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Risk Factors of Superficial Surgical Site Infection in Open Appendectomy

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ABSTRACT

Background and Objective: Surgical site infection (SSI) after open appendectomy (OA) is a common healthcare-associated infection. The most common form of SSI is superficial (SSSI) which is associated with substantial morbidity and mortality. The aim of the study is to assess factors contributing to SSSI in emergency OA.

Methods: This is a retrospective cohort study on patients who had emergency OA at Shar teaching hospital in Sulaimani City, Iraq for 6 months; from March to September 2022. Wound assessment was done by Centers for Disease Control and Prevention SSI Criteria (only skin of surgery site be affected, symptoms of pain or tenderness and erythema, purulent drainage, or organisms be found in wound culture). Demographic information, medical history, and preoperative and postoperative variables were compared and collected.

Findings: Of 320 participants, 51.6% were men and their mean age was 21±12.2. Total number of SSIs were 35 (10.9%). There were no differences between groups based on gender. Age, obesity, smoking, chronic illness, multiple intraoperative and preoperative factors were associated with SSI in the bivariable analysis. However, after adjusting for predictors, only use of subcuticular suturing techniques was associated with a significantly higher risk of SSI compared to simple interrupted suturing (p=0.004, OR=20.184, 95%CI [2.673-152.437]); and proper bathing within first 5 days after surgery had a significantly lower risk of SSI compared to others (p=0.025, OR=0.042, 95% CI [0.004-0.417]). No significant association was found between presence or timing of drain removal, postoperative length of stay, changing of dressing, antiseptics, or suture removal day.

Conclusion: The results of the study showed a wide range of effective factors in superficial surgical site infection in patients undergoing open appendectomy.

Keywords: *Infections, Surgical Site Infection, Open Appendectomy*.

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Introduction

One of the most common types of healthcare-associated infection is surgical site infection (SSI), which accounts for 14-25% of all hospital-acquired infections (1, 2). SSI is correlated with a prolonged hospital stay, long-term disability, and further financial burden, and it significantly hinders the potential advantages of surgical interventions (3). While the causes of SSIs are multifactorial, recognized risk factors include the length of hospital stay, obesity, patient comorbidities, duration and complexity of the surgery and a higher wound contamination score (4).

There are global variations around the definition of an SSI; the European Commission classified SSIs into superficial incisional surgical site infection (SSSI), deep incisional surgical site infection, or surgical site infection-organ/space, and the diagnostic criteria include the presence of one of the signs of infection (tenderness, swelling, reddening, and elevated skin temperature), purulent discharge from the incision site, and positive result of microbiological examination of material collected or after the surgical opening of the incision site (5, 6). Furthermore, SSI is defined by the Centres for Disease Control and Prevention (CDC) as infection related to an operative procedure that occurs at or near the surgical incision within 30 days of the procedure, or within 90 days if prosthetic material is implanted at surgery (7). In particular, SSI is theoretically preventable but requires special investigation for early detection and intervention (3). In the prevention avoidance of SSI, nurses play a vital role across the continuum of care. As a result, they can modify SSI risk factors in their everyday practice such as improper hand hygiene and skin preparation, in order to prevent SSI (8, 9).

The incidence of SSIs is higher in developing countries compared to developed countries. The incidence of all types of SSI after abdominal surgery can reach 14% of all hospital-acquired infections, and the most common form is Superficial Surgical Site Infection (SSSI) of incisional form, which is often the first to appear and is easily diagnosed (10). Appendectomy is considered a contaminated or potentially dirty procedure that is correlated with a substantial post-operative SSI (11). SSSI is common after appendectomy especially in complicated appendicitis (i.e., gangrenous and ruptured) with an incidence of 9 to 53%. Open appendectomy was found to have a higher incidence of SSI compared with laparoscopy (4.6 per 100 appendectomies) (12). SSIs can lead to a range of complications, including delayed wound healing (13), prolonged hospitalization (14), increased healthcare costs (14), and increased risk of deep wound infections (15). Superficial SSI can also cause pain (15), discomfort, and impaired mobility for the patient (16). In some cases, superficial SSI can progress to more severe infections, such as abscess formation (17) or sepsis, which can be life-threatening (18). In a study, the potential complications of appendectomy were reviewed, which involved 5,847 patients suspected of having acute appendicitis over a period of five years. The analysis showed that negative appendectomies have high rates of morbidity and mortality, with more wound infections (19).

Therefore, identifying the risk factors associated with SSIs in this surgical procedure is crucial for implementing preventative measures to reduce the incidence of these infections. The results of such a study could help healthcare professionals optimize their treatment protocols and improve patient outcomes. Additionally, the identification of risk factors could help in the development of guidelines to prevent SSIs, which can reduce healthcare-associated infections and associated costs.

Methods

This study was approved with the code 27-6/02/2022. This was a retrospective cohort study implemented to assess the factors that contributed to SSSI, during the period of March 1st, 2022 to September 1st, 2022.

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A census sampling method was used for all patients who had emergency OA at Shar Teaching Hospital in Sulaimani city, Iraq. Inclusion criteria were both genders of all age groups; those who were able to communicate and agreed to participate in the study. The exclusion criteria included the patients who underwent appendectomy by laparotomy incisions or laparoscopy and OA with other findings.

The data were collected through the utilization of a constructed questionnaire, and interview with the patients, and subjects were followed for 30 days in the outpatient clinic and through telephone interview, every two weeks in the mornings. Wound assessments were done according to the Center for Disease Control and Prevention and National Health Care Safety Network definition of SSI. The definition of SSI is as below: Infection occurring within 30 days after the operation that affect only skin or subcutaneous tissue (20). At least one of the following signs or symptoms should be present:

-Purulent drainage from the superficial incision

-Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision

-Pain or tenderness, localized swelling, redness, or heat

-Diagnosis of a superficial incisional SSI by the surgeon or attending physician.

Based on an extensive review of literature related to the study topic, the researcher constructs the tools of data collection for the study. The tools contain:

Demographic Variables: Age, Gender, Occupation, Educational level, Body Mass Index (BMI).

Medical History Variables: Duration of the pain before the surgery in hours, Re-admissions.

Preoperative Variables: Length of preoperative stay in the hospital in hours (as in case of late diagnosis or ruptured appendicitis which might delay the surgery), Smoking, Alcohol consumption, White blood cell count (WBC) per microliter, Blood glucose, C-reactive protein level.

Surgical Variables: Type of the incision, Intraoperative classification of appendicitis, Wound Suturing Techniques, Presence of Drain.

Postoperative Variables: Day of the Drain Removal, Lengths of postoperative hospitalization in hours, changing of the dressing, The time the changing of the dressing started, Frequency of changing of the dressing, Antiseptic used, Day of suture removal.

Patients were followed for 30 days in the same clinic where their surgery was done and through telephone interviews. During this period, the patients were asked about their wound status on a daily basis in hospital and weekly after discharge, as part of the wound assessment according to the Centers for Disease Control and Prevention SSI Criteria. The exact time of day when the patients were asked was not specified. In our study, the wound assessments were conducted by two trained healthcare providers who were experienced in following the Centers for Disease Control and Prevention SSI Criteria. Both providers were responsible for conducting daily assessments and were blinded to each other's evaluations to ensure objectivity and reliability. This approach helped minimize inter-rater reliability and ensure consistency in the assessment process.

The following statistical data analysis approaches were used to analyse and assess the results of the study under the application of the statistical package SPSS ver. 24.0. The statistical procedures that were applied to determine the results of the present study included descriptive statistical data analysis (Frequency, Percentage, Mean and Standard deviation), inferential data analysis like independent samples T-Test and Chi square Test with significant level of p-value under 0.05. We used logistic regression to adjust the baseline characteristics that had significant differences among the groups to predict the risk factors of SSI.

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Results

The distribution of demographic characteristics of the patients; the majority were male, most of the patients were young (12-17 years), and most were student, (Table 1): Regarding the preoperative factors; the majority (65.9%) had pain for less than 25 hours before the surgery, (49.1%) stayed between 9-16 hours before the surgery, (68.8%) had normal BMI. Only 7.8% were smokers and 0.6% were alcohol consumers. Out of the 350 patients, 35 had SSI. Significant differences were found between the two groups in terms of age, with older people in SSI group ($p<0.001$), occupation, with more cases among retired, housewives, and un-employed ones ($p=0.001$), illiteracy ($p=0.001$), higher BMIs ($p=0.001$), smokers ($p=0.001$), alcohol consumption history ($p=0.033$), hypertension ($p=0.001$), heart diseases ($p=0.012$), diabetes mellitus ($p=0.001$), hypothyroidism ($p=0.001$), and thyroid diseases ($p=0.033$). No significant difference was found in gender or asthma.

Table 1. Socio-demographic characteristics of the patients

Variable	Non-SSSI group (n=285) Number(%)	SSSI group (n=35) Number(%)	p-value
Age			<0.001
<12	66(23.16)	6(17.14)	
12-17	90(31.58)	6(17.14)	
18-30	82(28.77)	13(37.14)	
31-40	30(10.53)	2(5.71)	
>40	17(5.96)	8(22.86)	
Gender			0.290
Male	149(52.28)	16(45.71)	
Female	136(47.72)	19(54.29)	
Occupation			0.001
Child	4(1.4)	0(0)	
Government employed	21(7.37)	2(5.71)	
Self-employed	35(12.28)	8(22.86)	
Retired	3(1.05)	3(8.57)	
Housewife	33(11.58)	8(22.86)	
Unemployed	5(1.75)	1(2.86)	
Student	184(64.56)	13(37.14)	
Education level			0.001
Child	4(1.4)	0(0)	
Illiterate	4(1.4)	4(11.43)	
Able to read and write	6(2.11)	1(2.86)	
Primary school student	71(24.91)	10(28.57)	
Intermediate school student	51(17.89)	4(11.43)	
Secondary school student	57(20)	7(20)	
Institute or university student	44(15.44)	2(5.71)	
Post graduate	48(16.84)	7(20)	
BMI			0.001
Underweight	16(5.61)	0(0)	
Normal	204(71.58)	15(42.86)	
Overweight	43(15.09)	13(37.14)	
Obese	21(7.37)	7(20)	
Smoking	16(5.61)	9(25.71)	0.001
Alcohol consumption	0(0)	2(5.71)	0.033
HTN	2(0.7)	5(14.29)	0.001
Heart diseases	1(0.35)	2(5.71)	0.012
DM	0(0)	4(11.43)	0.001
Asthma	1(0.35)	0(0)	0.891
Hypothyroidism	0(0)	2(5.71)	0.001
Thyroid diseases	0(0)	2(5.71)	0.033

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The relationship between the Non-SSSI group and the SSSI group in terms of the preoperative investigations was represented in Table 2. There were statistically significant differences in wound assessment between both groups in WBC, Granulocytes count per microliter, FBS and RBS. There was no statistically significant difference in CRP and blood urea between both groups.

The majority of participants (80.6%) had grid-iron incisions, while (18.1%) had Lanz incisions and only (0.3%) had Grid-iron incisions and muscle-cutting Rutherford-Morrison incision. The majority of intra-operative classifications of appendicitis were simple AA (94.7%), perforated or gangrenous appendicitis (5%) and Periappendiceal abscess (0.3%). Furthermore, (75.95%) of the patients' wounds were sutured with mattress techniques, (21.2%) with subcuticular techniques, (5.3%) had corrugate drain and only (0.6%) had tube drain (Table 3). There were statistically significant differences in wound assessment of patients in terms of type of incision, intraoperative appendicitis classification, wound suturing techniques, presence of drain and day of drain removal (Table 3).

Table 2. Association between preoperative investigations and wound assessment

Characteristics	Non-SSSI group Fr.(%)	SSSI group (n=35) Fr.(%)	Statistic	p-value
White blood cell count (WBC) per microliter				
Normal	62(21.8)	3(8.6)	3.747	0.047
Elevated	223(78.2)	32(91.4)	-2.947	0.003
Mean±SD	13.2±3.9	15.3±4.7		
Granulocytes count per microliter				
Normal	71(24.9)	3(8.6)	4.682	0.03
Elevated	214(75.1)	32(91.4)	-2.383	0.018
Mean±SD	10.4±5.4	12.6±4.1		
Blood glucose mg/dl (Mean±SD)				
FBS	101.8±30.5	159.7±63.6	-2.556	0.02
RBS	115.9±25.1	184.7±147.9	-2.754	0.009
C-reactive protein level (CRP) (mg/l)	53.4±75.8	87.9±110.2	-0.708	0.486
Blood Urea levels (mg/dL)	26.2±9.6	20.7±8.6	1.675	0.102

Table 3. Logistic regression of predictors of SSI adjusted for age, occupation, smoking status, alcohol consumption status, BMI, and pre-existing diseases

	Model p-value	OR	CI 95%
WBC increased	0.343012	0.507346	0.124789-2.06268
Type of the incision	0.999	-	-
Intraoperative classification of appendicitis			
Periappendiceal abscess	<0.0001	ref	
Perforated or gangrenous appendicitis	1	0	-
Simple acute appendicitis	1	0	
Wound Suturing Techniques			
Simple interrupted	0.014051	ref	-
Subcuticular	0.00358	20.18434	2.672629-152.4371
Mattress	0.557252	1.431399	0.432136-4.741343
Day of post-operative bathing			
<5	0.025	ref	-
5-10	0.006	0.042109	0.004251-0.41711
>10	0.058	0.058105	0.00546-0.618338
Presence of Drain	0.999	-	-
Day of Drain Removal	0.998	-	-
lengths of postoperative hospitalization in hours	0.999	-	-
Changing of the dressing	0.874	-	-
When changing of the dressing started	NE	-	-
Frequency of changing of the dressing	0.574	-	-
Antiseptic used	0.679	-	-
Day of suture removal			
≤7	0.002	ref	
8-10	0.998	-	-
>10	0.998	-	-

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The study's findings show that there were statistically significant differences in the lengths of postoperative hospital stay, dressing changes, time of changing the dressing, day of suture removal and post-operative bathing. However, there was no statistically significant difference between the Non-SSSI and SSSI groups in terms of dressing change frequency, and using normal saline for cleaning (Table 4).

Table 4. Association between operative factors and wound assessment

Characteristics	Non-SSSI group Fr.(%)	SSSI group Fr.(%)	Significant Test	p-value
Type of the incision				
Grid-iron incision	225(78.9)	33(94.3)		
Grid-iron incision & Muscle cutting Rutherford-Morrison incision	0(0.0)	1(2.9)	14.475	0.002
Lanz incision	57(20)	1(2.9)		
Upper transverse incision	3(1.1)	0(0.0)		
Intraoperative classification of appendicitis				
Simple acute appendicitis	281(98.6)	22(62.9)		
Perforated or gangrenous appendicitis	4(1.4)	12(34.3)	79.756	0.000
Periappendiceal abscess	0(0.0)	1(2.9)		
Wound Suturing Techniques				
Simple interrupted	5(1.8)	4(11.4)		
Subcuticular	62(21.8)	6(17.1)	10.79	0.005
Mattress	218(76.5)	25(71.4)		
Presence of Drain				
No drain	279(97.9)	22(62.9)		
Corrugate drain	6(2.1)	11(31.4)	70.807	0.000
Tube drain	0(0.0)	2(5.7)		
Day of Drain Removal				
No-removable	279(97.5)	22(62.9)		
Day one	0(0.0)	0(0.0)		
Day two	1(0.7)	1(0.7)	65.7	0.000
After day two	5(1.8)	12(36.4)		
Total	285(100)	35(100)		
Lengths of postoperative hospitalization in hours				
<10	13(4.6)	0(0.0)		
10-15	232(81.4)	20(57.1)	18.992	
>15	40(14)	15(42.9)		0.000
Mean±SD	13.4±4.4	18.8±11.3	-5.477	
Changing of the dressing				
No	119(41.8)	23(65.7)	7.25	0.007
Yes	166(58.2)	12(34.3)		
When changing of the dressing started				
Day one	0(0.0)	1(8.3)		
Day two	6(3.6)	2(16.7)	18.614	0.000
<Day two	160(96.4)	9(75)		
Total	166(100)	12(100)		
Frequency of changing of the dressing				
1 time per day	73(44)	8(66.7)		
2 times per week	93(56)	4(33.3)	2.324	0.127
Total	166(100)	12(100)		
Antiseptic used				
Povidone	164(57.5)	11(31.4)	8.579	0.003
Normal saline	26(9.1)	5(14.3)	0.95	0.33
Topical gel or ointment	0(0.0)	1(2.9)	8.168	0.004
Day of suture removal				
≤7	190(66.7)	1(2.9)		
8-10	95(33.3)	27(77.1)	93.957	0.000
>10	0(0.0)	7(20)		
Day of post-operative bathing				
<5	191(67)	4(11.4)		
5-10	94(33)	24(68.6)	-16.757	
>10	0(0.0)	7(20)		0.000
Mean±SD	4.47±1.84	7.34±2.86	83.514	

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We conducted a logistic regression analysis to examine the incidence of surgical site infections (SSI) after appendectomy, adjusted for age, occupation, education, and preexisting disease. The results showed that increased white blood cell count was not a significant predictor of SSI (p=0.343, OR=0.507, 95% CI [0.125-2.063]). The type of incision was also not a significant predictor (p=0.999). However, the intraoperative classification of appendicitis was a significant predictor of SSI (p<0.0001), indicating that overall, this predictor variable was significantly associated with the risk of surgical site infections (SSI) after appendectomy. However, the ORs for different subgroups of appendicitis (Periappendiceal abscess, perforated or gangrenous appendicitis, and simple acute appendicitis) were all equal to 0 and not statistically significant. This indicates small sample size or a lack of statistical power to detect an effect (Table 3).

The use of subcuticular suturing techniques was associated with a significantly higher risk of SSI compared to simple interrupted suturing (p=0.004, OR=20.184, 95% CI [2.673-152.437]). Patients who bathed within the first 5 days after surgery had a significantly lower risk of SSI compared to those who bathed later (p=0.025, OR=0.042, 95% CI [0.004-0.417]). No significant association was found between the presence or timing of drain removal, length of postoperative hospitalization, changing of the dressing, antiseptic used, or day of suture removal and the risk of SSI.

Discussion

Our findings highlighted several risk factors of SSSI in patients undergoing OA: age, obesity, smoking, chronic illness, duration of the pain before the surgery, pre-operative hospital stay, dressing change and time of starting dressing change, type of cleaning solution and the frequency of changing dressing, type of appendectomy incision, wound suturing technique, post-operative body bathing and day of suture removal all are associated factors for SSSI after emergency OA. Analysis of the socio-demographic variables revealed that most SSSI subjects were female, in the age group of 18-30 years old and students. Regarding preoperative factors, most subjects in SSS group had pain for more than 48 hours before the surgery, were previously admitted, and had pre-operative hospital stay between 9-16 hours, with normal BMI, were passive smoker and alcohol consumer. In terms of operative factors, the majority of SSSI group had grid-iron incision, perforated or gangrenous appendicitis, mattress suturing technique, and corrugated drain. The post-operative factors for SSSI group were post-operative hospital stay for more than 15 hours, with no dressing change, using normal saline for dressing, their suture remained for 8-10 days and had post-operative bathing after 9 days.

In the present study, researchers found a significant relationship between female gender and SSSI, and this finding is similar to a study by Jurt et al., who found that SSI was more common in female gender than in males (17). However, the present study's result is in contrast with the result of Tseng et al. and Garcell et al. which concluded that SSI is more common in males (21, 22). This is because different studies may have different sample sizes, populations, study designs, and methods of data collection and analysis, which could lead to differences in the results obtained.

Current findings found that age group of 18-30 years was at higher risk for developing SSSI while a study by Koumu et al. found no significant relationship between the patients' demographic data and the SSI in relation to age of the patients (23). In addition, two other studies found that older patients are more likely to develop SSI (17, 21). Factors such as the patients' overall health, comorbidities, and surgical techniques could also contribute to the differences in results. In terms of duration of the pain before the surgery, the current study's result was in agreement with several studies, according to which delayed appendectomies

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after hospital presentation are associated with poor outcomes (24, 25). Giraudo et al. reported that delayed appendectomy, 24 hours after onset, increases the complication rate (25). In addition, Papandria et al. reported inpatient delay to be associated with a higher perforation rate (26).

In terms of preoperative hospital stay, current finding is supported by another study by Ansari et al (27). They concluded that preoperative hospital stay more than 24 hours was associated with overall incidence of SSI, while Scala et al. reported that the length of preoperative hospital stay cannot increase the rate of surgical infections (28). In terms of BMI, the current study's finding is in contrast to a study who found that SSSI rate was the highest in the underweight group (29) while a large-scale study revealed that the risk of SSSI gradually increases with increasing BMI (30).

Regarding smoking, this study agrees with the result of Mekhla et al, which revealed that tobacco smoking was significantly associated with development of SSSI (31), while another study found no association between smoking and the rate of infection (32). In terms of chronic disease, the current study's result is similar to the study by Zhang et al. and Mejía et al. which revealed that the significant factors associated with SSI were hypertensions (33, 34). In contrast with the current result, a large-scale study showed no significant relationship between hypertension, DM or both and SSI (23).

The current finding revealed that there was a positive relationship between appendectomy incision type and SSSI; most of those who had Grid-Iron incision had developed SSSI, while few of patients that had Lanz incision developed SSSI. After accounting for baseline characteristics, no association was found in our study.

In addition, there was statistically significant differences between the type of suturing technique and SSSI, subcuticular sutures had a low rate of SSSI compared with the vertical mattress sutures, which disagrees with a study by Javadi et al; they found no significant difference between subcuticular and interrupted suturing in uncomplicated appendectomy (35). Moreover, there were significant relationships in term of Intra-operative classification of appendicitis and SSSI. Complex appendicitis was the main risk factor for developing SSSI as supported by several studies (36, 37); but after adjusting for the baseline characteristics, we did not find any association.

In term of surgical drains, there were statistically significant differences between both groups of patients in regard with the presence of drain and day of drain removal, as the drains are usually used in complicated appendicitis, in which the rate of SSI is more than simple appendicitis. The current study's result is supported by a cohort study by Abdulhamid et al.; the study concluded that abdominal drain after emergency OA for complicated appendicitis did not prevent or reduce SSI significantly (38). Our analysis, which adjusted for baseline characteristics, did not reveal any significant association.

Concerning post-operative hospital length of stay, the current study showed that those stay more in hospital postoperatively will get more SSSI and this finding is supported by a study by Mujagic et al (39).

Regarding post-operative bathing, the current result found a strong relationship between post-operative bathing and SSSI; those who had early postoperative bathing had less SSSI. This finding is supported by a prospective randomized controlled trial by Hsieh et al. which found that clean and clean-contaminated wounds can be safely showered 48 hours after surgery, postoperative showering does not increase the risk of SSI (40). In term of the day of starting dressing change, antiseptic used and day of suture removal, there were a positive relationship in the incidence of SSSI among post-appendectomy patients (reaching 10.9% of the total). When this result is compared to other studies, a wide variation in the incidence of SSI after appendectomy is noticed; a study by Gul et al. found the frequency of SSI after OA was (10.07%) (41), while total incidence of SSI in the study of Koumu et al. was (7.2%) (23).

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Our study showed the importance of implementing strategies to prevent and manage SSSI in patients undergoing OA, particularly in those with identified risk factors. Further studies are required to identify effective prevention and management strategies.

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