate due to surgical infection (Boltz *et al.,* 2011).

Mean length of hospitalization was prolonged in case of Surgical infection, similar results were obtained for SSIs patients in the study conducted by Shepherd*et al.,* in 2013 found the patients having SSI had a mean LOS of 10.56 days (95% CI, 9.50 to 11.62) vs 5.64 days (95% CI, 5.34 to 5.95) for patients having no SSI (*P*<.001) (Shepard *et al.,* 2013).

CONCLUSION

In conclusion, this study has demonstrated that various factors that contribute to increased infection rates, such as age, gender, BMI, ASA score, pre morbid illness, type of

Table 4: Pre Operative& Surgical Variables Associated with Surgical Site Infection

Risk factors	SSI Yes (N; (%))	Non SSI No (N;(%))	N;(%)	Odd Ratio (OR)	*p* value 95% CI
1. Category of operation					
Elective	66 (13.0)	441(87.0)	507(100)	0.936 (0.660 - 1.328)	0.7138
Emergency	15 (31.9)	32 (68.1)	47(100)	0.468 (0.224 - 0.977)	0.0432
2. Wound class					
Clean	6(6.6)	84(93.3)	90(100)	0.456 (0.193-1.076)	0.0730
Clean Contaminated	24(71.6)	311(92.83)	335(100)	0.490 (0.304 - 0.788)	0.0033
Contaminated	39(36.4)	68(63.55)	107(100)	2.492 (1.614 - 3.849)	0.0001
Dirty	12(54.5)	10(45.45)	22(100)	3.730 (1.778 - 7.827)	0.0005
3. Type of Anesthesia					
Local	3(42.8)	4(57.1)	7(100)	2.931 (0.743 - 11.564)	0.1246
Spinal	6(4.3)	133(95.6)	139(100)	0.310 (0.132 - 0.727)	0.0071
General	72(17.6)	336(82.3)	408(100)	1.079 (0.761 - 1.529)	0.6678
4. Duration of operation					
Less than 1 hour	12(20.3)	47(79.6)	59(100)	1.746 (0.888 - 3.431)	0.1057
1 to 2 hours	27(7.82)	318(92.1)	345(100)	0.580 (0.367 - 0.917)	0.0197
More than 2 hours	42(28.0)	108(72.0)	150(100)	2.659 (1.737 - 4.072)	< 0.0001
5. Prosthetic Implantation					
Implant	6(8.3)	66(91.6)	72(100)	0.621 (0.261 - 1.480)	0.2831
6. Preoperative length of stay					
>1 day	8(12.5)	56(87.5)	64(100)	0.977 (0.449 - 2.124)	0.9533
1 day	42(11.35)	328(88.6)	370(100)	0.875 (0.588 - 1.302)	0.5120
2 days	15(21.12)	56(78.87)	71(100)	1.832 (0.989 - 3.390)	0.0539
3 days	10(35.7)	18(64.2)	28(100)	3.799 (1.694 - 8.51)	0.0012
More than 3 days	6(28.5)	15(71.4)	21(100)	2.735 (1.031 - 7.253)	0.0431
7. Pre operative blood Transfusion					
Blood transfused	30(46.8)	34(53.1)	64(100)	6.034 (3.504 - 10.392)	< 0.0001

Table 5: Clinical Consequences of SSI

Consequences of SSI	Study outcome	International bench mark	
		Author, year	Study reported
Readmission Frequency	18.5%	Merkow *et al*., 2015 Kassin *et al*., 2012 Wick *et al*., 2011	19.5% 22.0% 23.3%
Mortality Rate	2.4%	Koch *et al*., 2015 Astagneau *et al*., 2001 Boltz *et al*., 2011	4.5% 5.8% 2.1%
Rate of Infection	14.6%	Ige *et al*., 2011 Mwendwa, 2004 Karim, 2011	30.7% 22.4 % 17.1 %
Length of Hospitalization	8.9259 days (3-17 days)	Elliott *et al*., in 2017 Sheperd*et al.,* 2013 Gomila *et al*., 2017	12 days 10.56 days 15 days

procedure, degree of contamination, emergency procedure, type of anesthesia, duration of operation, intra operative blood transfusion, preoperative length of hospitalization and prosthetic implantation. Mortality and readmission were also influenced by surgical infection. In order to increase awareness and diminish rate of infection, we recommend that all hospitals should adapt protocols to assess their postoperative infection rates.

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