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Incidence Rate And Risk Factors Of Surgical Wound InfectionIn General Surgery Patients

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Abstract

Background: *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 (SWI).* ***This study aimed****: to determine the incidence rate and risk factors of SWI in general surgery patients.* ***Methods:*** *A cross-sectional study was performed on 506 patients undergoing general surgery at five hospitals in Jeddah from January to June 2023. 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 hospitalization, and levels of hemoglobin, albumin, and white blood cells after surgery were assessed. The frequency of SWI and its association with patient characteristics and laboratory results were evaluated. The SPSS software package (version 28.0) was used to analyze 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 no[1]t have a normal distribution. Hence,* χ^2 *and Fisher's exact tests were used to evaluate the relationship between variables.* ***Results:*** *SWI 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 SWI incidence. About 9.5% and 4.4% of SWI cases were significantly associated with pre- and postoperative antibiotic use. Gram-positive cocci were the most prevalent strains isolated from 24 SWI cases (15/24, 62.5%).* ***Conclusion:*** *Among these, Staphylococcus aureus was the predominant species, followed by coagulase-negative staphylococci. In addition, the most common Gram-*

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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 SWI associated risk factors. Identifying important risk factors could help control or prevent SWIs.

Keywords: *general surgery, incidence, risk factors, surgical wound infection*.

Introduction

Hospital-acquired infections (HAIs) are regarded as a significant worldwide health care system concern, since they may have a significant impact on treatment costs, duration of hospital stay, unfavorable circumstances, increased mortality, and antibiotic resistance [(1)]. HAIs are infections that appear 48–72 hours after admission or up to 6 weeks after discharge [(2)]. HAIs also include infections received from direct contact with hospital personnel and illnesses contracted from neonates [(3)]. Reports state that the frequency of healthcare-associated infections (HAIs) varied in 2019 from 5.7% to 17%. SWIs, urinary tract infections (UTIs), and pneumonia accounted for 64% of all HAIs [(4)].

Furthermore, it was stated that in 2014, SWIs and device-related infections accounted for 21.8 and 25.6% of all HAIs [(5)]. According to a meta-analysis of studies conducted in Iran in 2018, SWIs (4.4%), pneumonia (7.1%), bloodstream infections (9%), and urinary tract infections (UTIs) (3.1%) were the most prevalent HAIs [(6)]. Based on a report in 2020, the most common HAIs were related to ventilator-associated events (20.28%), SWIs (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 SWIs 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 Col´as-Ruiz et al., (2018) [(10)], the most common microorganisms causing SWIs were Escherichia coli (42.3%), Enterococcus faecalis (15.4%), and Proteus mirabilis (11.5%) [(10)]. SWI is one of the most commonly reported HAIs in Europe, accounting for 19.6% of all HAI cases [(11)]. In Africa, the prevalence of SWI ranges from 6.8% to 26% [(12)]. In Ethiopia, the prevalence of SWI among postoperative patients is still high (12.3%). SWI 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 enhances the risk of SWIs [(16)]. SWI 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 SWIs include hospital, patient, and surgery-related factors, which may play an important role in SWI occurrence [(18)]. Surgical wound infections could be produced 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., (2020) [(19)] revealed that the majority of SWI cases (86.8%) were discovered during hospitalization. The treatment results always depend on the outcomes. Recent and existing treatments and strategies for SWI prevention include the administration of antibiotics before wound closure at the operation site, intravenous antimicrobial prophylaxis, improved hygiene, surgical aseptic practices, microbial screening, and decolonization [20, 21]. In spite of advancements in preventive measures, SWI prevention remains problematic. Finding related risk factors could improve the healing and therapeutic outcome for patients. As a result of the lack of sufficient studies in this field, this study aimed to determine the incidence rate and risk factors of SWI in general surgery patients.

Methods

A cross-sectional study was performed on 506 patients undergoing general surgery at five hospitals in Jeddah from January to June 2023. Inclusion criteria included all patients undergoing general surgery. Exclusion criteria were as follows: having an active infectious wound and a history of immunodeficiency disease (taking chemotherapy or immunosuppressive drugs). The present research was approved by the University of Medical Sciences. After obtaining permission from the hospital administration, the researchers visited the hospitals. Sampling was performed in a private room and each medical record was evaluated separately by the researchers.

Laboratory parameters such as levels of hemoglobin, creatinine, albumin, and white blood cells were also recorded. Hemoglobin level and white blood cells were measured by a complete blood count test. 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 hospitalization, and levels of hemoglobin, albumin, and white blood cells after surgery. At the end of the study, the frequency of SWI (yes/no) and its association with patient characteristics and laboratory results were investigated.

The SPSS software package (version 28.0) was used to analyze 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. A P-value <0.05 was considered significant.

Results

Participant characteristics

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

Incidence rate of SWI in general surgery patients

In this cross-sectional study, among 506 patients undergoing general surgery, SWIs 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 SWIs (12.5%).

The most prevalent strains of SWI in general surgery patients

Gram-positive cocci were the most prevalent strains isolated from 24 SWI cases (15/24, 62.5%). Among these, Staphylococcus aureus was the pre- dominant 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%).

Risk factors of SWI in general surgery patients

The incidence of SWI was significantly associated with the duration of pre-and postoperative hospitalization. A high percentage of patients with a pre- and postoperative hospitalization of more than 3 and 7 days developed SWIs, respectively. In addition, the prevalence rate of SWI 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 SWI ($P = 0.021$) (**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 SWI 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 SWI cases were associated with pre-operative antibiotic use, and 4.4% were related to postoperative antibiotic use (**Table 2**).

In laparotomy, the incidence of SWI 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 SWI 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**).

Antibiotic resistance profile of bacterial isolates from SWIs

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).

Table (1): Frequency distribution of SWI in terms of patient characteristics

Variable	Level	Without surgical wound infection		With surgical wound infection		P-value
		N	%	N	%	
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	
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	
Hospitalization history	Yes	150	90.9	15	9.1	0.001*
	No	332	97.4	9	2.6	
Preoperative hospitalization	<3 day	24	75	8	25	<0.001
	>3 day	458	96.6	16	3.4	
Postoperative hospitalization	<7 day	432	99.5	2	5	<0.001
	>7 day	50	69.4	22	30.6	
Preoperative intensive care unit hospitalization	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.

Table (2): Frequency distribution of SWI in terms of drug or antibiotic use

Variable	Level	Without surgical wound infection		With surgical wound infection		P-value
		N	%	N	%	
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 (4): Frequency distribution of SWI in terms of laboratory results

Variable	Level	Without surgical wound infection (N = 482)		With surgical wound infection (N = 24)		P-value
		N	%	N	%	
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	

Variable	Level	Without surgical wound infection (N = 482)		With surgical wound infection (N = 24)		P-value
		N	%	N	%	
	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	
	Gastrostomy	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	
Hemoglobin 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.

Discussion

Surgical wound infection (SWI) is one of the most common prevalent infections, which is considered a worldwide challenge in healthcare systems as it currently accounts for 19.73% of all HAIs. Although SWIs 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 SWI in rectal surgery (10). In the present study, the prevalence rate of SWIs 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 SWI, 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 hospitalization, history of immunodeficiency, and individuals responsible for changing dressings were SWI 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 SWI and identification of related risk factors is important to provide timely therapeutic and preventive interventions (14).

In a study by Carvalho et al., (2017) (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 SWI associated risk factors. In the present study, the duration of hospitalization and duration of operation were identified as SWI risk factors. A high percentage of patients with a hospital stay of more than 7 days post-operation 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 SWI and the long duration of operation was also in line with a systematic review by Koro et al., (2013) [28] It has been proven that procedures lasting for more than 3 h result in an 80% increase in SWI incidence. Over-handling 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 SWIs 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 SWIs. The incidence rate of SWI 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 SWI 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 SWI was lower. Khan et al., (2020) [20] provided an overview of the incidence, associated risk factors, and treatment outcomes of SWIs. 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. In a study by Kashi et al., (2012) [32] reported that one of the reasons for the difference in findings could be the difference in patient preparation before surgery.

Conclusion

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 SWI associated risk factors. Identifying important risk factors could help control SWIs by planned measures. According to the results of this study, healthcare workers can know the risk factors of surgical wound infection and try to reduce modifiable factors. 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 SWI.

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