Received: 3 February 2023 | Revised: 14 February 2023 | Accepted: 16 February 2023

DOI: 10.1111/iwj.14137

ORIGINAL ARTICLE

IWJ WILEY

Incidence rate and risk factors of surgical wound infection in general surgery patients: A cross-sectional study

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Abstract

Hospital-acquired infections (HAIs) are considered a major challenge in health care systems. One of the main HAIs, playing an important role in increased morbidity and mortality, is surgical wound infection. Therefore, this study aimed to determine the incidence rate and risk factors of surgical wound infection in general surgery patients. This cross-sectional study was performed on 506 patients undergoing general surgery at Razi hospital in Rasht from 2019 to 2020. Bacterial isolates, antibiotic susceptibility pattern, antibiotic administration, and its type, operation duration and shift, the urgency of surgery, people involved in changing dressings, length of hospitalisation, and levels of haemoglobin, albumin, and white blood cells after surgery were assessed. The frequency of surgical wound infection and its association with patient characteristics and laboratory results were evaluated. The SPSS software package (version 16.0, SPSS Inc., Chicago, IL, USA) was used to analyse the data. Quantitative and qualitative variables were presented using mean (standard deviation) and number (percentage). The Shapiro–Wilk test was used to evaluate the normality of the data in this study. The data did not have a normal distribution. Hence, χ^2 and Fisher's exact tests were used to evaluate the relationship between variables. Surgical wound infection occurred in 4.7% (24 cases) of patients with a mean age of 59.34 (SD = 14.61) years. Preoperative (>3 days) and postoperative (>7 days) hospitalisation, history of immunodeficiency ($P < 0.001$), and interns responsible for changing dressings ($P = 0.021$) were associated with surgical wound infection incidence. About 9.5% and 4.4% of surgical wound infection cases were significantly associated with pre- and postoperative antibiotic use. Gram-positive cocci were the most prevalent strains isolated from 24 surgical wound infection cases (15/24, 62.5%). Among these, *Staphylococcus aureus* was the predominant species, followed by coagulase-negative staphylococci. In addition, the most common Gram-negative isolates identified were *Escherichia coli* bacteria. Overall, administration of antibiotics, emergency surgery, surgery duration, and levels of white blood cells and creatinine were identified as surgical wound infection-associated risk factors. Identifying important risk factors could help control or prevent surgical wound infections.

KEYWORDS

general surgery, incidence, risk factors, surgical wound infection

Key Message

- Surgical wound infection occurred in 4.7% (24 cases) of patients with a mean age of 59.34 (SD = 14.61) years.
- Preoperative (>3 days) and postoperative (>7 days) hospitalization, history of immunodeficiency ($P < 0.001$), and interns responsible for changing dressings ($P = 0.021$) were associated with surgical wound infection incidence.
- About 9.5% and 4.4% of surgical wound infection cases were significantly associated with pre- and post-operative antibiotic use. Gram-positive cocci were the most prevalent strains isolated from 24 surgical wound infection cases (15/24, 62.5%).
- Among which, *Staphylococcus aureus* was the predominant species, followed by coagulase-negative staphylococci. Also, the most common Gram-negative isolates identified were *Escherichia coli* bacteria.
- Overall, administration of antibiotics, emergency surgery, surgery duration, and levels of white blood cells and creatinine were identified as surgical wound infection associated risk factors. Identifying important risk factors could help control or prevent surgical wound infections.

1 | INTRODUCTION

Hospital-acquired infections (HAIs) are considered a major global challenge in health care systems, which could play an important role in increased mortality, adverse conditions, length of hospitalisation, treatment costs, misuse of antibiotics, and antibiotic resistance.[1] Infections that arise within 48–72 h of admission or up to 6 weeks following discharge are referred to as HAIs.[2] Besides, infections developed through direct contact with hospital staff or neonatal infections are also considered as HAIs.[3] According to reports, the prevalence of HAIs ranged from 5.7% to 17% in 2019, and the most common HAIs were surgical wound infections, urinary tract infections (UTIs), and pneumonia, accounting for 64% of all HAIs.[4] In addition, surgical wound infections and device-related infections were reported to account for 21.8 and 25.6% of all HAIs in 2014.[5] In a meta-analysis of research published in Iran in 2018, the most common HAIs were bloodstream infections (BSIs) (9%), pneumonia (7.1%), surgical wound infections (4.4%), and UTIs (3.1%).[6] Based on a report in 2020, the most common HAIs were related to ventilator-associated events (20.28%), surgical wound infections (19.73%), UTIs (26.83%), and BSIs (13.51%).[7]

The number of surgical procedures performed daily is currently increasing worldwide. On the other hand, patients undergoing surgery are often with several comorbidities. The incidence of surgical wound infections is still a serious problem, especially in middle- and low-income countries.[8] Surgical wound infections lead to prolonged hospital stays and an increase in HAI-related morbidity and mortality.[9] In a study by Colás-Ruiz et al. (2018), the most common microorganisms causing surgical wound infections were *Escherichia coli* (42.3%), *Enterococcus faecalis* (15.4%), and *Proteus mirabilis* (11.5%).[10] Surgical wound infection is one of the most commonly reported HAIs in Europe, accounting for 19.6% of all HAI cases.[11] In Africa, the prevalence of surgical wound infection ranges from 6.8% to 26%.[12] In Ethiopia, the prevalence of surgical wound infection among postoperative patients is still high (12.3%). Surgical wound infection risk factors include previous surgery, a clean-infected incision, and a preoperative hospital stay of more than 7 days.[13] Surgical wound infections after colorectal surgery remain a significant problem because of their negative clinical outcomes.[14,15] Variables related to the patient and the surgical process/procedure enhance the risk of surgical wound infections.[16] Surgical wound infection is an infection that develops at or near a surgical incision within 30 days after surgery, or up to 1 year in implant recipients.[17] The risk factors associated with surgical wound infections include hospital, patient, and surgery-related factors, which may play an important role in surgical wound infection occurrence.[18]

Surgical wound infections could be caused by a variety of factors, and patients undergoing gastrointestinal procedures are at higher risk of developing bacterial infections. In a study by Hassan et al.,[19] the majority of surgical wound infection cases (86.8%) were discovered during hospitalisation. The treatment results always depend on the outcomes. Recent and existing treatments and strategies for surgical wound infection prevention include the administration of antibiotics before wound closure at the operation site, intravenous antimicrobial prophylaxis, improved hygiene, surgical aseptic practices, microbial screening, and decolonisation.[20,21]

2 | RESEARCH QUESTIONS

The study aimed to answer the following research questions:

- What is the incidence rate of surgical wound infection in general surgery patients?
- What are the risk factors of surgical wound infection in general surgery patients?

2.1 | Aim

Despite advances made in preventive measures, the prevention of surgical wound infection remains a concern. Identifying associated risk factors may enhance patients' recovery and treatment process. As a result of the lack of sufficient studies in this field, this study aimed to determine the incidence rate and risk factors of surgical wound infection in general surgery patients.

3 | METHODS

3.1 | Study design and subjects

In this cross-sectional study, all patients undergoing general surgery at Razi hospital in Rasht from 2019 to 2020 were studied. Inclusion criteria included all patients undergoing general surgery at Razi hospital in Rasht. Exclusion criteria were as follows: having an active infectious wound and a history of immunodeficiency disease (taking chemotherapy or immunosuppressive drugs).

3.2 | Ethical consideration

The present research was approved by the Guilan University of Medical Sciences (IR.GUMS.REC.1397.511). After obtaining permission from the hospital administration, the researchers visited the hospital. Sampling was performed in a private room and each medical record was evaluated separately by the researchers.

3.3 | Data collection

Laboratory parameters such as levels of haemoglobin, creatinine, albumin, and white blood cells were also recorded. Haemoglobin level and white blood cells were measured by a complete blood count test at Razi hospital using a Sysmex XK-21 N haematology analyser. Creatinine and albumin levels were measured by a Hitachi 717 autoanalyzer. The creatinine diagnostic kit belonging to Pars Company was used to measure creatinine levels in serum, plasma, and urine samples according to Jaffe's colorimetric method without removing proteins. The albumin colorimetric assay kit (Bromocresol green method) belonging to Bionik Company was used for the quantitative measurement of albumin manually and instrumentally. If there was a wound at or around the surgery site, the type of wound was determined as clean, clean-infected, contaminated, and dirty. In the case of non-cooperation of patients because of decreased level of consciousness, intubation, memory disorders, and other disorders related to consciousness, patients' companions helped us. Moreover, bacterial isolates and their antibiotic susceptibility patterns were assessed. After surgery, patients were monitored for possible infections. Patients were assessed in terms of postoperative antibiotic use, type of antibiotics used, operation duration, operation shift (morning/evening/night), type of emergency or elective operation, people involved in changing dressings (nurse/intern), length of hospitalisation, and levels of haemoglobin, albumin, and white blood cells after surgery. At the end of the study, the frequency of surgical wound infection (yes/no) and its association with patient characteristics and laboratory results were investigated.

3.4 | Statistical analysis

The SPSS software package (version 16.0, SPSS Inc., Chicago, IL, USA) was used to analyse the data. Quantitative and qualitative variables were presented using mean (standard deviation) and number (percentage). The Shapiro–Wilk test was used to evaluate the normality of the data in this study. The data did not have a normal

TABLE 1 Frequency distribution of surgical wound infection in terms of patient characteristics.

Variable	Level	Without surgical wound infection N	%	With surgical wound infection N	%	*P*-value
Age (year)	<18	4	100	–	–	0.999
	18–65	305	95.3	15	4.7	
	>65	173	95.1	9	4.9	
Gender	Male	286	95	15	5	0.758
	Female	196	95.6	9	4.4	
Weight	< 70	182	95.8	8	4.2	0.845
	70–100	298	94.9	16	5.1	
	>100	2	100	–	–	
Smoking	Yes	108	96.4	4	3.6	0.509
	No	374	94.9	20	5.1	
Alcohol	Yes	24	100	–	–	0.620
	No	458	95	24	5	
Narcotic	Yes	50	92.6	4	7.4	0.31
	No	431	95.6	20	4.4	
Non-surgical wound infection	Yes	28	87.5	4	12.5	0.057
	No	454	95.8	20	4.2	
Hospitalisation history	Yes	150	90.9	15	9.1	0.001*
	No	332	97.4	9	2.6	
Preoperative hospitalisation	<3 day	24	75	8	25	<0.001
	>3 day	458	96.6	16	3.4	
Postoperative hospitalisation	<7 day	432	99.5	2	5	<0.001
	>7 day	50	69.4	22	30.6	
Preoperative intensive care unit hospitalisation	yes	25	96.2	1	3.8	0.999
	No	457	95.2	23	4.8	
History of Immune system deficiency	Yes	63	75.9	20	24.1	<0.001
	No	419	99.1	4	9	
People involved in changing the dressing	Nurse	83	100	–	–	0.021*
	Intern	399	94.3	24	5.7	

*Significant at the level of .05.

distribution. Hence, χ^2 and Fisher's exact tests were used to evaluate the relationship between variables. A *P*-value <0.05 was considered significant.

4 | RESULTS

4.1 | Participant characteristics

As shown in Table 1, a total of 506 patients undergoing general surgery participated in this study. Among the participants, 59.49% were men. In addition, 22.22%, 4.74%, and 10.71% reported using cigarettes, alcohol, and narcotics, respectively. Among the patients, 6.32% had non-surgical wound infections. 67.39% of patients had no history of hospitalisation. The length of hospitalisation before surgery was more than 3 days in 93.68% of patients and the length of hospitalisation after surgery was less than 7 days in 85.77% of patients. Also, 5.14% of patients were hospitalised in intensive care unit before surgery and 16.40% of them reported a history of immune system deficiency.

4.2 | Incidence rate of surgical wound infection in general surgery patients

In this cross-sectional study, among 506 patients undergoing general surgery, surgical wound infection occurred in 24 cases (4.7%). According to the results reported in Table 1, a high percentage of patients with non-surgical wound infections developed surgical wound infections (12.5%).

4.3 | The most prevalent strains of surgical wound infection in general surgery patients

Gram-positive cocci were the most prevalent strains isolated from 24 surgical wound infection cases (15/24, 62.5%). Among these, *Staphylococcus aureus* was the predominant species isolated (8/15, 53.3%), followed by coagulase-negative staphylococci (7/15, 46.7%). In addition, the most common Gram-negative isolates identified were *E. coli* (6/9, 66.7%) and *Pseudomonas* species (3/9, 33.3%).

4.4 | Risk factors of surgical wound infection in general surgery patients

The incidence of surgical wound infection was significantly associated with the duration of pre-and postoperative hospitalisation. A high percentage of patients with a pre- and postoperative hospitalisation of more than 3 and 7 days developed surgical wound infections, respectively. In addition, the prevalence rate of surgical wound infection was significantly higher in patients with a history of immunodeficiency ($P < 0.001$). Almost interns were responsible for changing dressings, and this group was significantly associated with the incidence of surgical wound infection ($P = 0.021$) (Table 1). Only 10 patients undergoing surgery were taking immunosuppressive drugs, and no surgical wound infection cases were found in this group of patients. There was a significant association between the incidence of surgical wound infection and preoperative antibiotic use ($P = 0.006$), postoperative antibiotic use ($P = 0.039$), and type of preoperative antibiotics ($P = 0.014$). About 9.5% of surgical wound infection cases were associated with preoperative antibiotic use, and 4.4% were related to postoperative antibiotic use (Table 2). In laparotomy, the incidence of surgical wound infection was higher than in other types of surgery. The urgent surgery (emergency) was significantly associated with surgical wound infection incidence (Table 3). Besides, the incidence of surgical wound infection was assessed according to preoperative laboratory factors, and the levels of white blood cells and creatinine were found to be significantly associated with surgical wound infection incidence ($P = 0.001$) (Table 4).

4.5 | Antibiotic resistance profile of bacterial isolates from surgical wound infections

According to antibiotic susceptibility patterns, *S. aureus* isolates showed high resistance toward clindamycin (62.5%), tetracycline (62.5%), and cotrimoxazole (62.5%), while coagulase-negative staphylococci showed resistance toward erythromycin (57.1%) and cotrimoxazole (57.1%). Among Gram-negative isolates, 66.7% of *E. coli* isolates were resistant to cotrimoxazole, ampicillin, ceftriaxone, and ciprofloxacin, while *Pseudomonas* species showed high resistance against cefepime (66.7%), ceftriaxone (66.7%), ciprofloxacin (66.7%), cefuroxime (66.7%), and ceftazidime (66.7%) (Table 5).

5 | DISCUSSION

Surgical wound infection is one of the most common infections, which is considered a global challenge in health care systems as it currently accounts for 19.73% of all HAIs. Although surgical wound infections have increased in recent years, there are no exact reports of their incidence. A study in 2018 reported an overall incidence rate of 11.9% for surgical wound infection in rectal surgery.[10] In the present study, the prevalence rate of surgical wound infections was estimated to be 4.7%, which is consistent with the findings of other studies.[16,19,22-25]

As a result of concerns about the increasing prevalence of surgical wound infection, recent studies have focused on its incidence and associated risk factors. Identifying associated risk factors may enhance patients' treatment and recovery process. This study's results showed that antibiotic use, laparotomy, emergency surgery of more than 2.5 h, white blood cells >11 000 cell/μL, creatinine level < 0.8 mL/min, duration of hospitalisation, history of immunodeficiency, and individuals responsible for changing dressings were surgical wound infection associated risk factors, these findings are consistent with the results of other studies.[19] The current study findings are in line with those of other recent investigations.[14,23] Early detection of surgical wound infection and identification of related risk factors is important to provide timely therapeutic and preventive interventions.[14] In a study by Carvalho et al.,[26] factors such as length of hospital stay more than 24 h before surgery, long duration of operation, and common microorganisms (*S. aureus* and *E. coli*) were introduced as surgical wound infection-associated risk factors. In the present study, the duration of hospitalisation and duration of operation were identified as surgical wound infection risk factors. A high percentage of patients with a hospital stay of more than

TABLE 2 Frequency distribution of surgical wound infection in terms of drug or antibiotic use.

		Without surgical wound infection		With surgical wound infection		
Variable	**Level**	***N***	**%**	***N***	**%**	***P*-value**
Immunosuppressed drugs	Yes	10	100	–	–	0.999
	No	472	95.2	24	4.8	
Preoperative antibiotic injection	Yes	105	90.5	11	9.5	0.006*
	No	377	96.7	13	3.3	
Type of preoperative antibiotics	Ceftriaxone	25	86.2	4	13.8	0.014*
	Cefazolin	42	100	–	–	
	Others	38	84.4	7	15.6	
Postoperative antibiotic injection	Yes	477	95.6	22	4.4	0.039*
	No	5	71.4	2	28.6	
Type of postoperative antibiotics	Ciprofloxacin	343	95.8	15	4.2	0.256
	Metronidazole	55	94.8	3	5.2	
	Cefixime	42	97.7	1	2.3	
	Clindamycin	17	89.5	2	10.5	
	Clarithromycin	3	75	1	25	
	Amoxicillin	1	100	–	–	
	Cephalexin	16	100	–	–	

*Significant at the level of .05.

TABLE 3 Frequency distribution of surgical wound infection in terms of surgical factors.

		Without surgical wound infection ($N = 482$)		With surgical wound infection ($N = 24$)		
Variable	**Level**	***N***	**%**	***N***	**%**	***P*-value**
Urgency of surgery	Emergency	31	86.1	5	13.9	0.022*
	Elective	451	96	19	4	
Surgery duration	< 2.5 h	425	96.4	16	3.6	0.007*
	>2.5 h	57	87.7	8	12.3	
Operation shift	Morning	223	95.9	10	4.1	0.776
	Evening	220	94.8	12	5.2	
	Night	29	93.5	2	6.5	
Type of surgery	Open-cholecystectomy	51	96.2	2	3.8	0.057
	Laparoscopic cholecystectomy	95	96.9	3	3.1	
	Laparotomy	54	85.7	9	14.3	
	Body amputation	23	95.8	1	4.2	
	Gastrectomy	51	96.2	2	3.8	
	Herniorrhaphy	41	95.3	2	4.7	
	Hemorrhoidectomy, fistulectomy, preanal abscess	45	97.8	1	2.2	
	Coronary surgery	56	100	–	–	
	Debridement tissue	32	97	1	3	
	Others	75	97.4	2	2.6	

*Significant at the level of .05.

TABLE 4 Frequency distribution of surgical wound infection in terms of laboratory results.

Variable	Level	Without surgical wound infection (*N* = 482)		With surgical wound infection (*N* = 24)		*P*-value
		N	%	*N*	%	
Haemoglobin level (g/dL)	<12	263	94.3	16	5.7	0.245
	12–17.5	219	96.5	8	3.5	
White blood cell count (cell/μL)	<4000	29	100	–	–	0.001*
	4000–11 000	423	97	13	3	
	>11 000	30	73.2	11	26.8	
Creatinine level (mL/min)	<0.8	59	85.5	10	14.5	0.001*
	0.8–1.3	376	96.9	12	3.1	
	>1.3	47	95.9	2	4.1	
Albumin (g/dL)	<3.5	42	100	–	–	0.247
	3.5–5.5	440	94.8	24	5.2	

*Significant at the level of .05.

TABLE 5 Antibiotic resistance profile of bacterial isolates from surgical sites.

Antibiotics	*Staphylococcus aureus* (*N* = 8)	Coagulase-negative staphylococci (*N* = 7)	*Escherichia coli* (*N* = 6)	Pseudomonas species (*N* = 3)
Erythromycin	4 (50)	4 (57.1)	ND	ND
Clindamycin	5 (62.5)	3(42.9)	ND	ND
Tetracycline	5 (62.5)	3 (42.9)	ND	ND
Cotrimoxazole	5 (62.5)	4 (57.1)	4 (66.7)	ND
Cefoxitin	3 (37.5)	3 (42.9)	ND	ND
Gentamicin	4 (50)	3 (42.9)	2 (33.3)	1 (33.3)
Ampicillin	ND	ND	4 (66.7)	ND
Cefepime	ND	ND	3 (50)	2 (66.7)
Ceftazidime	ND	ND	2 (33.3)	2 (66.7)
Ceftriaxone	ND	ND	4 (66.7)	2 (66.7)
Ciprofloxacin	3 (37.5)	4 (57.1)	4 (66.7)	2 (66.7)
Cefuroxime	ND	ND	3 (50)	2 (66.7)
Meropenem	ND	ND	1 (16.7)	1 (33.3)

Abbreviation: ND, not done.

7 days postoperation developed wound infection because of surgery. According to some studies results, surgeries lasting for more than 3 h could also cause wound infection.[27] Prolonged surgery may increase wound contact with bacteria, increase the extent of tissue trauma, and decrease antibiotic levels. In the present study, the duration of surgery in most patients was less than 2.5 h, and the number of wound infections was relatively low. The association between the incidence of surgical wound infection and the long duration of operation was also in line with a systematic review by Koro et al.[28] It has been proven that procedures lasting for more than 3 h result in an 80% increase in surgical wound infection incidence.[12] Overhandling of wound margins and contact with contaminated fluids coming out of the surgical field are both possible outcomes of the prolonged operation. Studies have shown that the incidence rate of surgical wound infections is higher in patients with colorectal complaints, undergoing exploratory laparotomy compared with all other surgical procedures so 12.30% of patients with colorectal complaints suffer from surgical wound infections. The incidence rate of surgical wound infection has been reported to be 5%–45% in exploratory laparotomy.[29,30]

According to susceptibility testing results, cefoxitin and gentamicin were the most effective antibiotics against Gram-positive isolates, whereas the most effective antibiotics against Gram-negative isolates were meropenem and gentamicin. The emergence of surgical wound infection leads to a significant increase in antibiotic use and the need for reoperation.[31] In this study, there was a significant relationship between wound infection and antibiotic use so in patients taking postoperative antibiotics, the prevalence of wound infection was lower. Khan et al. (2020) provided an overview of the incidence, associated risk factors, and treatment outcomes of surgical wound infections. They found that preoperative patient evaluation through various available parameters is necessary; in particular, the rational use of antibiotics may reduce the risk of misuse.[30] In a study by Kashi et al.[32,33] One of the reasons for the difference in findings could be the difference in patient preparation before surgery.

6 | LIMITATIONS

Patients whose information was not available were excluded from the study. The likelihood of infections is influenced by a variety of factors. While data are kept on a wide range of factors, it can be challenging to make sure that all potential predictors of infection are documented. Also, this study was conducted in a medical centre, which can reduce the generalisability of the results.

6.1 | Recommendations for future research

Future research on the risk factors of surgical wound infection is advised to include more cohort and prospective studies. In addition, it is advised that experimental research be performed in connection with efficient measures for reducing surgical wound infection.

6.2 | Implications for clinical practice

The findings of this study assist health care professionals to identify the risk factors of surgical wound infection and seek to reduce those that are modifiable.

7 | CONCLUSION

In sum, based on the findings of this study, the incidence of wound infection in the studied patients was not high. Overall, administration of antibiotics, emergency surgery, surgery duration, and levels of white blood cells and creatinine were identified as surgical wound infection-associated risk factors. Identifying important risk factors could help control surgical wound infections by planned measures. According to the results of this study, health care workers can know the risk factors of surgical wound infection and try to reduce modifiable factors.

AUTHOR CONTRIBUTIONS

Mohammad Taghi Ashoobi, Mohammad Reza Asgary, Milad Sarafi, Narjes Fathalipour, Amir Pirooz, Zakiyeh Jafaryparvar, Elahe Rafiei, Mohaya Farzin, Pirouz Samidoust, and Mohammad Sadegh Esmaeili Delshad contributed in preparing this article.

FUNDING INFORMATION

The author(s) received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The datasets used during the current study are available from the corresponding author upon request.

ETHICS STATEMENT

All ethical principles are considered in this article. The Ethics Committee of Guilan University of Medical Sciences approved the study. Patients or their legal representative are not informed that their data were collected for research purposes in this observational study.

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How to cite this article: Ashoobi MT, Asgary MR, Sarafi M, et al. Incidence rate and risk factors of surgical wound infection in general surgery patients: A cross-sectional study. *Int Wound J*. 2023;20(7):2640-2648. doi:10.1111/iwj.14137