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Original Research Article

A prospective study to evaluate incidence and risk factor for surgical site infection in patient undergoing abdominal surgeries at a tertiary care centre of Western Rajasthan

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ABSTRACT

Background: Study was conducted to evaluate the incidence, risk factors, identification of etiological agents, and antimicrobial sensitivity and resistance for surgical site infections in patients undergoing abdominal surgeries at Mathura Das Mathur Hospital, Jodhpur.
Methods: A prospective case series study was conducted at Mathura Das Mathur Hospital, Jodhpur, Rajasthan, involving all patients undergoing abdominal surgeries between 1 January 2021 and 1 January 2022. Patient demographics and associated risk factors were documented, and comprehensive investigations were carried out.
Results: This study included 220 patients, with an infection rate of 18.6%. Compared to other studies conducted in India, this rate is almost similar. However, studies conducted in the Western world show a lower infection rate.
Conclusions: The incidence of surgical site infection in this study was 18.6%, which is comparable to other studies conducted in India. Pseudomonas was the most commonly isolated organism, and older individuals were found to be more susceptible to infection. Risk factors such as diabetes mellitus, respiratory tract infection, urinary tract infection, emergency surgeries, and higher BMI also contributed to the development of surgical site infections.

Keywords: Surgical site infection, Respiratory tract infection, Urinary tract infection

INTRODUCTION

A surgical site infection (SSI) is defined as an infection that occurs when an organism multiplies at the surgical site. SSI not only disrupts the normal immunological response of the human body but also significantly prolongs hospital stays and increases healthcare costs.[1] Various studies conducted across India have reported SSI rates ranging from 6% to 39%, suggesting that the presence of risk factors increases the likelihood of infection. SSI not only extends the length of hospitalization but also escalates healthcare expenditures.[2] The risk of developing a surgical site infection varies significantly based on the nature of the surgical procedure and the specific clinical characteristics of the patient undergoing the operation. Different wound types show varying infection rates, for example: clean wounds (1.5%-3.7%), clean-contaminated wounds (3%-4%), contaminated wounds (8.5%), and dirty wounds (28%-40%).[3] Additionally, surgical procedures such as laparoscopy (10%), umbilical hernia (2%-5%), and colon surgery without antimicrobial drugs (30%-60%) have distinct infection rates. Numerous studies from around the world have demonstrated a significant association between SSI rates and factors such as the patient's American Society of Anesthesiologists (ASA) classification, obesity, preoperative antimicrobial agent use, immunosuppression, surgical drain usage, the use of iodine alone in skin preparation, wound contamination, as well as smoking, diabetes mellitus, hypertension, and hospital stay duration.[4] While many studies have explored the rate of SSI and causative agents and their antimicrobial susceptibility across India, limited research has been conducted in western Rajasthan.

Aim and objectives

The objective of this study is to determine the rate of abdominal surgical site infections, identify associated risk factors, assess the most common organisms encountered, and evaluate their antibiotic susceptibility and resistance in postoperative wounds within a tertiary care centre in western Rajasthan.

METHODS

Study design, location, duration and population

This is a hospital-based prospective observational study. The study took place in the Department of General Surgery Mathura Das Mathur Hospital Jodhpur, Rajasthan, Western India between 1 January 2021 and 1 January 2022. The study involved all patients undergoing abdominal surgeries, both elective and emergency cases, at the tertiary care centre in Western Rajasthan.

Sample size

The sample size was determined using a 95% confidence interval to verify an expected 16% proportion of surgical site infections, as reported by Patel et al while allowing for a 5% absolute allowable error.[5] The sample size was calculated using the formula for sample size estimation of proportions:

$$n = Z\left(1-\frac{a}{2}\right)^2 * \frac{P(1-P)}{E^2}$$

Where: Za/2 represents the standard normal deviation at a 95% confidence interval (considered as 1.96). P is the expected proportion of abdominal surgical site infection (16% based on Patel's study). E is the absolute allowable error (set at 5%). The calculated sample size was a minimum of 215 subjects, which was rounded up to 220 patients undergoing abdominal surgical site infection.

Inclusion and exclusion criteria

All patients, regardless of age and gender, who presented to the general surgery department requiring abdominal surgeries, whether attended outpatient departments or trauma cases, and provided written informed consent to participate in the study, were included. Patients with previously infected wound sites and patients with surgeries other than abdominal surgeries were excluded.

Data collection

After obtaining informed consent from patients, the study was explained to them, including its purpose and how it would be conducted. Upon receiving approval from the ethical committee, the following information was collected: Patient particulars: Name, age, gender, address, contact number, registration number, and date of admission. Patient history: Presenting chief complaints, history of presenting illness, past medical history, family history, history regarding previous radiation exposure, and steroid use. Clinical examination: General physical examination and a detailed systemic examination were performed for every case. Preoperative preparation: This included a range of tests and investigations such as CBC, blood sugar, renal function tests, liver function tests, serum electrolytes, ECG, abdominal and chest X-rays, abdominal ultrasound, and other relevant tests. Operative details: Information related to the surgical procedure, whether it was elective or emergency, wound contamination, and placement of drains. Post-operative details: Antibiotic use, dressing frequency, wound culture, swab culture, antibiotic sensitivity, and resistance. Outcome measures: Parameters analysed included fever, erythema, discharge, type and colour of wound exudate. Exudate was collected from the depth of the wound and sent for microbiological culture.

Laboratory procedures

In the microbiology department, swabs were inoculated onto blood agar plates, MacConkey's agar plates, and nutrient broth. Inoculated media was incubated aerobically at 37 degrees for 24-48 hours. If the original plates did not yield organisms, the nutrient broth was sub-cultured. Bacteria were identified based on their morphological and cultural characteristics. The following steps were taken for sample processing: Direct microscopic examination of gram-stained smear. Inoculation of samples onto different culture media for aerobic and anaerobic organisms, Preliminary identification, Biochemical tests and Antibiotic sensitivity. Patients were followed up for one month.

Data analysis

Data collection was facilitated using a pre-structured, pre-tested proforma. Data analysis was conducted using Microsoft Excel, and the data was analysed with the help of frequencies, figures, and proportions.

RESULTS

This study includes 220 patients undergoing abdominal surgeries, out of which 41 were found to present SSI. Patients from all age groups participated in the study, as shown in table 2 and it was found that age group above 60 years are more likely to present the etiology.

Table 1: Total incidence of abdominal surgical site infection.

Total number of cases	No, of cases infected	%
220	41	18.6

Table 2: Incidence of surgical site infection in relation to age group.

Age (years)	N	Infected	%
10-20	20	2	10
20-30	55	10	18.1
30-40	39	6	15.3
40-50	54	4	7.4
50-60	10	3	30
>60	42	16	38.09

Table 3: Incidence of SSI in relation to type of wound.

Type	N	Infected	%
Clean	55	3	5.45
Clean contaminated	76	9	11.8
Contaminated	47	10	21.2
Dirty	42	19	45.2

Table 4: Incidence of surgical site infection in relation to type of operation.

Type	N	Infected	%
Emergency	124	37	30
Elective	96	4	4.1

Table 5: Incidence of surgical site infection in relation to risk factors.

Risk factors		N	Infected	%
Anemia		70	20	28
Hypoprotenimea		36	10	27.7
DM		40	17	42.5
Preop-RTI		19	9	47.3
Duration of surgery (hrs)	**<1.5**	149	13	8.7
	>1.5	61	28	45.9
Preop-hospitalisation (days)	**<5**	183	22	12
	>5	37	19	51.3
Preop shaving time (hrs)	**<6**	62	8	12.9
	>6	158	33	20.8
Drain placement	**Yes**	120	31	25.8
	No	100	10	10
Type of surgical approach	**Open**	194	41	21.1
	Minimal invasive	26	0	0
Preop-UTI		9	3	33.3

The (Table 3) shows, 45.2% of dirty wound was infected, 21.2% of contaminated wound was infected, clean contaminated 11.8% and clean wound shows a low rate of 5.45% respectively. When attention was drawn to the risk factors, emergency surgeries showed a higher infection rate than elective surgeries. Emergency surgeries 30% and elective 4.1% respectively as shown in (Table 4). The (Table 5) shows an elaboration of different risk factors. The rate of SSI was more among patients with anaemia, diabetes, Respiratory tract infection, urinary tract infection, and hypoproteinaemia (Table 5). Among all pre-op respiratory tract infection and diabetic patients had a significantly higher rate of surgical site infection.

Table 6: Incidence of surgical site infection in relation to BMI.

BMI	N	Infected	%
≤20	24	5	20.3
21-24	83	3	3.6
25-29	66	5	7.5
≥30	49	28	57.1

Table 7: SSI in relation to type of organism.

Organism	N	%
Pseudomonas	16	39
S. aureas	12	29
E. Coli	8	19.5
Klebsiella	5	12.1

A significant rate of postoperative wound infection was found in longer-duration of surgeries. Surgeries with duration longer than 1.5hr had an infection rate of 45.9% while less than 1.5hr had an infection rate of 8.7%. Patient admitted for more than 5 days had a significant higher rate of SSI as compared to patient with less than 5 days of pre-op hospitalisation. It is also clearly evident that placement of drain increases the risk of surgical site infection. When comparison was made between minimal invasive and open surgeries, open surgeries clearly showed a higher infection rate. Role of various other factors such as pre-op shaving (preparation) time of the patient for surgery are also observed.

Pre-op shaving time for surgical preparation had a negative impact, greater the time of preparation more are the chances of infection. Shaving time from surgery more than 6hr had an infection rate of 20.8%, while less than 6hr had an infection rate of 12.9%. Different rate of SSI in the BMI range is depicted in the (Table 6). Incidence of ssi was found to be significantly higher in patients with BMI more than 30, while patients with normal BMI 21-24 had a lower infection rate of 3.6%. The (Table 7-9) show the bacteria identified from the surgical site of patients who participated in the study and antibiotic resistance and sensitivity of organism was obtained. In this study, 39% of the infected wounds had pseudomonas, staph aureus in 29%, *E. coli* in 19.5% whereas *Klebsiella* was seen in 12.1% of cases.

Table 8: Antibiotic sensitivity spectrum.

Micro-organism	N	AK	%	CF	%	CT	%	Cph	%	T	%	D	%	Pc	%	Tb	%	Cz	%	G	%	A	%	Ci	%
Sa	12	8	66.6	-	-	9	75	7	58.3	-	-	-	-	6	50	-	-	3	25	6	50	4	33.3	2	16.6
Ps	16	14	87.5	9	56.25	12	75	5	31.2	-	-	12	75	2	12.5	-	-	12	75	1	6.25	-	-	2	12.5
Ec	8	4	50	7	87.5	7	87.5	5	62.5	-	-	1	12.5	4	50	-	-	-	-	-	-	3	37.5	1	12.5
Kl	5	4	80	-	-	3	60	-	-	3	60	2	40	3	60	-	-	1	20	-	-	-	-	4	80
Total	41	30	73.17	16	39.02	31	75.6	17	41.4	3	7.3	15	36.5	15	36.5	-	-	16	39.02	7	17.07	7	17.07	9	21.09

Sa-*S. aureas*, Ps-*Pseudomonas*, Ec- *E. coli*, Kl- *Klebsiella*, Ak- amikacin, CF- ceftriaxone, Tb- Tazobactam, CT- cefotaxime, Cph-cefoperazone, T- tetracycline, D- doxycycline, Pc-piperacillin, Cz- ceftazidime, G- gentamicin, A- amoxicillin, Ci- ciprofloxacin

Table 9: Antibiotic resistance spectrum.

Micro-organism	N	AK	%	CF	%	CT	%	Cph	%	T	%	D	%	Pc	%	Tb	%	Cz	%	G	%	A	%	Ci	%
Sa	12	3	25	1	8.3	-	-	4	33.3	-	-	11	91.6	6	50	-	-	4	33.3	3	25	3	25	-	-
Ps	16	-	-	4	25	5	31	1	6,25	8	50	3	18.75	11	68.75	-	-	3	18.75	4	25	2	12.5	3	18.75
Ec	8	3	37.5	-	-	-	-	-	-	-		2	25	4	50	8	100	4	50	3	37.5	-	-	-	-
Kl	5	1	20	-	-	2	40	-	-	2	40	2	40	2	40	-	-	3	60	2	40	1	20	-	-
Total	41	7	17.07	5	12.1	7	17.07	5	12.1	10	24.3	18	43.9	23	56.09	8	19.5	14	34.14	123	29.2	6	14.6	3	7.3

Sa-*S. aureas*, Ps-*Pseudomonas*, Ec- *E. coli*, Kl- *Klebsiella*, Ak- amikacin, CF- ceftriaxone, Tb- Tazobactam, CT- cefotaxime, Cph-cefoperazone, T- tetracycline, D- doxycycline, Pc-piperacillin, Cz- ceftazidime, G- gentamicin, A- amoxicillin, Ci- ciprofloxacin

Table 10: Different studies conducted on surgical site infection.

Author	Country	Year	Total cases	Infection rate (%)
Cruse and Foord et al.[6,7]	Canada	1980	62939	4.7
Anvikar et al.[8]	India	1999	3280	6.09
Umesh et al.[9]	India	2008	114	30.7
Mahesh et al.[10]	India	2010	418	20.9

Staphylococci were found most sensitive to cefotaxime at 75% followed by amikacin, cefoperazone, piperacillin, ceftazidime, and ciprofloxacin. *E. coli* was most sensitive to ceftriaxone (87.5%) and cefotaxime (87.5%). Klebsiella was more sensitive to amikacin and ciprofloxacin (80%) followed by others. Pseudomonas was found to be more sensitive to amikacin 87.5% followed by cefotaxime, ceftazidime, and others.

DISCUSSION

This study was conducted at MDM hospital Jodhpur Rajasthan, in this study 220 cases of patients undergoing abdominal surgeries in the general surgical department of MDM Hospital Jodhpur were included and a follow-up of 30 days was done. The incidence of SSI in this study was found to be around 18.6% which in comparison to other studies conducted in India is almost similar, studies conducted in India show infection rates between 6% to 39%. Whereas, studies conducted in Western countries had a lower infection rate. This difference is clearly depicted in (Table 10) which occur because of a lack of proper infrastructure, poor socioeconomic status, illiteracy, and lack of attention toward hospitalization.

As age increases the tendency for infection increases this finding is confirmed by the study where an older individual had a higher infection rate. The incidence gradually increases from 10% in the 10-20 age group to 38.09% in the 60-70 age group. A similar finding was observed in past studies like Cruse and Foord.[6,7] Few studies such as Owen et al and Bharatnur et al showed that rate of SSI was greater among 36-50 year of age group.[11,12] 38.09% incidence of SSI is noted in patients above 60 years which is a clear indicator that advancing age causes a decrease in immunological capacity which is added on by other co-morbidity like DM, asthma, TB, smoking, alcoholism, etc. Thereby age is one of the risk factors for surgical site infection with clear evidence. In this study, the incidence in relation to the type of surgical wound, the clean wound had an infection rate of 5.4%. Clean contaminated had an infection rate of 11.2%, contaminated wounds had an infection rate of 21.2% and dirty wounds had an infection rate of 45.2%. Looking at other studies, similar results were obtained. Syed et al at an Iranian teaching hospital performed a study where he found SSI in clean wounds to be around 13.6%, clean contaminated 26.7%, contaminated 45.8%, and dirty wounds 14%.[3] Mahesh et al conducted a similar study and found the SSI rate in clean surgery 11.53%, clean contaminated 23.33%, contaminated 38.10%, and dirty wound to be around 57.14%.[10] The difference in the infectivity rate between types of wounds is because of internal and external factors. Internal factors can be host-related and external factors arise due to organisms.

Mahesh et al conducted a study and found that emergency surgeries are more prone to the risk of SSI than elective (21.05% vs 7.61%).[10] Similarly, another study conducted by Saravanakumar et al rate of SSI in elective surgery was 4.34% and emergency surgeries was 12.41% respectively.[13] In comparison to these studies, our study shows the infection rate among emergency surgeries to be around 30% and electives had an infection rate of 4.1%. This concludes that emergency surgeries have a high infection rate as compared to elective surgeries, probably because of highly contaminated and dirty caseload, inadequate pre-op preparation, and the presence of comorbid conditions. SSI was higher in patients who are suffering from respiratory tract disorder 47.3%, the diabetic patient had an infection rate of 42.5%, whereas others such as anaemic 28%, UTI 33%, and hypoproteinaemia had an infection rate of 27.7%. This finding concludes that comorbidity is an important risk factor, probably because of immunosuppression, reduced healing factors, hyperglycaemia, improper environment for wound healing, and preexisting conditions. Similar results were noted in study conducted by Mohan et al where diabetes mellitus and smoking are found to be an important risk factor in developing SSI.[14]

Hospitalization before surgery longer than 5 days had an incidence of 51.3%. Increased duration of pre-op hospitalization increases the risk of SSI. A higher incidence of SSI due to longer pre-op hospitalization is attributed to increased colonization of patients with nosocomial strains, also longer preoperative stay in the hospital reflects the severity of the illness and other associated comorbid conditions which causes prolong optimization of patient for surgery. Similar results were obtained in other studies such as Mansour et al where hospitalization less than 15 days had an infection rate of 18.6% and longer than 15 days had an infection rate of 25.9%.[3] Saravanakumar et al report SSI frequency with drain (66.6%) without drain (33.3%).[13] In the present study, the use of drain had an infection rate of 25.8%. A similar observation was made in other studies with the use of a drain.

Drain placement is decided on the basis of surgery, but it acts as a portal of entry for the organism. On the contrary study conducted by Nivitha et al placement of drain had an infection rate of 16% and no drain had SSI frequency of 84%.[14] In our study, we observe patients in whom pre-op shaving is done more than 6hr before surgery are likely to have a higher infection rate of 20.8%, whereas those who are prepared within 6hr had an infection rate of 12.9%. This observation is probably because pre-op shaving causes the surface prone to infection and the longer the period greater will be the time for the organism to settle. A trial conducted by Brown et al and Rojanapirom et al compared shaving and no shaving of hairs preoperatively.[15,16] Trail observations showed SSI of 9.6% in patients with hair removal, whereas patients in whom hair is not removed had SSI of 6%.

Study by Cheng et al shows likelihood of SSI increases with increased operating time.[17] In the present study, we found the infection rate of surgery less than 1.5hr to be around 8.7% and surgeries whose duration is more than

1.5 hr had an infection rate to be around 45.9%. This effect is because the longer the duration of surgeries, the higher the chance of breakage of aseptic barriers. In this study incidence of SSI is least seen in minimal invasive surgeries whereas open abdominal surgeries had the higher infection rate, similar results were seen in the study Kulkarni et al.[18] Patients with a BMI above 30 had an infection rate of 57.1% which in comparison to a study conducted by Mejis et al reported increased risk of SSI with increasing trend of BMI.[19] This concludes higher the BMI, the higher the infection rate, this is because obesity decreases blood supply to fatty tissues.

Kamat et al performed a prospective study of surgical site infection in Goa and noted the most common organism associated were pseudomonas and staphylococcus pyogenes.[9] Saravanakumar et al *E. coli* is the most common organism isolated from elective wound and Proteus Mirabilis from emergency wound.[13] In our study, 39% of the infected wounds had pseudomonas, staph aureus in 29%, *E. coli* in 19.5% whereas *Klebsiella* was seen in 12.1% of cases. Our finding suggests a predominance of gram-negative bacteria, similar to other studies. Organisms that are endogenous to the gastrointestinal tract become so prevalent in the hospital that they become endemic and are difficult to eradicate from the surface with the use of common antiseptic solutions. This organism plays an important role in hospital-acquired infections. In this study, *Staphylococci* were found most sensitive to cefotaxime at 75% followed by amikacin, cefoperazone, piperacillin, ceftazidime, and ciprofloxacin. *E. coli* was most sensitive to ceftriaxone (87.5%) and cefotaxime (87.5%).

Klebsiella was more sensitive to amikacin and ciprofloxacin (80%) followed by others. Pseudomonas was found to be more sensitive to amikacin 87.5% followed by cefotaxime, ceftazidime, and others. Overall, amikacin and cefotaxime were found to be more sensitive antibiotics. *Staphylococci* are most resistant to doxycycline (91.6%), and cefotaxime (83%) followed by others. *Pseudomonas* is most resistant to piperacillin (68.75%) followed by other, *E. coli* is most resistant to ceftazidime, piperacillin followed by other, *Klebsiella* is most resistant to ceftazidime (60%) followed by others. Overall, piperacillin is the most resistant antibiotic, followed by doxycycline. Saravanakumar et al showed *E. coli* to be more sensitive to piperacillin, clavulanic acid and cephalosporin.[13] Most of the studies conducted shows similar results, and antibiotic such as ampicillin and doxycycline show high resistance. Most of the aerobic bacteria demonstrate less than 50% sensitivity to cephalosporin's. These finding shows a high level of resistance among bacteria and reflect the abuse of antibiotics in general population.

Limitations

Limitations were; this is a single centre study in which paediatric patients whose age is below 10 years are not included, since this study is a cross sectional study the relation between SSI and risk factors do not need to be a causative factor. Various other factors such as operating room environment, pre-op scrubbing etc. are not included in this study.

CONCLUSION

In our study, the rate of surgical site infection was found to be around 18.6% after proper clinical examination of the wound. This is comparable to a larger number of studies conducted in India, whereas Western studies show a lower infection rate this is due to various poor infrastructure, lower literacy rates, and poor socioeconomic status.

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