Article published online: 2023-09-22



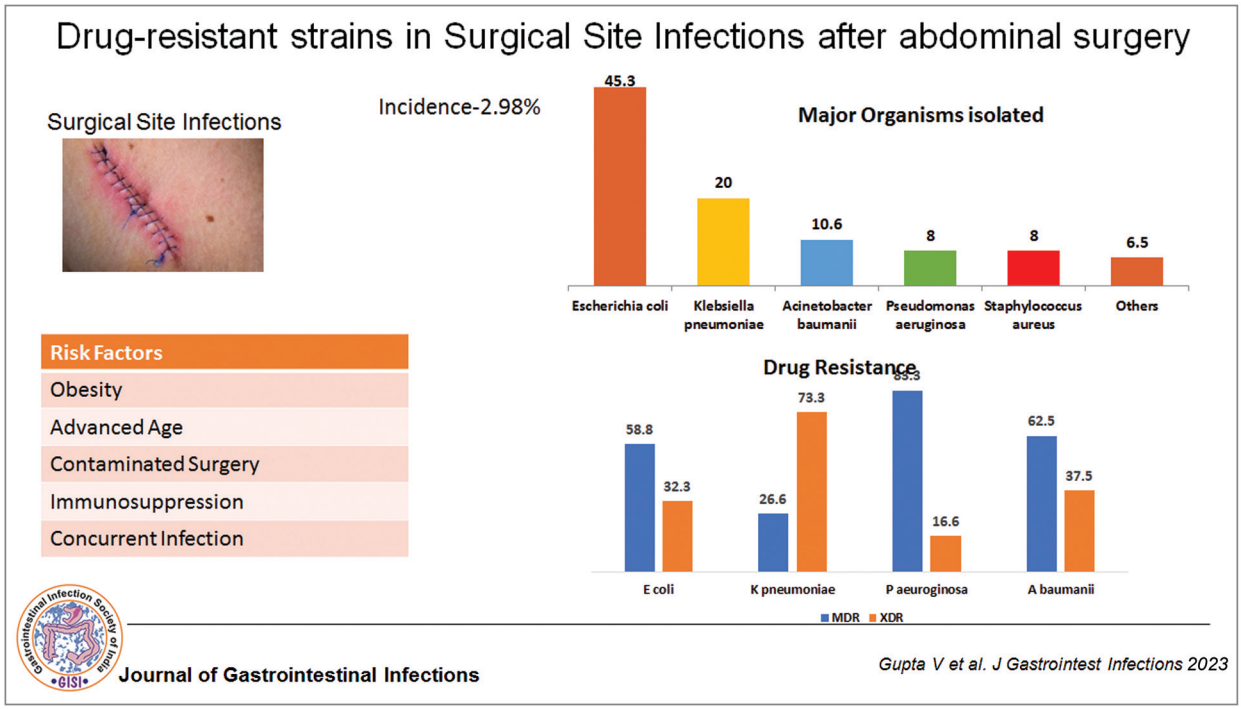
# Drug-Resistant Strains in Surgical Site Infections after Abdominal Surgery: A Prospective Study

Veenu Gupta[1] Prateet Kaur[2] Deepinder Chhina[1] Jaspal Singh[3] Rama Gupta[1]

[1] Department of Microbiology, Dayanand Medical College and Hospital, Ludhiana, Punjab, India
[2] Department of Microbiology, SMS Medical College and Hospital, Jaipur, Rajasthan, India
[3] Department of Surgery, Dayanand Medical College and Hospital, Ludhiana, Punjab, India

**Address for correspondence** Veenu Gupta, MBBS, MD, Department of Microbiology, Dayanand Medical College and Hospital, Ludhiana 141001, Punjab, India (e-mail: vsunilgupta@rediffmail.com).

J Gastrointest Infect 2022;12:106–111.




**received**
September 9, 2022
**first decision**
September 30, 2022
**accepted after revision**
November 7, 2022

**DOI** https://doi.org/10.1055/s-0042-1760423.
**ISSN** 2277-5862.



Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

## Abstract

**Background** Surgical site infection (SSI) is a common complication of abdominal surgery associated with substantial discomfort, morbidity, and cost.

**Objective** The aim of this study was to determine the incidence, risk factors, and antimicrobial susceptibility pattern of the associated bacterial causes of SSI in patients after abdominal surgery.

**Methods** A prospective study over a 1-year (Jan 2019–Dec 2019) period was conducted at a tertiary care institution in North India. Postoperative patients of abdominal surgeries with SSI were included in the study. Any exudate from the surgical site was collected aseptically and was processed as per standard operating procedures.

**Results** Of 2,509 patients with abdominal surgeries included in the study, 75 (2.98%, majority, i.e., 50 males) developed SSI. Common risk factors found to be associated with the development of SSI include contaminated surgical sites, obesity, age, immunosuppression, and simultaneous infection at some other sites, with a predominance (89.3%) of gram-negative isolates. *Escherichia coli* was the most frequently isolated organism (45.3%), followed by *Klebsiella spp*. (20%), *Acinetobacter spp.*(10.6%), *Pseudomonas spp.*, and *Staphylococcus aureus* (8% each). There was a very high (53%) prevalence of extended-spectrum β lactamase production among the *E. coli* and *Klebsiella* isolates. Additionally, 58.8% of the *E. coli* isolates were multidrug-resistant, whereas 73.3% of the *Klebsiella* isolates were exclusively drug resistant. All the *S. aureus* isolates were found to be methicillin-resistant.

**Conclusion** Although the SSI rates after abdominal surgery were low, multidrug-resistant gram-negative bacteria were predominant in SSI.



**Keywords**

- abdominal surgeries
- surgical site infection
- risk factors
- antimicrobila susceptibility
- multidrug-resistant


## Introduction

Surgical site infections (SSIs) or postoperative wound infections increase the hospital stay and many times complicate the recovery process. Centers for Disease Control and Prevention (CDC) has defined-"SSI is an infection occurring in an incisional site within 30 days after the procedure in which the incision was made or within 1 year if a prosthesis is implanted."[1] SSI has been classified as superficial/incisional (limited to the skin and subcutaneous tissue), deep incisional (involving the fascia and muscle), or organ space(involving a body cavity, e.g., an abdominal cavity in case of gastrointestinal surgery).[2,3] Deep tissue and organ space SSIs though less common but are associated with heightened morbidity/mortality and hence can further augment cost to the patient.[4–6]

SSIs frequently complicate the postoperative recovery in 10 to 30% of the patients undergoing gastrointestinal surgeries.[2,7–9] Patients' indigenous skin and gut flora are the primary sources responsible for SSIs in such patients.[10] Exogenous sources, such as noncompliance with aseptic precautions by the health care workers and improper sterilization of equipment, may contribute, though infrequently, to the development of SSIs.[11] SSI is associated with numerous patient-related risk factors, including advanced age, malnutrition, diabetes mellitus, smoking, morbid obesity, remote body site infection, and impaired immune system. The SSI records coming from different tertiary care hospitals are scanty. Hence, the data may not reveal the authentic extent of the problem. With this background, this study was planned to determine the incidence, concomitant risk factors, and antimicrobial susceptibility pattern of the associated bacterial agents of SSI in patients after abdominal surgery. The findings of the study will also help devise a strategy for infection control and to implement antibiotic stewardship.

## Patients and Methods

### Setting

This prospective study was conducted in the department of microbiology in coordination with the hospital infection control committee (HICC) and the surgery department of a tertiary care teaching hospital in Northern India after the initial approval from the institutional ethical committee. The study was performed for a period of 1 year (Jan 2019–Dec 2019) and included all the patients who underwent gastrointestinal surgery at our hospital. Patients who underwent liver transplantation surgeries were excluded from the study.

### Inclusion and Data Collection

Necessary information/data was gathered from hospital records (records of the surgery department and SSI Performa filled by the infection control nurses under the supervision of HICC). The data was also collected on the associated risk factors with SSI, which included age, gender, obesity, infection/concurrent infection at a distant site, immunosuppression, immobilization, diabetes, smoking, vascular disease, prolonged preoperative hospital stay, and classification of surgical incision. Surgical incision was classified as clean,

clean-contaminated, contaminated, or dirty/infected as per criteria laid down by CDC.[7]

### Follow-Up

After surgery, a daily assessment of the patient was done during hospitalization. The incision site was regularly examined by the consultant surgeon. The criteria developed by the CDC and the National Nosocomial Infections Surveillance System were used to diagnose SSI. "Wound infection was diagnosed if any one of the following criteria were fulfilled: serous or nonpurulent discharge from the wound, pus discharge from the wound, serous or nonpurulent discharge from the wound with signs of inflammation (edema, redness, warmth, raised local temperature, fever more than 38°C, tenderness, induration) and wound deliberately opened up by the surgeon due to localized collection (serous/purulent)."[1] Any exudate from the surgical site was collected aseptically and was processed as per standard operating procedures. Characterization of bacterial isolates (identification, antibiotic susceptibility profile, multidrug-resistant [MDR], exclusively drug resistant [XDR], extended-spectrum β lactamase [ESBL], metallo β lactamase, AmpC β lactamase production, methicillin, and vancomycin resistance) was done per National Committee for Clinical Laboratory Standards (NCCLS) guidelines. All the patients who underwent abdominal surgeries were followed up for 1-month duration for the development of SSIs post-discharge of the patients.

## Results

### Patients and SSI

A total of 2,509 patients with abdominal surgeries were included in the study. ►**Table 1** depicts the number and type of abdominal surgeries and the number of patients who developed SSI in each category. The surgeries performed during this period included cholecystectomies (975/2,509, 39%), followed by laparotomy (508/2,509, 20.2%), fistulectomy (380/2,509, 15.1%), ileostomy/pancreatic necrosectomy (271/2,509, 10.8%), appendicectomy (192/2,509, 7.6%), hemicolectomy (84/2,509, 3.35%) splenectomy (24/2,509, 0.96%), and liver resection (12/2,509, 0.48%). The incidence of SSI was found to be highest in hemicolectomy and liver resection surgeries, 8.33% each. This was followed by appendicectomy (5.21%), laparotomy (4.33%), splenectomy (4.17%), and ileostomy/ pancreatic necrosectomy (4.06%) with an overall incidence of 2.98% (75/2509). The rate of SSIs was found to increase along the spectrum from clean (0.08%), clean-contaminated (0.5%), dirty wound types (0.5%), and contaminated (1.9%), as per the criteria laid down by CDC.

### Risk Factors for SSI

Male gender was found to be associated with an increased risk of SSI as out of the 75 patients identified with SSI, the majority (50/75, 66.7%) were males. Another host demographic risk factor identified was the advanced age of the patient undergoing surgery, as many patients were greater than or equal to 50 years old (37/75, 49.3%). However, smoking was not associated with an increased risk of SSI (nonsmokers: 73/75, 97.4%). A total of 72 patients who developed SSI (96%) had a fully independent functional status, whereas 3 (4%) were immobile and required nursing care. Only three of the patients (4%) had diabetes mellitus. Other important risk factors identified were infected surgical site/concurrent infection at a distant site/sepsis (20/ 75, 26.7%) and obesity (15/75, 20%). Approximately 9.3% (7/75) had immunosuppression, and 2.6% of the patients had vascular disease.

### Bacteriology of SSI

All 75 patients diagnosed with SSI revealed growth of one or the other organism from the pus discharge taken from the surgical site wound with the predominance of gram-negative organisms (89.3%). *Escherichia coli* was found to be the most frequent isolate (45.3%), followed by *Klebsiella* spp (20%), *Acinetobacter spp*(8%) and *Pseudomonas* (8%; ►**Fig. 1**). ►**Fig. 2** depicts the antibiotic resistance profile (%) of predominant gram-negative isolates in SSIs. All the isolates were found to be highly resistant to most of the antibiotics tested; however, *Klebsiella* and *Acinetobacter* were relatively more resistant. In the case of *E. coli*, resistance to commonly used antibiotics ranged from 11.7% (tigecycline) to 91.1%

**Table 1** Distribution of abdominal surgeries and surgical site infections (SSIs)

| Surgical procedure | No. of patients ($n = 2509$) | No. of (SSI) ($n = 75$) | Percentage (%) of SSI |
|---|---|---|---|
| Cholecystectomy | 975 | 17 | 1.74 |
| Appendicectomy | 192 | 10 | 5.21 |
| Laparotomy | 508 | 22 | 4.33 |
| Fistulectomy | 380 | 4 | 1.05 |
| Hepaticojejunostomy/gastrojejunostomy | 63 | 2 | 3.17 |
| Ileostomy/pancreatic necrosectomy | 271 | 11 | 4.06 |
| Hemicolectomy | 84 | 7 | 8.33 |
| Splenectomy | 24 | 1 | 4.17 |
| Liver resection | 12 | 1 | 8.33 |

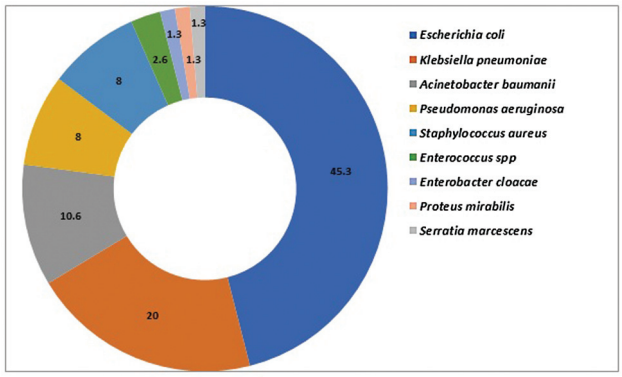



**Fig. 1** Distribution (%) of various isolates from infected surgical site ($n = 75$).

(ampicillin). However, the resistance to cephalosporins in the case of *E. coli* varied from 64.7% (cefuroxime) to 88.2% (cefotaxime). Additionally, 85.2% of the *E. coli* were resistant to fluoroquinolones. Carbapenems are relatively effective against *E. coli* with a resistance varying from 23.5%(imipenem) to 58.8% (ertapenem). Among *Acinetobacter* and *Klebsiella pneumoniae* isolates, resistance to third-generation cephalosporins varied from 75 to 100%. Conversely, *Pseudomonas aeruginosa* isolates showed relatively less resistance to commonly used antimicrobials. The prevalence of ESBL was found to be approximately 53% in the case of *E. coli* and *Klebsiella* isolates. In contrast, approximately 63% of the *Acinetobacter* species were found to be ESBL producers and only 16.6% of the *Pseudomonas* species were ESBL producers. However, a majority (83.3%) of *Pseudomonas* spp. were

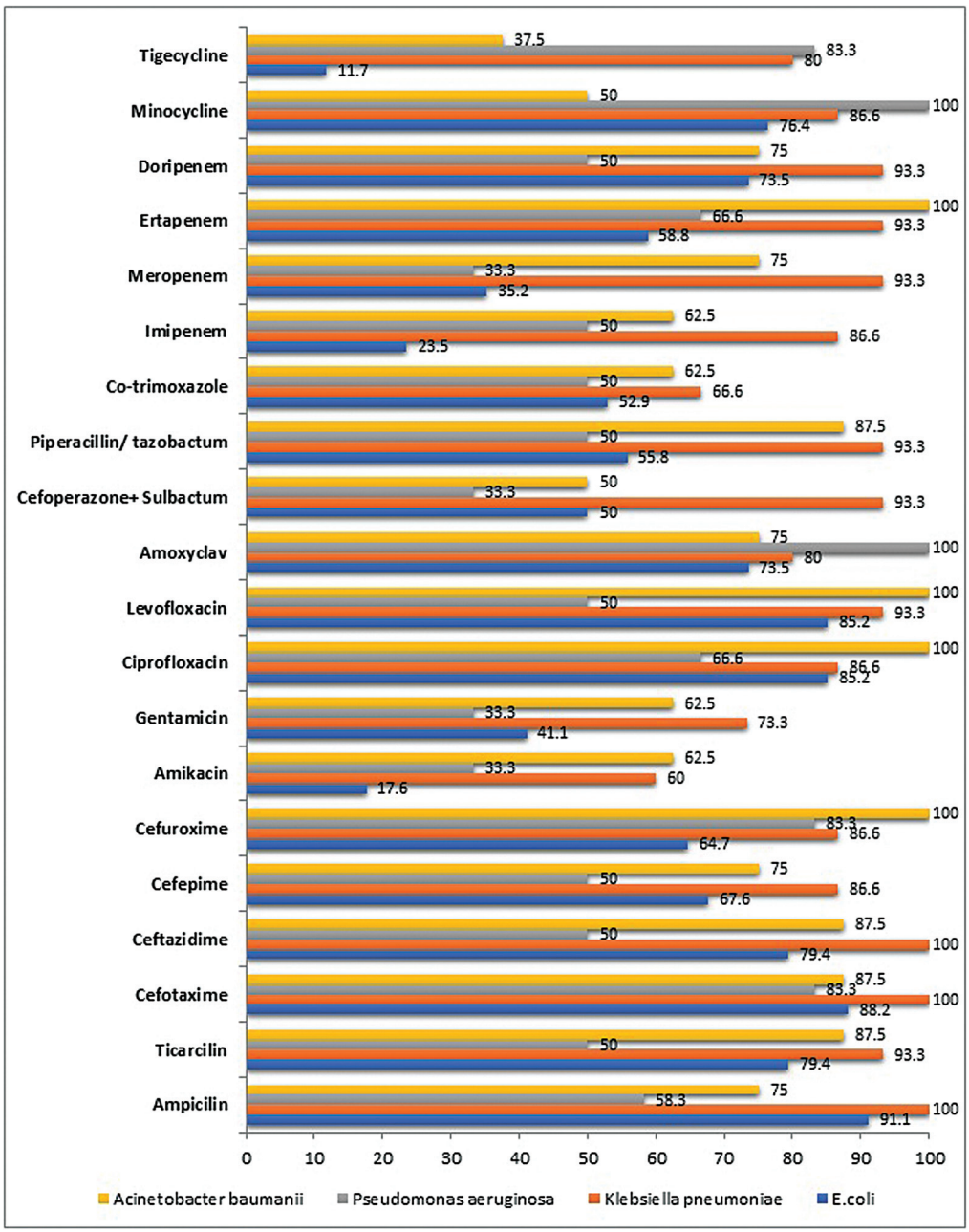



**Fig. 2** Antibiotic-resistant profile (%) of predominant gram-negative isolates in surgical site infections.

categorized as MDR, and the majority of *Klebsiella* isolates were XDR (73.3%; ►**Fig. 3**). Among the gram-positive organisms, *Staphylococcus aureus* remained the predominant pathogen. All *S. aureus* isolates were found to be resistant to ampicillin, penicillin, and methicillin (methicillin-resistant *Staphylococcus aureus* [MRSA]) and a few were found (12.5%) susceptible to amoxycillin–clavulanate combination. However, all the *S aureus* isolates from this study were found susceptible to linezolid, vancomycin, and teicoplanin.

## Discussion

In this prospective study, the results indicate SSI incidence of 2.98% in patients with abdominal surgeries, which is far less than many previous reports from India and other developing countries with an incidence of 20 to25%.[12,13] This may be due to the differences in surgical procedures, infection control practices, implementation of surgical prophylactic policies, antibiotic stewardship, and hospital environment. It has previously been demonstrated that stringent implementation of hospital infection control programs can drastically reduce infection by 35 to 50%.[14,15]

The contaminated surgical site, advanced age, and male gender have been reported to be the main risk factors for SSI, as has been highlighted in various studies.[12,13,16–18] The patients undergoing potentially dirty surgeries had an 8 to 10-fold higher risk for developing SSI. An increase in SSI rates along the scale from clean (0.08%), clean-contaminated (0.5%), dirty wound types (0.5%), and contaminated (1.9%) has also been observed in this study as well. In this study, 49.3% of the patients had an age more than or equal to 50 years with an average of $47.3 \pm 16.3$ years, and there was male preponderance. It has been previously reported that there is a decreased deposition of collagen during the healing process at the surgical site in aging men may be responsible for this gender bias.[19] Further, the data obtained on the obese patient as associated risk factors in this study is corroborated by Segal et al.[5] Use of immunosuppressive/steroids has been associated with the risk of SSI; however, the underlying condition requiring these therapeutics in itself predisposes to the SSIs.[20] Therefore, additional studies to elucidate the use of immunosuppressive/steroids as the risk factors and its confounders are required. As against a previous study, diabetes mellitus was not associated with SSIs.[12,13,21]

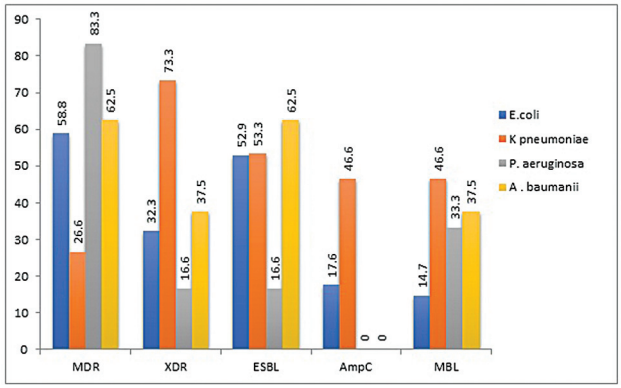



**Fig. 3** Distribution of multidrug resistant (MDR), extensively drug resistant (XDR), extended spectrum β lactamases (ESBL), AmpC β lactamases (AmpC), and metallo β lactamases (MBL) among the predominant gram-negative isolates.

The predominance of gram-negative organisms, specifically *E. coli*, in the development of SSIs in the patient with abdominal surgeries has already been reported in many studies,[22–26] although few other studies have observed *K. pneumoniae* as the commonest gram-negative bacteria from the SSIs.[27] All the *S. aureus* isolates were found to be resistant to ampicillin, penicillin, and methicillin (MRSA), and a few were found (12.5%) susceptible to amoxycillin–clavulanate combination. However, an incidence of MRSA in abdominal SSIs has been reported in the range varying from 14 to 56.5%.[28,29] Inefficacy of penicillin in *S. aureus* isolates has been reported in previous studies as well.[23] However, *S. aureus* isolates from this study did not show any resistance toward linezolid, vancomycin, and teicoplanin. This corroborates with other studies as well.[30]

A very high level of resistance to most of the antimicrobials tested (as per the recommendations of NCCLS) among the gram-negative isolates, which is in line with previous studies (23–25, 28, 32). The level of resistance to quinolones was 85.2 to 93.3% in members of the family *Enterobacteriaceae*, whereas *Acinetobacter* species showed absolute resistance to fluoroquinolones. On the contrary, *Pseudomonas* species were relatively susceptible to this group of antibiotics. We observed very high levels of acquired resistance to third-generation cephalosporins, among gram-negative bacteria, with most of *E. coli* and *K. pneumoniae* being ESBL producers. These findings are supported by recent studies that show a very high proportion of ESBL-producing isolates.[24,31] Further, carbapenems and minocycline were found to be more effective against gram-negative isolates in this study. In addition to the high rate of resistance to individual antibiotics, 100% of the gram-negative isolates were either MDR or XDR except for *E. coli* (90%), which is substantially higher than the previous reports.[27,31]

Although the study included a large number (2,509) of patients with abdominal surgeries and out of these only 75 patients developed SSIs. However, the risk factors were studied only in patients with SSIs. No comparison of these risk factors was made with patients who did not develop SSIs. Hence, data could not be tested against a null hypothesis.

## Conclusion

The overall SSI rate in patients undergoing abdominal surgeries in our hospital was comparatively low as compared with other Indian hospitals as well as other developing countries, indicating that a satisfactory hospital infection control program, antibiotic stewardship, and surgical prophylaxis were in place in our hospital. However, in view of the predominance of MDR gram-negative bacteria and MRSA, prophylactic strategies need to be re-evaluated to improve outcomes and minimize the emergence of antimicrobial resistance. There is a further need to improvise the implementation of antibiotic stewardship programs based on hospital infection surveillance data.

Ethical Statement
Not applicable.

Author Contributions
All authors contributed equally to the article.

Data Availability Statement
There is no data associated with this work.

Funding
None.

Conflict of Interest
None declared.

Acknowledgments
None.

## References

1 Horan TC, Gaynes RP, 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(10):606–608
2 Barie PS, Wilson SE. Impact of evolving epidemiology on treatments for complicated skin and skin structure infections: the surgical perspective. J Am Coll Surg 2015;220(01): 105–116.e6
3 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(05):309–332
4 Anderson DJ, Chen LF, Sexton DJ, Kaye KS. Complex surgical site infections and the devilish details of risk adjustment: important implications for public reporting. Infect Control Hosp Epidemiol 2008;29(10):941–946
5 Segal CG, Waller DK, Tilley B, Piller L, Bilimoria K. An evaluation of differences in risk factors for individual types of surgical site infections after colon surgery. Surgery 2014;156(05): 1253–1260
6 Ho VP, Stein SL, Trencheva K, et al. Differing risk factors for incisional and organ/space surgical site infections following abdominal colorectal surgery. Dis Colon Rectum 2011;54(07): 818–825
7 Azoury S, Farrow N, Hu Q, et al. Postoperative abdominal wound infection-epidemiology, risk factors, identification, and management. Chron Wound Care Manage Res 2015;22(02):137–148
8 Stevens DL, Bisno AL, Chambers HF, et al. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the Infectious Diseases Society of America. Clin Infect Dis 2014;59(02):10–52
9 Khuri SF, Henderson WG, DePalma RG, Mosca C, Healey NA, Kumbhani DJParticipants in the VA National Surgical Quality Improvement Program. Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. Ann Surg 2005;242(03):326–341, discussion 341–343
10 Altemeier WA, Culbertson WR, Hummel RP. Surgical considerations of endogenous infections–sources, types, and methods of control. Surg Clin North Am 1968;48(01):227–240
11 Anderson DJ. Surgical site infections. Infect Dis Clin North Am 2011;25(01):135–153
12 Aga E, Keinan-Boker L, Eithan A, Mais T, Rabinovich A, Nassar F. Surgical site infections after abdominal surgery: incidence and risk factors. A prospective cohort study. Infect Dis (Lond) 2015;47 (11):761–767
13 Giri S, Kandel BP, Pant S, Lakhey PJ, Singh YP, Vaidya P. Risk factors for surgical site infections in abdominal surgery: a study in Nepal. Surg Infect (Larchmt) 2013;14(03):313–318
14 Brandt C, Sohr D, Behnke M, Daschner F, Rüden H, Gastmeier P. Reduction of surgical site infection rates associated with active surveillance. Infect Control Hosp Epidemiol 2006;27(12): 1347–1351
15 Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121(02):182–205
16 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(07):2258–2263
17 Offner PJ, Moore EE, Biffl WL. Male gender is a risk factor for major infections after surgery. Arch Surg 1999;134(09):935–938, discussion 938–940
18 Cohen B, Choi YJ, Hyman S, Furuya EY, Neidell M, Larson E. Gender differences in risk of bloodstream and surgical site infections. J Gen Intern Med 2013;28(10):1318–1325
19 Lenhardt R, Hopf HW, Marker E, et al. Perioperative collagen deposition in elderly and young men and women. Arch Surg 2000; 135(01):71–74
20 Malone DL, Genuit T, Tracy JK, Gannon C, Napolitano LM. Surgical site infections: reanalysis of risk factors. J Surg Res 2002;103(01): 89–95
21 Martin ET, Kaye KS, Knott C, et al. Diabetes and risk of surgical site infection: a systematic review and meta-analysis. Infect Control Hosp Epidemiol 2016;37(01):88–99
22 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(04):1927–1934
23 Bansal D, Singh RR, Ded KS, et al. Bacteriological profile and antimicrobial susceptibility in surgical site infection in elective abdominal surgeries. Int Surg J 2016;3:1879–1882
24 Misha G, Chelkeba L, Melaku T. Bacterial profile and antimicrobial susceptibility patterns of isolates among patients diagnosed with surgical site infection at a tertiary teaching hospital in Ethiopia: a prospective cohort study. Ann Clin Microbiol Antimicrob 2021;20 (01):33
25 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
26 Jain BK, Banerjee M. Surgical site infections and its risk factors in orthopaedics: a prospective study in teaching hospital of central India. IJRM 2013;2:110–113
27 Ramesh A, Dharini R. Surgical site infection in a teaching hospital. Clinico microbiological and epidemiological profile. Int J Biol Med Res 2012;3:2050–2053
28 Kono K, Arakawa K. Methicillin-resistant Staphylococcus aureus (MRSA) isolated in clinics and hospitals in the Fukuoka city area. J Hosp Infect 1995;29(04):265–273
29 Udaya Shankar C, Harish BN, Umesh Kumar PM, Navaneeth BV. Prevalence of methicillin resistant *Staphylococcus aureus* in JIPMER hospital - a preliminary report. Indian J Med Microbiol 1997;15:137–138
30 Giacometti A, Cirioni O, Schimizzi AM, et al. Epidemiology and microbiology of surgical wound infections. J Clin Microbiol 2000; 38(02):918–922
31 Manyahi J, Matee MI, Majigo M, Moyo S, Mshana SE, Lyamuya EF. Predominance of multi-drug resistant bacterial pathogens causing surgical site infections in Muhimbili National Hospital, Tanzania. BMC Res Notes 2014;7(01):500