Original Article

A prospective study on bacteriological profile and antibiogram of postoperative wound infections in a tertiary care hospital in Western Rajasthan

Himanshu Narula[1], Gaurav Chikara[2], Pratima Gupta[1]

Departments of [1]Microbiology and [2]Pharmacology, All India Institute of Medical Sciences, Rishikesh, Uttarakhand, India

Abstract

Background: Surgical site infections (SSI) are one of the most common hospital-acquired infections worldwide. SSI are known to increase morbidity, mortality, length of stay in hospital as well as the cost of treatment to the patients. The incidence varies from 1% to 20% among developed countries to as high as 40% in developing world. **Aims:** To find the incidence and risk factors, bacteriological profile, and antibiogram for SSI in General Surgery department of a tertiary care hospital in Western Rajasthan. **Methods:** Culture and sensitivity of wounds of all the clinically suspected cases of SSI were taken. Bacterial identification and antimicrobial susceptibility were performed according to standard CLSI guidelines. Statistical analysis was done using Microsoft Excel, SPSS 13 software. **Results:** Among total 609 patients, 102 were clinically suspected SSI and 88 were culture positive. Incidence of SSI was 14.45%. The most common organism was *Staphylococcus aureus* followed by *Klebsiella pneumoniae.* Most of the Gram-positive isolates were resistant to penicillin and cephalosporin antibiotics and were moderately susceptible to fluoroquinolones and aminoglycosides. Gram-negative isolates were resistant to beta-lactam and beta-lactam/beta-lactamase inhibitor combination also but were susceptible to fluoroquinolones, aminoglycosides, and carbapenems. **Conclusion:** High incidence rate of SSI in our setup emphasizes the need of quality surgical care which takes into consideration all the three important factors, i.e. host, environmental, and microorganism characteristics before doing any surgery. Increasing resistance to commonly used antibiotics warrants the judicious use of antibiotics and establishment of antibiotic policy in the hospital.

Keywords: Antimicrobial resistance, infection control, surgical site infections

Introduction

Infection is encountered by all the surgeons, as surgeries invariably impair the first line of host defenses between environmental microbes and the host's internal milieu resulting in postoperative wound infection known as surgical site infections (SSI).[1] SSI are associated with increased morbidity, mortality, prolonged hospital stays, and increased economic costs for patient care.[2] Centre for Disease Control guidelines define SSI as infection occurring within 30 days or in some specific surgeries 90 days after a surgical operation. The incidence of SSI in developing countries has been reported to be around 2-40%. The aim of the present study is to find incidence and risk factors for SSI in the General Surgery department of our hospital and to know bacteriological profile and antibiogram of organisms causing SSIs.

Address for correspondence: Dr. Himanshu Narula, Department of Microbiology, All India Institute of Medical Sciences, Rishikesh - 249 203, Uttarakhand, India.
E-mail: narula02himanshu@gmail.com

Received: 14-12-2019 **Revised:** 21-12-2019
Accepted: 25-02-2020 **Published:** 30-04-2020

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_1154_19

Material and Methods

Study unit

All patients who underwent elective surgery in General Surgery department of institute and who developed sign and symptoms of wound infection after surgery were included in the study.

How to cite this article: Narula H, Chikara G, Gupta P. A prospective study on bacteriological profile and antibiogram of postoperative wound infections in a tertiary care hospital in Western Rajasthan. J Family Med Prim Care 2020;9:1927-34.

Surgical sites were considered to be infected according to the set of clinical criteria mentioned by CDC.[3] Wounds were classified as clean, clean contaminated, contaminated, and dirty using wound contamination class system, proposed by U.S. National Research Council (1964).[4]

Study setting

This descriptive cross-sectional study was carried out in Mahatma Gandhi hospital, a government tertiary care hospital associated with Dr. S.N. Medical College, Jodhpur. The study was done between April 2014 to August 2014. Elective surgery patients with sign and symptoms of wound infection post-surgery and who gave informed consent were included in the study and wounds from burn patients were excluded in the study.

Sample size

The sample size for this study was calculated using the following formula:

$$N = \frac{Z2\ P\ (1\text{-}P)}{E2}$$

Z is the standard deviation corresponding to two specified confidence interval and is 1.96 (at confidence interval 95%).

P is the proportion of SSI in a study conducted in tertiary care hospital in India which was approximately 15% (14).

E = Margin of error in the present study which we have set to 20%.

The minimum sample size *N* is 92; therefore, 102 participants were recruited into the study. Every day new patients were enrolled until the desired sample size was attained.

Methods

A structured questionnaire was used to extract the information including demographic data like age and sex of patients, any comorbidities, e.g. anemia, smoking, and diabetes mellitus, length of preoperative hospital stay, and duration of operation. The wound was examined for the presence of any sign of infection on 3rd postoperative day and every 3 days thereafter. Wound samples were taken using sterile swabs under all aseptic precautions using Levine technique. Two swabs were obtained from surgical site without contaminating with skin commensals and transported to the laboratory immediately with minimum delay.

Gram-stained smear was prepared directly from a sample using the first swab. It was screened for the presence of pus cells, morphology, and arrangement of microorganisms. Culture was done from the 2nd swab. Colony morphology, Gram staining, and conventional standard biochemical tests were used for the final identification of bacterial species. Antibiogram was prepared by evaluating the antimicrobial susceptibility testing performed by Kirby–Bauer disc diffusion method according Clinical and Laboratory Standards Institute guidelines.

Statistical analysis was done using Microsoft Excel, SPSS 13 software.

Results

A total of 609 patients underwent surgeries in the Department of General Surgery during the study period**.** Among the 609 patients, 102 patients with clinically suspected postoperative wound infections were enrolled and samples from these patients were further processed. Out of these 102 samples, 88 were found to be culture-positive which yielded an incidence of 14.45% [Table 1].

The majority (87.25%) of the Gram-stained smears revealed the presence of pus cells. Among these, 89.9% had bacterial growth while 10.1% had no bacterial growth. Out of the 13 smears with no pus cell, eight (61.5%) showed bacterial growth suggesting that the absence of pus cell on Gram stain does not exclude the possible presence of bacteria. Eight (8.5%) smears with obvious bacterial cell morphology on Gram stain had no bacterial growth on culture suggesting the possibility of anaerobic infection [Table 2].

Incidence of SSI with associated risk factors

Among males, 32 (29%) developed infection and among females, 7 (10%) developed SSI. Although SSI was slightly higher in females, the difference was not statistically significant ($P = 0.896$). The SSI incidence varied from 23.75% to 10.07% among different age groups, with highest being in the age group of >60 years and the least in the age group of ≤20 years. The change in SSI incidence among different age groups was highly significant ($P = 0.000$).

SSI incidence increased in patients with longer preoperative hospital stay. SSI developed in 15 (7.25%) of 207 patients with the preoperative stay of <2 days, 44 (15.02%) of 293 patients with the preoperative stay of 2–5 days, and 29 (26.61%) out of 109 patients with the preoperative hospital stay of >5 days. The

Table 1: Incidence of surgical site infections in the study

	Number (Total: 609)	Incidence (%)
Clinically suspected SSI	102	16.75
Culture confirmed SSI	88	14.45

Table 2: Gram-stain morphology in relation to culture results

Pus cell	Culture results	
	Bacterial growth	No bacterial growth
Seen (89)	80 (89.9%)	9 (10.1%)
Not seen (13)	8 (61.5%)	5 (38.5%)
Bacterial cell morphology	**Culture results**	
	Bacterial growth	No bacterial growth
Present (94)	86 (91.5%)	8 (8.5%)
Absent (08)	2 (25%)	6 (75%)

change in SSI incidence in relation to preoperative hospital stay was highly significant ($P = 0.000$).

With respect to duration of operation, it was observed that SSI incidence was highest (55.56%) among 18 cases that took >120 min per operation to complete and lowest (9.12%) in 340 operations that took ≤60 min per case. Among 251 operations that were completed between 61 to 120 min each, 47 (18.73%) developed SSI. The rate of SSI increased with the prolongation of duration of operation. The difference was highly significant ($P = 0.000$).

Comorbidities like anemia, smoking, and diabetes effecting SSI were also included in the study. Among 71 anemic patients, 16 (22.53%) developed SSI, whereas in 538 patients without anemia, 72 (13.38%) developed SSI. The difference in SSI incidence in relation to hemoglobin level was statistically significant ($P = 0.039$). In 19 (24.05%) patients out of 79 diagnosed to have diabetes mellitus, 19 (24.05%) developed SSI, whereas in 530 patients with normal glucose profile, 69 (13.02%) developed SSI. The difference in the rate of infection between these two groups was very obvious. Moreover, the difference was statistically significant ($P = 0.009$). While studying the relationship between SSI incidence and smoking, it was observed that 28 patients (17.28%) developed SSI among 162 smoker patients, whereas 60 (13.42%) of the 447 nonsmoker patients developed SSI. SSI incidence was higher in smokers, but the difference in SSI rate among the two groups was statistically not significant ($P = 0.231$) [Table 3].

Incidence of SSI with respect to wound class

With relation to different types of wounds, by the degree of contamination, it was observed that SSI developed in 22 (8.91%) of the total 247 clean cases. There were 220 clean contaminated cases, among them SSI occurred in 34 (15.45%), whereas SSI developed in 25 (19.84%) of 126 patients with contaminated wounds. SSI incidence was highest in patients with dirty wounds, where 07 (43.75%) among 16 developed SSI. Change in SSI incidence among different wound classes was highly significant ($P = 0.000$). It can be assumed that the infection rate increased with that of a degree of wound contamination [Table 4].

Frequency of pathogenic bacterial isolates from postoperative wounds

Staphylococcus aureus was the most common organism isolated, accounting for 35.16% isolates (32 isolates) followed by *Klebsiella pneumoniae* which accounted for 23.08% isolates (21 isolates). *Pseudomonas aeruginosa* was the third most common organism isolated in 15 samples (16.48%). Other organisms isolated from postoperative wounds with their frequency of occurrence in

Table 3: Incidence of surgical site infections with respect to associated factors

		Surgeries performed	Surgical site infection cases		*P*
			Number	Incidence (%)*	
Gender					
	Male	467 (76.68%)	67	14.35	0.896
	Female	142 (23.32%)	21	14.79	
Age in years					
	<20	45	06	13.33	
	21-40	288	29	10.07	0 0.000
	41-60	196	34	17.35	
	> 60	80	19	23.75	
Preoperative hospitalization duration		**Surgeries performed**	**Surgical site infection cases**	**Incidence (%)***	
	< 2 Days	207	15	7.25	
	2-5 Days	293	44	15.02	0 0.000
	> 5 days	109	29	26.61	
Duration of Surgery		**Surgeries performed**	**Surgical site infection cases**	**Incidence (%)***	
	≤ 60 min	340	31	9.12	
	61-120 min	251	47	18.73	0 0.000
	> 120 min	18	10	55.56	
Comorbidities					
Diabetes		**Surgeries performed**	**Surgical site infection cases**	**Incidence (%)***	
	Present	79	19	24.05	0.009
	Absent	530	69	13.02	
Anemia					
	Present	71	16	22.53	0.039
	Absent	538	72	13.38	
Smoking					
	Present	162	28	17.28	0.231
	Absent	447	60	13.42	

decreasing percentage were *Escherichia coli* (12.09%), *Proteus mirabilis* (6.59%), *Coagulase-negative Staphylococcus* (5.49%), and *Enterococcus sp.* (1.10%) [Table 5].

Distribution of each organism with respect to wound class

Taking into consideration of individual organism, *Staphylococcus aureus* was the most common isolate in clean, clean contaminated, and dirty wounds with SSI, whereas *Klebsiella pneumoniae* was the most common isolate in contaminated wounds with SSI [Table 6].

Antibiotic resistance pattern of Gram-positive bacterial isolates

14 (43.75%) out of 32 *Staphylococcus aureus* (43.75%) were screened as MRSA. All the Gram-positive isolates were highly resistant to ampicillin (resistance varying from 88.9% to 100%), amoxycillin-clavulanic acid (resistance varying from 80% to 100%), and cotrimoxazole (resistance varying from 60% to 100%), while all were highly susceptible to vancomycin (100% susceptibility) and linezolid (susceptibility varying from 92.86% to 100%). *Methicillin-resistant Staphylococcus aureus* isolates were significantly resistant to piperacillin-tazobactam (71.43%) and clindamycin (85.71%) also. All the isolates were moderately susceptible to ciprofloxacin, doxycycline, and amikacin [Table 7].

Antibiotic resistance pattern of Gram-negative bacterial isolates

Antibiogram of Gram-negative isolates showed most organisms were resistant to amoxycillin-clavulanic acid and other antibiotics of penicillin and cephalosporin group. Moderate susceptibility was seen to ciprofloxacin, doxycycline, and amikacin. Susceptibility to imipenem was good. *Pseudomonas sp.* was having good susceptibility toward ceftazidime and amikacin [Table 8].

Table 4: Incidence of surgical site infections with respect to wound class

Wound class	Surgeries performed	Surgical site infection cases	
		Number	Incidence (%)*
Clean	247	22	8.91
Clean contaminated	220	34	15.45
Contaminated	126	25	19.84
Dirty	16	07	43.75
Total	609	88	14.45

*P=0.000

Table 5: Frequency of pathogenic bacterial isolates from postoperative wounds

Organism detected	Number of isolates	% of total isolates
S. aureus	32	35.16
Klebsiella	21	23.08
Pseudomonas aeruginosa	15	16.48
E. coli	11	12.09
Proteus mirabilis	06	6.59
CONS*	05	5.49
Enterococcus	01	1.10
Total	91	14.45

* CONS-*Coagulase-Negative Staphylococcus*

Discussion

Despite several advances made in asepsis, antimicrobial drugs, sterilization, and operative techniques, SSI continues to be a major problem in all surgical specialties in hospitals. These infections are responsible for the increasing cost, morbidity, and mortality related to surgical operations. For any given type of surgery, the development of a wound infection approximately doubles the cost of hospitalization.[5-7] SSI not only increase the cost of hospitalization but also can lead to antimicrobial resistance development in patient, which can further spread to other individuals in community, thus can affect the primary care also. The present study is an attempt to know the incidence of SSI in our setup, the bacteriological profile of organisms responsible for SSI, and their antibiogram and correlation with associated risk factors.

The overall SSI incidence rate of 14.45% of the present study can be well correlated with the infection rates of 6.09% to 38.7% in various Indian studies conducted between 1999 and 2013.[8-17] Reports from other developed countries showed a lower incidence of infection range between 2.8% and 19.4%.[18-28] Other studies done previously in India showed SSI rate ranging up to 49.50%.[8] SSI incidence has been decreased in many of the recent Indian studies[11,13,16] but still higher as compared to developed countries. SSI rates assessed in a Canadian and Irish hospital over a prolonged period of 10–16 years showed a rate of only 4.7% and 4.5%, respectively,[18,24] which indicates that larger groups studied over a longer duration give a better assessment of SSI rates. A higher infection rate in developing countries emphasizes the need of better implementation of infection control practices along with a proper surveillance system for the use of antibiotics.

Taking the host factors into consideration, SSI incidence was maximum among patients of the age >60 years (23.75%), whereas the lowest infection rate was in the age group of 21–40 years (10.07%) in the study. Similar findings have been reported in other studies,[7,29,30] which signifies that with increasing age, the incidence of SSI increases because of impairing immunity. There was a marginal preponderance of females (14.79%) over males (14.35%) with SSI, which is not statistically significant. There are various studies supporting the fact that gender difference is not significant.[7,15,17,30,31]

There was a statistically significant difference in the rate of SSI with respect to wound class with an increase in the rate of SSIs from clean to dirty surgeries. Similar results were observed in other studies also.[16,19,32-34] It shows that increasing degree of contamination in the wound increases the chances of infection in the wound. Another important factor is preoperative hospital stay duration. Higher preoperative stay duration is associated with high SSI rates. SSI rate was 7.25% in patients hospitalized

for <2 days, 15.02% in patients hospitalized for 2 to 5 days, and 26.61% in patients hospitalized for >5 days [Table 3]. The rates of SSIs increased with the increasing duration of preoperative hospitalization in almost every documented study.[11,13,15,17,29,35] This can be attributed to increased chances of colonization of patients with nosocomial strains in the hospital.[8,36]

With respect to the duration of surgery and percentage of SSI, it was observed that the infection rate increases with increased duration of surgery. It was only 9.12% when the duration of surgery was less than one hour and raised to 18.73% when it was between one and two hours and was as high as 55.56% when it was more than two hours [Table 3]. The reason could be that prolonged exposure of wound to the environment leads to more chances of inoculation of microorganisms in environment. These findings were consistent with the observation in different studies conducted in Tehran,[7] Aurangabad,[11] Hyderabad,[13] Canada,[18] Mumbai,[37] Brazil,[38] and Thailand.[39]

Certain underlying comorbid conditions like anemia, diabetes, and smoking may alter or decrease the immune status, thus significantly increase the risk of SSI. They are also an important cause of increased preoperative stay of the patient which also increases the chances of postoperative wound infections.[40] SSI incidence among patients with diabetes mellitus was found to be 24.05% as compared to 13.02% in normoglycemic patients. A significant difference in SSI rates between two groups has also been shown in the previous studies.[17,18,30,41]

Among a total of 609 patients who underwent surgery during the study period, 102 patients were clinically suspected and 88 (86.27%) were found to be culture-positive and were considered the definite cases of SSI. Similarly, in a previous study, 676 patients clinically diagnosed on basis of signs and symptoms to have postoperative wound infection, yielded 614 (90.8%) culture-positive cases.[42] Gram-negative bacilli (60.23%) were more common than Gram-positive cocci (43.18%). Gram-negative organisms were reported to be the predominant cause of postoperative wound infections in other studies as well.[43-46] Although as a group, Gram-negative organisms were most frequently isolated, *Staphylococcus aureus* was the most common organism accounting for 35.16% of total isolates. Similar was the observation in studies done for bacteriological profiling of organisms causing SSI.[13,37,45-51] Conversely, in some studies members of Enterobacteriaceae family were identified as the most common organism.[11,33,34] Among the Gram-negative isolates, *Klebsiella pneumoniae* was the most common isolate similar to the results of a study conducted in Puducherry, India.[52]

In our setup, the incidence of Gram-positive organisms was greater in infected clean wounds (68.18%) while Gram-negative organisms dominated in rest three categories, i.e. infected clean contaminated wounds (64.71%), infected contaminated wounds (76%), and infected dirty wounds (71.43%). Highest percent of total *Staphylococcus aureus* isolates were found in infected clean wounds (37.50%), while highest percent of both *Klebsiella pneumoniae* and *Pseudomonas sp.* isolates were found in infected contaminated wounds (47.62% and 33.33%, respectively) [Table 6].

Out of a total 32 *Staphylococcus aureus* isolates, 14 (43.75%) were *Methicillin-resistant Staphylococcus aureus* (*MRSA*). Other studies have reported the incidence of MRSA ranging from 20% to 56.5%.[53-55] The antibiogram of Gram-positive isolates including *Staphylococcus aureus* showed maximum susceptibility to vancomycin (100%), linezolid (92.86% to 100%), and amikacin (78% to 100%), whereas they were highly resistant to ampicillin (88.9% to 100%) and amoxycillin-clavulanic acid (80% to 100%). Other studies also support rise in resistance against penicillins and cephalosporin.[11,13,34,49,51] The antibiogram of Gram-negative isolates showed resistance to amoxycillin-clavulanic acid and cephalosporins, moderate susceptibility to fluoroquinolones and aminoglycoside, and good susceptibility to carbapenems. The rising resistance to penicillin and cephalosporin group of antibiotics could be due to the overuse of these drugs and the high prevalence of extended-spectrum beta-lactamases (ESBLs) producing organisms, which is an alarming situation. Other studies also support the gradual increase in the emergence of antibiotic-resistant microorganisms in post-surgical patients.[29,56] To decrease the emergence of such multidrug-resistant organisms, all the three important factors must be taken into account: host factors, microbial factors, and environmental factors.

Conclusion

On the basis of the above findings in our study, the following recommendations can be made:

- To decrease the emergence of multidrug-resistant organisms, all the three important factors must be taken into account: host factors, microbial factors, and environmental factors
- Duration of operation should be optimum and aseptic

Table 6: Distribution of each organism with respect to wound class

Organism	Total	Clean		Clean contaminated		Contaminated		Dirty	
		n	Percentage	*n*	Percentage	*n*	Percentage	*n*	Percentage
S. aureus	32	12	37.50	10	31.25	06	18.75	04	12.50
Klebsiella pneumoniae	21	03	14.29	06	28.57	10	47.62	02	9.52
P. aeruginosa	15	03	20.00	04	26.67	05	33.33	03	20.00
E. coli	11	01	9.09	07	63.64	03	27.27	00	00.00
Proteus mirabilis	06	00	00.00	05	83.33	01	16.67	00	00.00
CONS	05	02	40.00	02	40.00	01	20.00	00	00.00
Enterococcus sp.	01	01	100.00	00	00.00	00	00.00	00	00.00

Table 7: Antibiotic resistance pattern of Gram-positive bacterial isolates

Antimicrobials	MSSA* (18)		MRSA* (14)		CONS (05)		Enterococcus (01)	
	n	Percentage	*n*	Percentage	*n*	Percentage	*n*	Percentage
Ampicillin	16	88.90	14	100.00	05	100.00	01	100.00
Amoxy/clav	15	83.33	13	92.86	04	80.00	01	100.00
Pip./Tazo.	02	11.11	10	71.43	01	20.00	00	00.00
Cotrimoxazole	14	77.78	12	85.71	03	60.00	01	100.00
Ciprofloxacin	05	27.80	04	28.57	01	20.00	00	00.00
Cefoxitin	00	00.00	14	100.00	03	60.00	00	00.00
Doxycycline	05	27.77	04	28.57	02	40.00	00	00.00
Amikacin	04	22.22	03	21.43	01	20.00	00	00.00
Clindamycin	05	27.78	12	85.71	01	20.00	00	00.00
Vancomycin	00	00.00	00	00.00	00	00.00	00	00.00
Linezolid	00	00.00	01	7.14	00	00.00	00	00.00

*MSSA: *Methicillin-sensitive Staphylococcus aureus*, MRSA: *Methicillin-resistant Staphylococcus aureus*

Table 8: Antibiotic resistance pattern of Gram-negative bacterial isolates

Antibiotic	*Klebsiella* (21)		*P. aeruginosa* (15)		*E. coli* (11)		*P. mirabilis* (06)	
	n	Percentage	*n*	Percentage	*n*	Percentage	*n*	Percentage
Amoxy/clav	20	95.24	15	100.00	10	90.90	05	83.33
Cotrimoxazole	17	80.95	13	86.67	10	90.90	04	66.67
Ciprofloxacin	06	28. 57	04	26.67	04	36.36	02	33.33
Pip./Tazo.	07	33.33	02	13.33	03	27.27	01	16.67
Ceftriaxone	14	66.67	-	-	08	72.73	04	66.67
Ceftazidime	15	71.43	03	20.00	07	63.64	04	66.67
Gentamicin	13	61.90	06	40.00	08	72.73	05	83.33
Amikacin	03	14.28	02	13.33	01	9.09	01	16.67
Doxycycline	08	38.09	-	-	04	36.36	02	33.33
Imipenem	00	00.00	00	00.00	00	00.00	00	00.00

measures must be strictly followed to minimize the level of wound contamination and prevention of SSI

- Reducing the preoperative stay to minimum and proper care of the patients throughout the postoperative period are very vital to reduce the rate of SSI
- Ensuring fitness of patient before undertaking the procedure, especially in patients of extreme age groups
- Proper collection and transport of samples from the surgical site immediately on suspicion of infection, and perform routine culture along with antibiotic susceptibility testing (AST)
- Awaiting antibiotic sensitivity test results and following strict guidelines while prescribing antibiotics in patients of SSIs
- Review guidelines for surgical antimicrobial prophylaxis at respective hospitals. Appropriate antibiotic prophylaxis should be practiced to avoid the emergence of resistant strains
- Conduct large study enrolling patients from all possible surgical specialties to isolate large number of isolates including anaerobic bacteria, establish the magnitude of SSIs due to antimicrobial-resistant pathogens, and identify relevant gene responsible for antibiotics resistance
- Establish continuous surveillance and feedback of results to surgeons, which may influence the surgical techniques.

Acknowledgements

We are grateful to all the patients who gave us permission to participate in the study. We acknowledge the support from all the technical staff from the Department of Microbiology.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Howard JR, Brunicardi FC, Andersen DK, Billiar TR, *et al.* Surgical Infections: Principles of Surgery. Vol. I. 8th ed. Schwartz: Tata Mc.Grawhill; 2005. p. 143-75.
2. Weigelt JA, Lipsky BA, Tabak YP, Derby KG, Kim M, Gupta V. Surgical site infections: Causative pathogens and associated outcomes. Am J Infect Control 2010;38:112-20.
3. Horan TC Gaynes R, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: A modification of CDC definitions of surgical wound infections. Infect Control Hosp Epidemiol 1992;13:606-8.
4. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36:309-32.

5. Dellinger EP, Ehrenkranz NJ. Surgical Infections. In: Bennett JV, Brachnan PS, editor. Hospital Infections. 4th ed. Philadelphia: Lippincott Raven publishers; 1998. p. 571-86.
6. Nandi PL, Rajan SS, Mak KC, Chan SC, So YP. Surgical wound infection. Hong Kong Med J 1999;5:82-6.
7. Razavi SM, Ibrahimpoor M, Kashani AS, Jafarani A. Abdominal surgical site infections: Incidence and risk factors at an Iranian teaching hospital. BMC Surg 2005;5:1-5.
8. Agarwal PK, Agarwal M, Bal A, Gahlaut YVS. Incidence of postoperative wound infection at Aligarh. Indian J Surg 1984;46:326-33.
9. DeSa LA, Sathe MJ, Bapat RD. Factors influencing wound infection (A prospective study of 280 cases). J Postgrad Med 1984;30:232-6.
10. Murthy R, Senguptha S, Maya N, Shivananda PG. Incidence of postoperative wound infection and their antibiogram in a teaching and referral hospital. Indian J Med Sci 1998;52:553-5.
11. Anvikar AR, Deshmukh AB, Karyakarte RP, Damle AS, Patwardhan NS, Malik AK, *et al.* A one-year prospective study of 3,280 surgical wounds. Indian J Med Microbiol 1999;17:129-32.
12. Ganguly PS, Khan Y. Malik A. Nosocomial infection and hospital procedures. Indian J Community Med 2000;990-1014.
13. Lilani SP, Jangale N, Chowdhary A, Daver GB. Surgical infection in clean and clean- contaminated cases. Indian J Med Microbiol 2005;23:249-52.
14. Sharan H, Misra AP, Mishra R. Determinants of surgical site infection in rural Kanpur, India. J Evol Med Dent Sci 2012;1921-8.
15. Mahesh CB, Shivakumar S, Suresh BS, Chidanand SP, Vishwanath Y. A prospective study of surgical site infections in a teaching hospital. J Clin Diagn Res 2010;4:3114-9.
16. Rao Bandaru N, Rao AR, Prasad KV, Murty DVSS R. A Prospective Study of Postoperative Wound Infections in a Teaching Hospital of Rural Setup. J Clin Diagn Res 2012;6:1266-71.
17. Saxena A, Singh MP, Brahmchari S, Banerjee M. Surgical site Infection among postoperative patients of tertiary care centre in central India-A prospective study. Asian journal of Biomedical and Pharmaceutical Sciences 2013;3:41-4.
18. Cruse PJ, Foord R. The epidemiology of wound infection. A 10-year prospective study of 62,939 wounds. Surg Clin North Am 1980;60:27-40.
19. Olson M, O'Connor M, Schwartz ML. Surgical wound infections. A 5-year prospective study of 20,193 wounds at the Minneapolis VA Medical Center. Ann Surg 1984;199:253-9.
20. Wanger MB, da Silva NB, Vinciprova AR, Becker AB, Burtet LM, Hall AJ. Hospital acquired infection among surgical patients in a Brazilian hospital. J Hosp Infect 1997;35:277-85.
21. Vilar-Compte D, Sandoval S, Gordillo P, de la Rosa M, Sanchez-Mejorada G, Volkow P. Surveillance of surgical wound infections: 18-month experience in the Instituto National de Cancerologia. Salud Publica Mex 1999;41:44-50.
22. Communicable Disease Surveillance center: NINSS reports on surgical site infection and hospital-acquired bacteremia. CDR Weekly 2000;10:213-6.
23. Geubbels EL, Mintjes-de Groot AJ, van den Berg JM, de Boer AS. An operating surveillance system of surgical-site infections in The Netherlands: results of the PREZIES national surveillance network. Preventie van Ziekenhuisinfecties door Surveillance. Infect Control Hosp Epidemiol 2000;21:311-8.
24. Creamer E, Cunny RJ, Humphrey H, Smyth EG. Sixteen years' surveillance of surgical sites in an Irish acute-care hospital. Infect Control Hosp Epidemiol 2002;23:36-40.
25. Soleto L, Pirard M, Boelaret M. Incidence of surgical site infection and the validity of the National Nosocomial Infection Surveillance System risk index in a general surgical ward in Santa Cruz, Bolivia. Infect Control Hosp Epidemiol 2003;24:26-30.
26. Eriksen HM, Chugulu S, Kondo S, Lingaas E. Surgical site infections at Kilimanjaro, Christian Medical Centre. J Hosp Infect 2003;55:14-20.
27. Saito T, Aoki Y, Ebara K, Hirai S, Kitamura Y, Kasaoka Y, *et al.* Surgical site infection surveillance at a small-scale community hospital. J Infect Chemother 2005;11:204-6.
28. Chattopadhyay R, Zaroukian S, Potvin E. Surgical site infection rates at the Pontiac Health care Centre, a rural community hospital. Can J Rural Med 2006;11:41-8.
29. Lingaraj B, Rathish K. Bacteriological Study of Post-Operative Wound Infections and Their Antibiograms. RGUHS; 2006. P (6).
30. Sahu S, Shergill J, Sachan P, Gupta P. Superficial incisional surgical site infection in elective abdominal surgeries-A prospective study. Internet J Surg 2009;26.
31. Shanthi J, Shankar T, Balagurunathan R. The scenario of post-operative wound infection from a Government hospital in South India. J. Microbiol Biotech Res 2012;2:396-401.
32. Abu Hanifah Y. Post-operative surgical wound infection. Med J Malaysia 1990;45:293-7.
33. Kamat US, Fereirra AMA, Kulkarni MS, Motghare DD. A prospective study of surgical site infections in a teaching hospital in Goa. Indian J Surg 2008;70:120-4.
34. Tripathy BS, Roy N. Post-operative wound sepsis. Ind J Surg 1984;47:285-8.
35. Kowli SS, Nayak MH, Mehta AP, Bhalerao RA. Hospital infection. Indian J Surg 1985;48:475-86.
36. Siguan SS, Bernard S Ang, Isaac M. Pala, Reynaldo M. Baclig. Aerobic Surgical Infection: A Surveillance on Microbiological Etiology and Antimicrobial Sensitivity Pattern of Commonly Used Antibiotics. Phil J Microbiol Infect Dis 1990;19:27-33.
37. Khan MA, Ansari MN, Bano S. Post-operative wound infection. Ind J Surg 1985;48:383-6.
38. Medeiros AC, Tertuliano AN, Azevedo GD, Vilar JP, Pinheiro LA, Neto JB. Surgical site infection in a university hospital in north east Brazil. Brazilian J Infect Dis 2005;9:310-4.
39. Kasatpibal N, Norgaard M, Sorensen HT, Schonheyder HC, Jamulitata S, Chongsuvivatwong V. Risk of surgical site infection and efficacy of antibiotic prophylaxis: A cohort study of appendicectomy patients in Thailand. BMC Infect Dis 2006;6:111.
40. Berard F, Gandon J. Factors influencing the incidence of wound infection. Ann Surg 1964;160:32-81.
41. Mekhla, Borle FR. Determinants of superficial surgical site infections in abdominal surgeries at a Rural Teaching Hospital in Central India: A prospective study. J Family Med Prim Care 2019;8:2258-63.
42. Giacometti A, Cirioni O, Schimizzi AM, Prete MS, Barchiesi F, D'Errico MM, *et al.* Epidemiology and

microbiology of surgical wound infections. J Clin Microbiol 2000;38:918-22.

43. Saha SC, Zaman MA, Khan MR, Ali SM. Common aerobic bacteria in post-operative wound infection and their sensitivity pattern in Bangladesh. Mwd Res Coun Bull 1995;21:32-7.
44. Choojitv W, Ruangkris T. Surgical wound infection in Gynaecology at Rajvithi Hospital. J Med Assoc Thai 1995;78:578-80.
45. Gupta P. A study of postoperative wound infection among post-surgical patients at Calicut medical college, Kerala, India. J Evol Med Dent Sci 2012;1:582.
46. Birendra K Jain, Molay Banerjee. Surgical site infections and its risk factors in orthopaedics: A prospective study in teaching hospital of central India. IJRM 2013;2:110-3.
47. Yalcin AN, Bakir M, Bakici Z, Dokematas I, Sabir N. Postoperative wound infections. J Hosp Infect 1995;29:305-9.
48. Trans TS, Jamulitrat S, Chongsuvivatvong V, Geater A. Postoperative hospital acquired infection in Hungvnong Obstetric and Gynalcological hospital Vietnam. J Hosp Infect 1998;40:141-7.
49. Rao AS, Harsha M. Postoperative wound infections. J Indian MA 1975;64:90-3.
50. Sampson P. Postoperative wound sepsis rate can be cut by simple measures. JAMA 1978;239:9-10.
51. Prabhakar H, Arora S. A bacteriological study of wound infections. J Indian Med Assoc 1979;73:145-8.
52. Ramesh A, Dharini R. Surgical site infection in a teaching hospital. Clinico Microbiological and Epidemiological profile. Int J Biol Med Res 2012;3:2050-3.
53. Kona K, Arakawa K. Methicillin-resistant *staphylococcus aureus* (MRSA) isolated in clinics and hospitals in Fukuoka city area. J Hosp Infect 1995;29:265-73.
54. Udaya Shankar C, Harish BN, Umesh Kumar PM, Navaneeth BV. Prevalence of methicillin resistant Staphylococcous aureus in JIPMER hospital - A preliminary report. Indian J Med Microbiol 1997;15:137-8.
55. Pal N, Mukherjee RG. Surgical site infection in surgery ward at a tertiary care hospital: The infection rate and the bacteriological profile. IOSR J Pharm 2012;2:1-5.
56. Shahane V, Bhawal S, Lele U. Surgical site infections: A one-year prospective study in a tertiary care center. Int J Health Sci 2012;6:79-84.