

Original Research Article

Identifying risk factors for surgical site infections in abdominal surgeries and establishing common pathogenic bacteria

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ABSTRACT

Background: Infections that occur in the wound created by an invasive surgical procedure are generally referred to as surgical site infections (SSIs). SSIs are one of the most important causes of health care associated infections. Aims of the study was to study surgical site infections following abdominal surgeries.

Methods: A hospital based prospective observational study was conducted on patients operated on elective and emergency basis admitted to the hospital, the study was conducted for one year in 813 cases influence of various risk factors in developing surgical site infections and the outcome were studied.

Results: A total of 813 patients were studied, out of which 587 were Elective cases and 226 were Emergency cases. Out of 587 elective cases 34 cases developed SSI. Among 226 emergency cases 40 cases developed SSI. The overall wound infection rate was 9.10%. Study shows higher rate of infection in dirty wounds (75%) when compared to contaminated (7.58%), clean contaminated (8.71%) and clean wounds (5.48%) respectively. prolonged operation duration more than 3 hours, out of 195 cases 32 developed SSI. Among 74 cases of wound infection, gram negative bacilli were very often responsible for postoperative wound infection than gram positive organisms. the mean postoperative stay of patients who developed SSI increased by 3.54 days when compared to the rest of the cases.

Conclusions: *Staphylococcus* species were most frequently isolated, next in order are *E. Coli*, *Klebsiella*, and *Proteus* then comes *Pseudomonas*. Surgical site infections were associated with increased hospital stay and thereby increasing health care expenditure and morbidity.

Keywords: Surgical site infection, Wound, Risk factors, Hospital stay

INTRODUCTION

Infection is the clinical manifestation of an inflammatory response triggered by microorganism invasion and proliferation. Surgical site infection puts a tremendous strain on both the patient and the health-care system, lengthening hospital stays and increasing costs. The knowledge of wound infection has progressed

significantly from the days when pus was laudable to the present day, where advancements in therapeutics, surgical procedures, and asepsis maintenance have all contributed to managing the scourge of surgery, postoperative infection. A century ago, infection was considered an unavoidable consequence of surgery. While there are many reports on SSI in the adult literature, there are few reports for children, and the surgical armamentarium in combating infection now includes a clear knowledge of

pathogens and their pathogenicity, developments in the field of asepsis and aseptic technique, the introduction of antibiotics, and effective suture materials. As a result, the surgical community must maintain a constant knowledge of the current infection danger. Surgical Wound Infection was replaced by SSI by the surgical wound infection task force in 1992.²

One of the most common causes of HCAs is SSIs. SSIs were responsible for 14% of these infections, and approximately 5% of patients who had undergone a surgical operation were found to have acquired an SSI. However, since many of these infections happen after the patient has been discharged from the hospital, prevalence studies appear to underestimate SSI. About one-third of postoperative deaths are attributed, at least in part, to SSI, according to reports. It's important to remember, however, that SSIs can range from a minor wound infection with no other complications to a life-threatening disease. Other clinical effects of SSIs include unattractive scars, such as hypertrophic scars, keloid, constant discomfort, itching, mobility restriction, especially over joints, and a major effect on emotional well-being.³

Bacteria infect all surgical wounds, but only a small percentage of them display clinical infection. In most cases, infection does not occur because the inherent host defences are very effective at removing pollutants from the surgical site.

Coagulation proteins, platelets, mast cells, complement protein, and bradykinin are all triggered when a surgical incision is made through the skin and into the subcutaneous tissues. Vasodilation and increased blood flow at the surgical incision site are the net effects of these five factors, while bulk flow is increased and velocity is reduced in preparation for phagocyte margination. Nonspecific chemoattractant signals, as well as some unique chemokine signals, are produced, "Draw" specific neutrophil, monocyte, and other leukocyte populations to the surgical site. The fact that tissue damage from the incision triggers the recruitment of phagocytes into the wound before bacterial contamination occurs because of the operation gives the patient an advantage against infection. The result of intense neutrophilic stimulation, tissue autolysis, and continuous inflammatory initiation stimulation is the formation of a wound space that serves as a host-pathogen battleground. Eventually, necrotic tissue, neutrophils, bacteria, and the proteinaceous fluid that makes up pus fill the wound space. The natural history of surgical site infection concludes with the discharge of pus from the wound interface through the incision.

For elective cases, our hospital practise involves urging patients to bathe with antiseptic soap prior to surgery, as well as part planning by hair clipping to be taken care of before the surgery. Maintaining laminar flow in the operating room with positive pressure, temperature, and humidity monitoring, and administering prophylactic

antibiotic 60 minutes prior to incision. HEPA filters are used to clean the air. At the entrance and exit of the theatre, there is a double door air lock. Surfaces in the environment must be cleaned and disinfected properly. Using acceptable standard procedures, sterilise surgical instruments, surgical attire, and drapes. For all operations, stringent aseptic protocols must be followed.

Bacterial factors, local wound factors, and patient factors are the three types of factors that affect infection rates. Bacterial factors include bacterial number (load), virulence, and bacterial tolerance, pre-operative length of stay, remote site infection, procedure duration, wound class, prior antibiotic therapy, and pre-operative shaving. Surgical procedures, hematoma/seroma, necrosis, sutures, drains, and foreign bodies are all local wound causes. Age, immunosuppression, malignancy, obesity, diabetes mellitus, malnutrition, cigarette smoking, O₂ tension, temperature, and glycaemic control are several of the patient factors.

Individual hospitals and national health-care planners will be able to use this information to set programme targets, track the results of various preventive measures, and set goals for their infection-control efforts. Our research focuses on SSI after abdominal procedures, with the aim of determining the overall incidence and identifying known risk factors, as well as isolating and studying the susceptibility trends to widely used antimicrobials.

The aim of this study is to investigate surgical site infections after abdominal surgeries.

Objectives of the study were to determine the overall incidence of SSI in abdominal surgery, classify identified risk factors, isolate species involved, and investigate antimicrobial susceptibility trends.

METHODS

This is a prospective observational study which consists of 813 patients operated on elective/emergency basis admitted to the Kamineni hospital, LB Nagar, Hyderabad. The study was conducted from January 2018 to December 2018. A series of 813 cases undergoing elective and emergency abdominal surgeries with surgical site infection were considered for study.

Inclusion criteria

Patients undergoing elective and emergency abdominal surgeries in department of general surgery of all age groups.

Exclusion criteria

Patients with wound site previously infected are excluded from the present study.

SSI rate has been found to be between 2.5%-41.9% by institutional infection control team. Assuming 25% as the basic percentage of development of surgical site infections patients requesting a 95% confidence interval for the proportion with width no higher than 25%, the minimum sample size needed is 801. A conservative estimate gave a sample size as 813.

When infection was suspected, a cotton swab was taken from the wound after surgery. To avoid contaminating the specimen with commensal species from the skin, special precautions were taken. Before applying an antiseptic dressing, a sample of the wound was taken as far as possible. Up to 5 mL of pus was collected from the drainage tube using sterile technique and transferred to a leak-proof sterile container. A sterile cotton-wool swab was used to extract the sample from the contaminated site while pus was not being discharged. The specimen was sent with special care to ensure that it arrived at the Microbiology laboratory within 6 hours. On the first day, one swab was used to create a slide for gramme staining. For culture, another swab was used. Blood agar and nutrient agar plates were used for pus culture and were aerobically incubated for 24 hours. Colony morphology and coagulation tests were used to identify isolates. If the culture is positive, antibiotic sensitivity testing was done (Muller Hilton method).

There was no control group in this retrospective prospective analysis. The data was analysed, and the findings were compared to those of other research in the literature. The data was entered into a Microsoft excel spreadsheet and analysed with the SPSS 22 programme. For qualitative evidence, the Chi-square test was used as a significance test. After assuming all statistical laws, a p value (probability that the result is true) of 0.05 was considered statistically important.

RESULTS

Out of 813 patients 587 were elective cases and 226 were emergency cases. Out of 587 elective cases 34 cases developed SSI. Among 226 emergency cases 40 cases developed SSI. The overall wound infection rate was 9.10%.

Table 1: Nature of surgery.

Variables	Total cases	Infected cases	Percentage (%)
Surgical procedure			
Elective	587	34	5.79
Emergency	226	40	17.70
Total	813	74	9.10
Type of surgery			
Laparoscopic	298	10	3.36
Open	515	64	12.43

In the present study 515 cases were open surgeries and 298 were laparoscopic surgeries.

The Incidence of SSI increases with increase of age. The highest incidence is found in the age group of more than 60 years. As per above data there was no statistical significance of sex in the development of SSI.

Table 2: Demographic details in study.

Demographic details	Total cases	Infected cases	Percentage (%)
Age group (years)			
0-9	22	1	4.55
10-19	60	5	8.33
20-29	86	8	9.30
30-39	153	13	8.50
40-49	140	11	7.86
50-59	163	16	9.82
≥60	189	20	10.58
Gender			
Male	449	45	10.02
Female	364	29	7.97

Table 3: Comorbidities in the patients.

Variables	Total cases	Infected cases	%	P value
Diabetic/non diabetic				
Diabetic	252	43	17.06	<0.0001
Non-Diabetic	561	31	5.53	
Obese/non-obese patients				
Obese	212	38	17.92	<0.0001
Non obese	601	36	5.99	
History of consumption of steroids				
Yes	75	14	18.67	0.002
No	738	60	8.13	
Tobacco consumption				
Yes	138	22	15.94	
No	675	52	7.70	

There were 252 diabetic patients and 561 non-diabetic patients among the 813 patients. SSI had developed in 43 of the 252 diabetic patients. surgical site infections had formed in 31 of the 561 non-diabetic cases. Patients with diabetes mellitus have a higher rate of infection, according to our findings.

Out of the 813 patients in this sample, 212 were obese and 601 were not. SSI developed in 38 cases among 212 obese patients and 36 cases among 601 non-obese patients. In comparison to non-obese patients, patients with obesity have a higher risk of infection.

75 of the 813 patients in our sample were on steroids, while the other 738 were not. Fourteen of the 75 patients on steroids were tainted. There were 60 contaminated patients out of 738 who were not on steroids. The above data indicates that steroid use is associated with an increased risk of Surgical site infection.

In our sample of 813 patients, 138 patients had a history of tobacco use, while 675 patients had never used tobacco. Fourteen of the 138 patients who use tobacco were contaminated. There were 52 infected patients out of 675 were not eating. The data above indicates a connection between tobacco use and increased risk of SSI.

As per the above data there was higher rate of infection in patients with increased duration of preoperative stay in the hospital, highest during 3-4 days.

The data from our study shows higher rate of infection in dirty wounds (75%) when compared to contaminated (7.58%), clean contaminated (8.71%) and clean wounds (5.48%) respectively.

In the present study prolonged operation duration more than 3 hours, out of 195 cases 32 developed SSI. Whereas out of 618 cases, the duration of surgery is less than 3 hours only 42 developed SSI. This is attributed prolonged operation duration time to development of surgical site infections.

Among 74 cases of wound infection, gram negative bacilli were very often responsible for post-operative wound infection than gram positive organisms.

Out of 69 culture positive reports the antibiotic sensitivity pattern is as shown in Table 6.

Out of 18 cases in which *S. Aureus* is grown, 5 cases are found to be MRSA (Methicillin resistant *S. Aureus*) and 3 cases are ESBL out of 14 cases of *E. Coli* as shown in the Table 7.

Table 4: Incidence of SSI based on class of wound.

Surgical procedure	Total cases	Infected cases	Percentage (%)
Clean	347	19	5.48
Clean contaminated	310	27	8.71
Contaminated	132	10	7.58
Dirty	24	18	75

Table 5: Incidence of individual organism isolated from infected wounds.

Name of organism	Infected case	% of cases infected (%)	Surgical procedure
<i>S. aureus</i>	18	24.32	Hernia, Biliary
<i>Escherichia Coli</i>	14	18.91	Biliary, Appendicectomy
<i>Klebsiella Species</i>	7	9.45	Biliary, Appendicectomy
<i>Proteus Species</i>	3	4.05	Intestinal, Biliary
<i>Pseudomonas Aeruginosa</i>	7	9.45	Miscellaneous, Intestinal
No pathogen grown	25	33.78	

Table 6: Antibiotic sensitivity of the isolated organisms.

Name of the organisms	Amikacin	Ciprofloxacin	Gentamycin	Cefotaxime	Amoxicillin	Clavulanic acid	Imipenem	Cephalexin	Erythromycin
<i>Pseudomonas</i>	S	S	S	R	R	R	S	R	S
<i>E. Coli</i>	S	S	S	R	R	R	R	S	S
<i>Klebsiella</i>	S	S	S	R	R	R	S	R	R
<i>Proteus</i>	S	S	R	S	S	R	R	R	R
<i>S. Aureus</i>	S	R	S	S	S	S	R	R	R

Table 7: Post-operative hospital stays.

Post-op stays (days)	Infected cases	Percentage of patients infected (%)
0 to 2	0	0.00
3 to 4	0	0.00
5 to 6	33	44.59
>6	41	55.40
Total	74	
Mean±SD	8.5±4.96	3.43±1.98

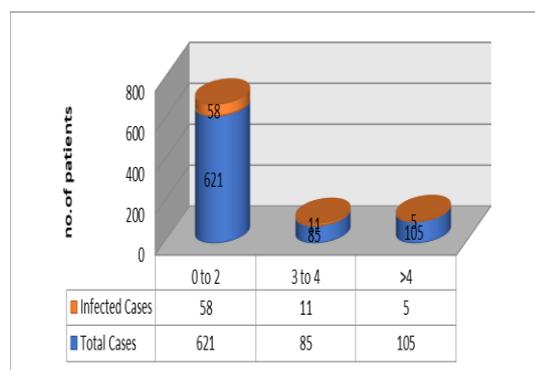


Figure 1: Preoperative stay in patients who developed SSI.

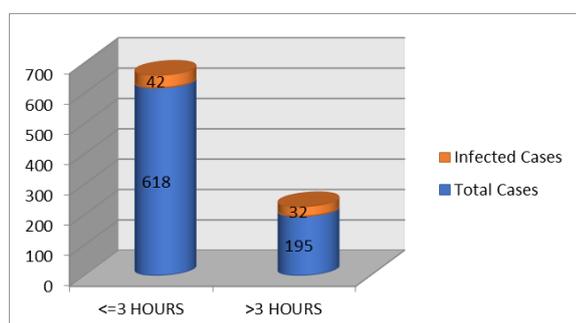


Figure 2: Correlation between duration of surgery and SSI.

According to the data analysed from our study the mean postoperative stay of patients who developed surgical site infections increased by 3.54 days when compared to rest of cases.

DISCUSSION

Surgical Site Infection (SSI) is a surgeon's worst nightmare. Although seemingly infrequent and almost never fatal, this complication increases morbidity, delays incisional healing, and thus produces high marginal care costs when calculated in aggregate, with an additional hospital stay of 6-14 days. Wasek et al reported a total loss of 12 patient-days for each episode of SSI in India in 1961-62.⁴ Though global estimates of SSI range from 0.5 to 15%, the Indian situation differed significantly, with estimates ranging from 2.5 to 41.9 percent.⁵ According to various reports, the incidence of SSIs is 4.75 percent in Haley et al, USA, 12.8 percent in Kaya et al, Turkey, 13 percent in Sangrasi et al, Pakistan, and 30.7% in Kamat et al, India.⁶⁻⁸ The average infection rate in this sample was 9.10%, which is similar to the incidence rates in other studies, which ranged from 2.5% to 41.9%. The variability in estimates is due to variations in patient population characteristics, underlying conditions, clinical practises, the extent of infection prevention measures, and the hospital climate. Poor nutritional status, ineffective infection-control measures, and poor diabetic control are all contributing factors. Intraoperative aseptic

measures, preoperative co morbidities of the patient, postoperative nutritional condition of the patient, postoperative nursing care, and hospital atmosphere all contribute to the variability in the occurrence. Surgical site infections were more common in emergency procedures (17.70%) than in elective surgeries (5.79%), and the incidence of clean, clean infected, and contaminated wounds was 5.48%, 8.71%, and 7.58%, respectively, in the current report. This is similar to the findings of Haley et al, who found a 2.1%, 3.3%, and 6.1% occurrence of clean, clean infected, and contaminated wounds, respectively.⁶ In their report, Kaya et al found that 3.4 percent of clean wounds had SSIs, 9.2% of clean infected wounds had SSIs, and 9.7% of contaminated wounds had SSIs.⁷ In contrast, Sangarasi et al found 5.4% infections in clean wounds, 12.3% in clean infected wounds, and 36.3% in contaminated wounds in their study.⁸ Kamat et al from India conducted a study that found 5.4% SSIs in clean wounds, 35.5% in clean infected wounds, and 77.8% in contaminated wounds.⁹

The high incidence of infections in emergency cases may be due to the time it took for the patient to arrive at the hospital after being treated elsewhere. Most of the cases taken to the hospital had developed peritonitis and a few had pre renal uraemia. SSIs are a leading cause of prolonged hospitalisation, and they have a direct impact on the morbidity and mortality risk of surgical patients, especially the elderly. McGarry et al found that older patients with *Staphylococcus aureus* SSIs had a three-fold higher mortality rate, longer post-operative hospital stays, and higher hospital charges than younger patients with *S. aureus* SSIs.¹⁰ Various groups of researchers have published conflicting findings regarding the relationship between rising age and the risk of SSI. For example, multiple studies found that getting older was linked to a higher risk of all types of postoperative infections; in several of these studies, getting older was linked to a higher risk of developing SSI.

The factors that led to the above results, however, are still up for debate. Some researchers believe that factors unrelated to age, such as a higher prevalence of co-morbid conditions, a higher severity of acute disease, and a reduced host response to bacterial invasion, are the real reasons why older patients tend to have a higher risk of SSI. To add to the confusion, some researchers have concluded that growing older is not an independent risk factor for SSI. However, the current research hypothesised that the incidence of SSIs increased with each decade rise in the patient's age, from 4.55 percent in children under the age of nine to 10.58% in people over 60. The length of surgery has a direct impact on the rate of surgical site infection and is used as an independent indicator for SSI assessment. It was 1.3 percent for surgeries that lasted less than an hour and 4.0 percent for those that lasted three hours or more. In the current report, infection rates were 6.7% for procedures lasting three hours or less and 16.41% for procedures lasting

more than three hours. Since the independent contribution of diabetes to SSI risk has not traditionally been measured after correcting for possible confounding factors, the contribution of diabetes to SSI risk is controversial. Preliminary results from a study of patients who underwent coronary artery bypass graft surgery revealed a connection between rising HbA1c levels and higher SSI rates. Increased glucose levels (>200 mg/dL) in the 48-hour postoperative cycle were also linked to an increased risk of SSI. More research is required to determine the effectiveness of perioperative blood glucose regulation as a wound infection prevention measure. In the current report, out of 813 patients operated, 252 were documented diabetics with regulated or poorly controlled blood sugar levels pre or post operatively, with 43 patients having post-operative wound infection at a rate of 17.06 percent, indicating that poorly controlled diabetes is associated with postoperative SSI. Nicotine use slows the healing of primary wounds and raises the risk of SSI. Current cigarette smoking was found to be an independent risk factor for sternal and/or mediastinal SSI after cardiac surgery in a broad prospective study.¹ Cigarette smoking has been confirmed as a significant SSI risk factor in another research.¹¹ In the current research, 138 of the 813 patients surveyed were active smokers, with 22 of them developing a postoperative surgical site infection at a rate of 15.94%, indicating that nicotine misuse has a substantial impact on surgical outcomes. In the current report, 75 of the 813 patients surveyed were steroid users, and 14 of them had postoperative surgical site infection at a rate of 18.67 percent, indicating that steroid use may play a role in the surgical outcome. Obese patients have a high body fat percentage, impaired blood circulation, and a slow rate of healing. In both sides of the tissue, the intra-operative incision is under a lot of strain. Extrusion and clamping are mechanical acts that can damage fat tissue. Obesity played a major role in the results of surgery in the current study, with 212 patients out of 813 surveyed being obese, with 38 patients having postoperative surgical site infection at a rate of 17.92 percent. According to our findings, patients with a longer preoperative stay in the hospital have a higher risk of infection, with the highest rate occurring within the first 3-4 days. The distribution of pathogens isolated from SSIs has not changed significantly between 1986 and 1996, according to data from the NNIS (National nosocomial surveillance system). In the present study gram positive organisms dominated among the isolated pathogenic organisms, with *staphylococcus aureus* about 24.32% among the isolated organisms followed by *E. coli*-18.91 percentage, *Klebsiella* species- 9.45%, proteus species-4.05%, *Pseudomonas*-9.45% and no pathogens were isolated in about the 33.78% among infected patients.

Gram negative organisms were found to be more often responsible for wound infection than gram positive organisms in the current research, which included 74 cases of wound infection. The most common bacteria

isolated were *Staphylococcus species*, followed by *E. Coli*, *Klebsiella*, and *Proteus*, and finally the *Pseudomonas*.

Table 8: Comparison of the incidence of isolated pathogens.

Isolated organisms	NNIS system (%)		Present study (%)
	1986-1989	1990-1996	
<i>S. aureus</i>	17	20	24.32
<i>E. coli</i>	10	8	18.91
<i>Klebsiella</i>	3	3	9.45
<i>Proteus</i>	8	7	4.05
<i>Pseudomonas</i>	8	8	9.45
No pathogens grown	-	-	33.78

Surgical site infections were linked to longer hospital stays, which resulted in higher health-care costs and morbidity. The mean postoperative stay of patients who developed SSI increased by 3.54 days as compared to the rest of the cases, according to the data analysed from our report. Wound gaping (superficial or deep) was present in all 74 cases. Just 25% of the 74 cases healed with secondary intention, while the rest needed secondary suturing. The burst abdomen caused two cases: one of advanced stomach carcinoma for which palliative anterior gastrojejunostomy with jejunostomy was performed, and the other of duodenal perforation. Three patients developed incisional hernias: one in the Mc Burney's incision, where an appendectomy was performed, another in the upper midline scar, where a gastric perforation closure was performed, and a third case of ileal perforation, which resulted in advanced peritonitis and shock and was opened through the midline incision.

Surgical site infection patients are up to 60% more likely to spend time in an intensive care unit, 5 times more likely to be readmitted to the hospital, and 2 times more likely to die than patients who do not experience surgical site infection. Patients that experience SSIs have significantly higher health-care costs Bratzler et al.¹²

Limitations

The limitation of this study could be an underestimation of the prevalence of SSI because many of these infections occur after the patient has been discharged from hospital. Besides, the research is not supported with culture investigation, which is done by other studies, so that there might be underestimation or overestimation of the prevalence.

CONCLUSION

Active wound infection monitoring and accurate wound infection rate reporting are the best ways to reduce wound infection. Several techniques may be used to

prevent surgical site infection. Better preoperative preparation of the surgical site, sound infection control practise when performing operations, and adherence to principles of prophylactic antibiotic therapy may reduce the viable inoculum of bacteria in the wound. Modified surgical technique may reduce the risk of hematoma, tissue injury, and foreign bodies within the surgical site, which increase the risk of infection for a patient. Enhanced oxygen delivery, improved core body temperature regulation, and strict blood glucose control in surgical patients are all new fields that have the potential to minimise surgical site infection rates even further. While surgical site infections cannot be completely eliminated, lowering the infection rate to a low level can have major benefits in terms of lowering postoperative morbidity and mortality as well as reducing health-care resource waste.

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