An Assessment Scale for Patients with Postoperative Superficial Incisional Surgical Site Infection: a Cross-Sectional Study

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Abstract Superficial incisional surgical site infection (SSI) is a common postoperative complication in surgical patients. The aim of this study was to assess the predictive power of an assessment scale for identifying patients at risk of superficial incisional SSI. A cross-sectional survey was conducted at the Department of Surgery at the Medical Research Institute Hospital, Alexandria University. A sample of 150 adult patients aged from 18 to 65 years, who undergoing general surgeries that had clean sutured surgical wounds, was randomly selected. Forty-six patients (30.7%) had SSI. The total score can significantly discriminate between positive and negative superficial incisional SSI patients with diagnostic accuracy of AUC (SE) = 0.66 (0.048). Each score more than the cutoff point (11.5) will increase the risk of surgical site infection development by 2.5 times (OR (95% CI) = 2.5 (1.26–3.1)). The developed assessment scale can discriminate between patients who are at risk of superficial incisional SSI and those

who are not. It can be used as a preliminary screening tool for subsequent investigation for the presence of infection.

Keywords Surgical wound infection · Surgical site infection · Wound · General surgery

Introduction

Superficial incisional surgical site infection (SSI) is the most frequent and accounting for 38% of nosocomial infections [1]. The WHO reported that the incidence varies from 0.5 to 15% depending on the type of operation and underlying patient status. In the USA, superficial incisional SSI is a major source of complications for the millions of individuals undergoing surgery each year [2]. In Egypt, a study which was conducted to estimate the risk factors and major pathogens involved in surgical site infections in an orthopedic hospital in Cairo detected an overall wound infection rate of 25.8% [3].

SSIs have major consequences as limiting the potential benefits of surgical interventions and increasing the economic burden on hospitals. Adding to the functional disability and emotional stress of the patient, the increased length of stay for infected patients is the greatest contributor to cost. The increased use of drugs, the need for isolation, and the use of laboratory and other diagnostic studies also contribute to costs. For patients with wound infection, studies showed that the average increase in duration of hospitalization was 8.2 days [2, 4].

Assessment of the health risk status of patients and the indications for intervention is extremely important. It provides a critical guide to the follow-up of an action plan that enhances personal health status. Nurses and other health care workers are able to establish baseline data about the patient's current health condition before providing care [5].

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A wide variety of assessment tools are used to facilitate assessment. Scales are considered as an effective method which can provide an accurate scoring system. Scales are important in identifying patients who are critically ill and therefore at risk [6], thus prompting the implementation of therapy to improve modifiable conditions [7].

We hypothesized assessing the risk factors for superficial incisional SSI development may provide information that could help in predicting wound infection with subsequently reducing complications and improving outcome. Our objective is to determine the association between the different pre-operative, intraoperative, and postoperative factors and the occurrence of superficial incisional surgical site infection.

Methods

Eligible patients were adult patients aged from 18 to 65 years. A cross-sectional survey was conducted at the Department of Surgery of the Medical Research Institute Hospital, Alexandria University. A sample of 150 patients was randomly selected using a table of random number. We calculated our sample based upon a research conducted to identify risk factors for postoperative nosocomial infection among patients in Northwest Ethiopia [8]. A sample size of 124 achieves 83% power to detect nosocomial infection incidence of 11% (± 3) [8] among the admitted patients using a two-sided, binomial hypothesis test with a target significance level of 0.01 (the actual significance level is 0.00923) [9]. Patients were undergoing general surgeries that had clean closed and sutured surgical wounds. An official permission to carry out the study was secured from the hospital administrative staff. Patient's approval to be included in the study was obtained after the explanation of the purpose of the study.

Scale Development Process

The assessment scale for patients at risk of superficial incisional surgical site infection was constructed using the process of scale development proposed by Slavec and Drnovšek [10], Reynolds [11], Barnes and Burchard [12], and Farag [13]. According to this process, three phases were carried out by the authors as follows.

Phase I

Content Domain Specification The authors reviewed all the factors leading to superficial incisional SSI occurrence during the three perioperative stages and group of patients who are at risk to develop it.

- 1- *Item pool generation:* A list of independent variables considered relevant to the problem of SSI was compiled, and

a rating system was devised. The resulting product of this step was the first version of the assessment scale for patients at risk of SSI (Appendix 1, 2).

- 2- *Content validity evaluation:* The researcher tested the content validity of the developed scale by a panel of experts about 30 nursing and surgical teaching staff. Each expert was individually asked to read and evaluate the relevance of each item using the following four-point scale: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, and 4 = very relevant. They were also asked to reflect on each item's measuring feasibility through a "yes" or "no" response. The kappa measure of agreement was calculated ($\text{kappa} = 0.86$, $\text{SE} = 0.104$). Accordingly, the necessary corrections and reconstruction of the scale were carried out and a second version was released (Appendix 3).

Phase II

Pilot Test A pilot study was conducted on 15 patients to test the applicability of the scale and to determine difficulties in using it. Based on the findings, appropriate modifications were made and the final version of questionnaire was edited (Table 1) that consists of two main parts:

1. *Personal and clinical data* such as name, sex, residence, work, and diagnosis
2. *Perioperative patient assessment scale:* This part constitutes risk factors for the development of superficial incisional surgical site infection. They were divided into three parts related to the perioperative stages (preoperative, intraoperative, and postoperative).

Data collection using the scale was conducted as follows:

1. After the patients' admission to hospital to assess the patient for preoperative risk factors
2. At the first or second postoperative day in order to assess for the intra- and postoperative risk factors
3. Follow-up was carried out after patient's discharge till the day of suture removal to detect the occurrence of superficial incisional SSI. Diagnosis of SSI was based upon the observed signs of infection occurred within 30 days after the operation, and then confirmation was done with evident infection involving only skin or subcutaneous tissue of incision [14].

Phase III

This phase included the statistical analysis to estimate the relation between different questions and the presence or absence of wound infection.

Table 1 Final form of the intended nursing assessment scale

Factor	Score
1. Preoperative risk factors	
Age (years)	
20–<30	0
30–<40	1
40–<50	2
50–60	3
Smoking	
Non-smoker	0
Smoker (< packet/day)	1
Smoker (> packet/day)	2
Body weight	
Ideal weight	0
Underweight	1
Overweight	2
Corticosteroids	
No	0
Yes	1
Antibiotic prophylaxis	
Yes	0
No	1
Site of surgical operation	
Non-abdominal	0
Abdominal	1
Associated diseases	
No	0
Yes	1
Results of lab investigations	
Normal value	0
Abnormal value	1
Length of hospital stay (days)	
1	0
2	1
3 or more	2
Shaving (time)	
At night before operation	0
Immediate before operation	1
Total patient's score	30
2. Intraoperative risk factors	
Type of anesthesia	
Spinal	0
General	1
Surgical wound classification	
Clean	0
Clean-contaminated	1
Contaminated	2
Infected	3
3. Postoperative risk factors	
Body temperature	
Normal	0
Hypothermia	1
Hyperthermia	2
Both	3
Presence of drain (s)	
Absent	0
Closed	1
Open	2
Both	3
Day of drain removal	
1st day	0
2nd day	1
3rd day or more	2
Type of sutures	
Removable	0
Absorbable	1
Length of hospital stay (days)	
1	0
2	1
3 or more	2
Total preoperative score	15
Total intraoperative score	4
Total postoperative score	11

Statistical Methods

The Statistical Package for Social Sciences (SPSS) was utilized for statistical analysis [15]. Quantitative variables were summarized by mean, median as measures of central tendency and standard deviation, and range as measures of dispersion while categorical variables were summarized by frequency and percent. Chi-square test was used to study the significant association between the two qualitative variables. Fisher's exact and Monte Carlo tests were used if more than 20% of the total expected cell counts <5 at a 0.05 level of significance.

Receiver operation coefficient (ROC) curve analysis was done to detect the diagnostic accuracy of total nursing score in SSI. The area under the curve (AUC), sensitivity (SE = true positive/true positive + false negative), and specificity (SP = true negative/true negative + false positive) were calculated. Logistic regression with the maximum likelihood estimation (MLE) method was carried out to determine the predictive power of total scale to assess superficial incisional SSI [16].

Results

We assessed 150 patients. Forty-six patients (30.7%) had surgical site infection, whereas the remaining 104 patients had no infection (69.3%). The current study presents the developed scale which consists of three parts, corresponding to the peri-operative phases. The preoperative part of the scale includes preoperative risk factors which are the patient's age, smoking, body weight, taking corticosteroids, antibiotic prophylaxis, site of surgical operation, associated diseases, laboratory investigation results (white blood cells, hemoglobin, serum albumin, coagulation profile, prothrombin activity, and INR), length of hospital stay, and shaving time (Table 1).

Regarding the intraoperative part, it consists of the type of anesthesia and wound classification as intraoperative risk factors. The postoperative part of the scale includes body temperature, presence of drain(s), day of drain removal, type of sutures, and length of hospital stay (days) as postoperative risk factors (Table 1).

Table 2 shows that there were no statistically significant differences between the proportion of the patients who developed and those who did not develop superficial incisional SSI in relation to age, smoking, administration of corticosteroids, antibiotic prophylaxis, site of surgical operation, associated diseases, and shaving time. On the other hand, there were statistically significant differences between the proportion of positive and negative superficial incisional SSIs according to body weight, results of laboratory investigations, and preoperative length of hospital stay (days) ($P = 0.024$, 0.006 , and 0.011 , respectively). The table also reveals that there were no statistically significant differences between the occurrence of wound

Table 2 Relationship between the preoperative and intraoperative risk factors of the participated patients and surgical site infection development

	Surgical site infection				χ^2	<i>P</i>
	No (<i>N</i> = 104)		Yes (<i>N</i> = 46)			
	No	%	No	%		
Preoperative risk factors						
Age (years)						
20–<30	17	85.0	3	15.0	7.1	0.069
30–<40	29	72.5	11	27.5		
40–<50	13	50.0	13	50.0		
50–60	45	70.3	19	29.7		
Smoking						
Non-smoker	88	71.5	35	28.5	1.6	0.210
Smoker	16	59.3	11	40.7		
Body weight						
Ideal weight	23	88.5	3	11.5	7.4	0.024*
Underweight	10	83.3	2	16.7		
Overweight	71	63.4	41	36.6		
Corticosteroids						
No	99	68.8	45	31.3	FEP ^a	0.448
Yes	5	83.3	1	16.7		
Antibiotic prophylaxis						
Yes	3	100.0	0	0.0	FEP ^a	0.245
No	101	68.7	46	31.3		
Site of surgical operation						
Non-abdominal	49	75.4	16	24.6	1.9	0.160
Abdominal	55	64.7	30	35.3		
Associated diseases						
No	72	72.7	27	27.3	1.6	0.209
Yes	32	62.7	19	37.3		
Results of lab investigations						
Normal	84	65.1	45	34.9	7.7	0.006*
Abnormal	20	95.2	1	4.8		
Length of hospital stay (days)						
1	97	71.9	38	28.1	MCp ^b	0.011*
2	3	100.0	0	0.0		
3 or more	4	33.3	8	66.7		
Shaving (time)						
Immediate preoperative	81	71.1	33	28.9	0.66	0.416
Night before	23	63.9	13	36.1		
Intraoperative risk factors						
Type of anesthesia						
Spinal	14	60.9	9	39.1	0.91	0.339
General	90	70.9	37	29.1		
Classification of surgical wound						
Clean	49	76.6	15	23.4	4.3	0.229
Clean-contaminated	47	61.8	29	38.2		
Contaminated	7	77.8	2	22.2		
Infected	1	100.0	0	0.0		

For laboratory investigations of white blood cells, hemoglobin, serum albumin, coagulation profile, prothrombin activity, and INR, they are considered as abnormal if at least one test result is not within its normal range

**P* < 0.05 (significant)

^a *P* value based on Fisher's exact probability

^b *P* value based on Monte Carlo exact probability

infection in relation to type of anesthesia and the classification of surgical wound (*P* = 0.339 and 0.229, respectively).

Table 3 presents the relationship between the postoperative risk factors of the participated patients and the superficial incisional SSI development. While there were statistical significant differences between the proportion of the patients with and without SSI in relation to normal body temperature

(*P* < 0.001), the same table shows that there were no statistically significant differences between those patients with and without superficial incisional SSI in relation to the presence of drain(s), day of removal of drain(s), suture type, and postoperative length of hospital stay (*P* > 0.05).

Table 4 and Fig. 1 illustrate the ROC curve analysis and proved that the total score of the developed superficial

Table 3 Relationship between the postoperative risk factors of the participated patients and surgical site infection development

Postoperative risk factors	Surgical site infection				χ^2	<i>P</i>
	No (<i>N</i> = 104)		Yes (<i>N</i> = 46)			
	No	%	No	%		
<hr/>						
Normal body temperature						
Yes	100	74.1	35	25.9	14.0	<0.001*
Hypothermia	4	26.7	11	73.3		
Presence of drain(s)						
Absent	19	70.4	8	29.6	0.18	0.911
1 drain	78	69.6	34	30.4		
>1 drain	7	63.6	4	36.4		
Day of drain removal						
1st day	40	52.9	22	47.1	MCp ^a	0.201
2nd day	20	87.0	3	13.0		
3rd day	3	75.0	1	25.0		
>3 days	41	68.3	20	31.7		
Type of sutures						
Removable	98	68.5	45	31.5	FEP ^b	0.336
Absorbable	6	85.7	1	14.3		
Length of hospital stay (postoperative)						
1	57	65.5	30	34.5	4.9	0.082
2	36	81.8	8	18.2		
3 or more	11	57.9	8	42.1		

**P* < 0.05 (significant)^a *P* value based on Monte Carlo exact probability^b *P* value based on Fisher's exact probability

incisional surgical site infection assessment scale can significantly discriminate between positive and negative SSI patients with diagnostic accuracy of AUC (SE) = 0.66 (0.048). Patients are considered at risk to develop surgical wound infection if their score is greater than or equal to 11.5 while those with a score <11.5 are considered with less risk to have surgical wound infection. Odds ratio of 2.5 (95% CI 1.26–3.1) was calculated for the cutoff point of the total nursing score. Each

score more than the cutoff point will increase the risk of superficial incisional SSI development by 2.5 times.

The logistic regression in Table 4 proves that the total score of the developed SSI assessment scale has higher prediction power. Regarding the patients who did not develop SSI, the correct prediction value percentage of the scale was 91.3%. In other words, 95 out of 104 infection-free patients were not predicted to get infection. Furthermore, among the 46 patients

Table 4 Area under the curve and predictive validity (sensitivity, specificity, cutoff point, and odds ratio for the cutoff point of the total assessment score using ROC curve and logistic regression analysis)

Area under the curve (AUC) (SE)	0.660 (0.048)		
<i>P</i> value	0.002*		
Sensitivity ^a	71.7%		
Specificity ^b	51%		
Cutoff point	11.5		
Odds ratio for the cutoff point (95% CI)	2.5 (1.26–3.1)		
Observed surgical site infection	Predicted to get SSI	Predicted no SSI	Overall percentage
	Frequency (%)		
No (<i>n</i> = 104)	9 (8.7)	95 (91.3)	77.2
Yes (<i>n</i> = 46)	20 (43.5)	26 (56.5)	

Each score more than the cutoff point will increase the risk of surgical site infection development by 2.5 times

**P* < 0.05 (significant)^a Those with surgical site infection whose scores are equal to or greater than the cutoff point^b Those without surgical site infection whose scores are less than the cutoff point

Fig. 1 ROC curve analysis for total score screening of superficial incisional SSI. *Diagonal segments are produced by ties*

who developed surgical site infection, the correct prediction value percentage of the scale was 43.5%, which means that only 20 patients were predicted to get infection.

However, the overall percentage of the developed assessment scale was 77.2%, which means that the developed superficial incisional SSI assessment scale has high prediction power.

Discussion

Superficial incisional SSI is one of the most common postoperative complications, occurring in at least 5% of all patients undergoing surgery and 30–40% of patients undergoing abdominal surgery [17, 18].

SSI has also been shown to increase mortality, readmission rates, length of stay, and costs. Furthermore, wound infection can lead to revision surgery, delayed wound healing, increased use of antibiotics, and increased length of hospital stay, all of which have a significant impact on patients and the cost of health care [19–21].

The findings of the present study indicated that 46 patients out of 150 (30.7%) developed SSI. In fact, this percentage means that almost one third of the sample developed SSI. A research that was done in 2010 supported our results. It studied the relationship between SSI and patient's risk factors, and the incidence was 24 infected patients out of 93 of the total sample (25.8%) [3]. However, a study found that the wound infection rate in their study was 1.4% only [22].

The age was not a significant factor, but approaching the statistical significance, although the incidence of wound infection was increasing as the age increases among the study samples. The greater likelihood of certain chronic conditions and decreased immunity with delayed wound healing, which are factors usually associated with old ages, could increase the risk of wound infection [23]. This finding was supported by other studies that indicated a higher incidence of superficial incisional SSI was observed significantly in patients above 40 years of age [22, 24].

Fortunately, the doubtless positive association between surgical wound infection and patient's body weight, meaning overweight or obesity, was supported by the current study findings. This finding is in agreement with Dohmen [25] who reported that the incidence of wound infection increased significantly among obese patients. That increase could be due to the relative vascularity of adipose tissues or technical difficulties of handling adipose tissues that can result in more traumas to the abdominal wall [26].

Moreover, our current study shows that the patient's results of laboratory investigations were a significant indicator of SSI among the studied patients. Noticeably, this factor was not correlated with superficial incisional SSI or investigated before as a risk factor.

In relation to the length of hospital stay, the present study findings revealed that there was a significant relationship between wound infection development and the preoperative patient's stay. This phenomenon could be explained by the lengthy exposure of patients to the hospital environment which is full of infection transmission risk. Two supporting studies concluded that the prolonged hospital stays were associated with increased superficial incisional SSI and readmission rates which resulted in the psychological stress to the patient along with added cost [3, 27].

Unfortunately, none of the intraoperative risk factors showed a significant difference between the infected and uninfected patients. On the other hand, these study findings do not agree with that of Kasatpibal et al. [22], Chattopadhyay et al. [28], and Khaleid et al. [3] who indicated the significant association between the surgical wound classification, duration of surgery, and SSI.

Regarding the postoperative risk factors, the current study findings showed that all of the postoperative risk factors showed no significant relationship with wound infection except for the patient's body temperature. A systematic review supported this result as they stressed the importance of maintaining perioperative normothermia in order to prevent or decrease the incidence of wound infection [29].

Conclusion and Recommendations

The results of the present study concluded that the developed assessment scale for patients at risk of surgical site

infection has good accuracy to discriminate between patients who are at risk of superficial incisional SSI and those who are not. Patients with low score are less likely to develop SSI. The scale is quick to administer, simple, and easy to use, owing to its scoring system which lessens the burden of documentation; however, we cannot rely on it to diagnose SSI due to its low prediction value. We recommend using this scale as a preliminary screening tool to guide further investigations about the occurrence of superficial incisional surgical site infection.

Compliance with Ethical Standards An official permission to carry out the study was secured from the hospital administrative staff. Patient's approval to be included in the study was obtained after the explanation of the purpose of the study.

Conflict of Interest The authors declare that they have no conflict of interest.

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Appendix 1

Biosociodemographic data:

Name:

Age (in years):

Sex:

Male ()

Female ()

Work

Working ()

Not working ()

Residence

Urban ()

Rural ()

Diagnosis:

Date of admission:

Date of operation:

Date of discharge:

Laboratory investigations:

Hemoglobin

White blood cells

Serum albumin

Coagulation profile

Prothrombin time

Prothrombin activity

INR

Appendix 2: Surgical Site Infection Assessment Scale

Factors	Score
1. Preoperative risk factors	
Age	
20–<30	0
30–<40	1
40–<50	2
50–60	3
Educational level	
Educated	0
Non-educated	1
Smoking	
Non-smoker	0
Smoker	1
Body weight	
Ideal weight	0
Underweight	1
Overweight	2
Preoperative medications	
Corticosteroids	
No	0
Yes	1
Antibiotic prophylaxis	
24 h preoperative	0
Immediate preoperative	1
None	2
Site of surgical operation	
Non-abdominal	0
Abdominal	1
Associated diseases	
No	0
One disease	1
More than one	2
Results of laboratory investigations	
Normal	0
Abnormal	1
Length of hospital stay (days)	
1	0
2	1
3 or more	2
Surgical site preparation	
Showering	
Complete bath	0
Partial bath	1
Not done	2
Shaving time	
Immediate preoperative	0
At night before surgery	1

Shaving method		Closed	0
Electrical machine	0	Open	1
Razor	1	Both	2
Use of skin antiseptic solution		Day of drain removal	
Yes	0	1st	0
No	1	2nd	1
Covering the site of operation after disinfection		3rd	2
Yes	0	More than 3 days	3
No	1	Use of antiseptic solutions in wound cleansing	
2. Intraoperative risk factors		Yes	0
Type of anesthesia		No	1
Regional	0	Use of wound dressing	
Spinal	1	Conventional (gauze and cotton)	0
General	2	Other	1
Classification of surgical wound		Length of hospital stay (days)	
Clean	0	1	0
Clean-contaminated	1	2	1
Contaminated	2	3 or more	2
Infected	3	Hydration status	
Use of antibiotics		Normal	0
Yes	0	Abnormal	1
No	1	Nutritional status	
Blood transfusion		Normal	0
No	0	Abnormal	1
Yes	1	Use of antibiotics	
Hemodynamic stability (vital signs and hydration)		Yes	0
Normal	0	No	1
Abnormal	1	Closure technique	
Excessive use of diathermy		Staples	0
No	0	Sutures	1
Yes	1	Other	2
Duration of surgery (h)		Suturing material	
<2	0	Non-silk	0
2	1	Silk	1
>2	2	Total preoperative score	22
3. Postoperative risk factors		Total intraoperative score	11
Body temperature		Total postoperative score	22
Normal	0	Total score	55
Abnormal	1		
Mobility			
Early ambulation	0		
Bed ridden	1		
Day of the first dressing			
1st	0		
2nd	1		
3rd	2		
More than 3 days	3		
Presence of drains			
Absent	0		
1 drain	1		
More than 1 drain	2		
Type of drain			

Appendix 3: Surgical Site Infection Assessment Scale

Factors	Score
1. Preoperative risk factors	
Age	
20–<30	0
30–<40	1
40–<50	2
50–60	3
Educational level	
Educated	0
Non-educated	1
Smoking	
Non-smoker	0
Smoker	1
Body weight	
Ideal weight	0
Underweight	1
Overweight	2
Preoperative medications	
Corticosteroids	
No	0
Yes	1
Antibiotic prophylaxis	
Yes	0
No	1
Site of surgical operation	
Non-abdominal	0
Abdominal	1
Associated diseases	
No	0
Yes	1
Results of laboratory investigations	
Normal	0
Abnormal	1
Length of hospital stay (days)	
1	0
2	1
3 or more	2
Surgical site preparation	
Showering with antiseptic solution	
Yes	0
No	1
Shaving time	
Immediate preoperative	0
At night before surgery	1
Shaving method	
Electrical machine	0
Razor	1
Covering the site of operation after disinfection	

Yes	0
No	1
2. Intraoperative risk factors	
Type of anesthesia	
Spinal	0
General	1
Classification of surgical wound	
Clean	0
Clean-contaminated	1
Contaminated	2
Infected	3
Use of antibiotics	
Yes	0
No	1
Body temperature	
Normal	0
Abnormal	1
Duration of surgery (h)	
<2	0
2	1
>2	2
3. Postoperative risk factors	
Body temperature	
Normal	0
Abnormal	1
Mobility	
Early ambulation	0
Bed ridden	1
Presence of drains	
Absent	0
1 drain	1
More than 1 drain	2
Type of drains	
Closed	0
Open	1
Both	2
Day of drain removal	
1st	0
2nd	1
3rd	2
More than 3 days	3
Length of hospital stay (days)	
1	0
2	1
3 or more	2
Use of antibiotics	
Yes	0
No	1
Suturing technique	
Removable	0
Absorbable	1
Suturing material	

Non-silk	0
Silk	1
Total preoperative score	18
Total intraoperative score	8
Total postoperative score	14
Total score	40

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