Factors Predicting Surgical Site Infection in Older Adults Undergoing Abdominal Surgery: A Retrospective Cohort Study

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Abstract: Surgical site infection is a significant health problem among nosocomial infections, leading to post-operative mortality in surgical older adults. Identifying risk factors is essential in surgical care quality. This retrospective cohort study, conducted at a university hospital in Bangkok, rigorously examined the surgical site infection rate and its predictive factors in older adults undergoing abdominal surgery. The study employed convenience sampling to recruit 300 older adults who underwent abdominal surgery using the code of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and completion of electronic medical records between January 1 and December 31, 2020. The instruments used included the Demographic Characteristics Form, the Preoperative Clinical Characteristics Form, the Intraoperative Record Form, and the Post-operative Record Form. The data collected were analyzed using descriptive statistics and binary logistic regression analysis, ensuring a comprehensive and robust analysis of the risk factors for surgical site infection in older adults undergoing abdominal surgery.

The results of this study revealed that 63.25% of participants were female, with a mean age of 74.5 years. The surgical site infection rate was 12 per 100 patients, varying across anatomical locations and surgical procedures, ranging from 0.33% to 5.66%, with colon surgery being the most common. The study identified significant risk factors predicting surgical site infection, including comorbidities and obesity class 2, while the American Society of Anesthesiologists Physical Status class 2 and 3 were identified as protective factors. These findings provide a powerful tool to screen patients at risk of surgical site infection in nursing practice, particularly with older adults undergoing colon surgery, and to prevent surgical site infection.

Keywords: Abdominal surgery, Comorbidity, Obesity, Older adults, Surgical site infection

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Introduction

Surgical site infection (SSI) is a significant health problem for older adults. It has been estimated that the number of general surgeries in older adults will increase by at least 18% between 2010 and 2050.[1] Abdominal surgery is considered a major surgery that aims at diagnosing the disease and determining abnormality of the abdominal organs so that necessary treatment can be administered to maintain their functioning. After the surgery, the older persons will have a large surgical wound on their abdomen. When SSI takes place, undesirable treatment

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outcomes may quickly arise. However, a lot of abdominal surgery these days is undertaken using laparoscopy.

One of the most critical post-operative complications is SSI. The global incidence rate of SSI within 30 days post-operative is approximately 11 per 100 general surgical patients.[2] The SSI rate in abdominal surgery ranges from 4.09% to 26.9%.[3] The incidence of SSI is higher among those who are older adults.[4]

SSI is a nosocomial infection that occurs while hospitalized. It can be found at all levels, including public and private hospitals. It reflects the quality of care provided by the hospital. Patients who experience SSI have to be hospitalized for a more extended period, they may suffer long-term disability, they may develop resistance to antibiotics used in the treatment, and they may have to bear the burden of increased medical care costs.[5]

SSI affects older adults physically, psychologically, and economically. As for physical effects, SSI can lead to death. It has been found that SSI is responsible for 3% of post-operative deaths, and 75% of those who died had SSI.[6] In addition, there are also long-term effects. A previous study on post-operative infection reported an SSI rate of 40.2% within 30 days in post-operative infection. Individuals who had infections within this initial 30-day period were found to have a 3.2 times increased risk of developing long-term infections within 365 days and 1.9 times increased risk of mortality compared to those who did not have post-operative infections within the first 30 days after surgery.[7] Besides physical effects, psychological effects can result from pain that is caused by inflammation in the surgical site as well as increased anxiety after the onset of SSI. Finally, regarding economic effects, older adults have to face increased medical care costs from the prescribed treatment, including examination fees, antibiotics, and prolonged hospitalization.[5] Some older adults must return to the hospital for readmission and re-operation after initial discharge.[5] Prevention of SSI can be done by providing close and regular care and reducing various risk factors that can lead to SSI. Therefore, to ensure quality of care, nosocomial infections, including SSI, need to be monitored and prevented.

According to the Centers for Disease Control and Prevention, SSI risk factors can be divided into host, agent, and environmental factors.[8] Older adults tend to have different host factors due to age-related deteriorations and comorbidities. For example, they have to take different types of medication regularly, and their wound heals at a slower rate.[9] In addition, their immune system changes in different ways, both inside and outside of the body, such as thinning of the skin and less effective functioning of the innate immunity, which make them more susceptible to infection when they are injured due to a poor mechanism that fights against the pathogens that have entered the body.[10] These changes make older adults undergoing abdominal surgery more susceptible to SSI.

SSI in abdominal surgery is common, especially in older adults who tend to have comorbidities and polypharmacy. In previous studies, risk factors of SSI include age, comorbidities, obesity, low albumin level, the American Society of Anesthesiologists (ASA) classification, and emergency surgery.[3] Previous research has explored numerous risk factors associated with SSI; however, significant gaps remain in understanding specific risk factors and their associated outcomes in older adult patients undergoing abdominal surgery. In addition, older adults exhibit unique risk factors due to physiological changes associated with aging and frailty. Further investigation is warranted to clarify the relationship between these risk factors and SSI in older adult patients undergoing abdominal surgery.

In this study, data were collected from the electronic medical records (EMR) of older adults aged 60 years and older who had undergone abdominal surgery. The aim was to predict risk factors and the rate of SSI in these adults. It was anticipated that the findings of this study could be used as baseline data to develop a practice guideline to monitor and prevent SSI in these older adults to increase the quality of care outcomes.

Conceptual Framework

In this study, the conceptual framework was synthesized from a review of literature on selected study variables and the epidemiology theory proposed by the Centers for Disease Control and Prevention (CDC), which explains that there are three components of infection—the host, agent, and environment.[8] These three components should be considered to search for the SSI rate and determine the factors predicting SSI in older adults undergoing abdominal surgery. SSI is an infection that occurs within 30 days after the patient has undergone surgery.[6] In our study, the physicians diagnosed SSI.

A literature review has shown that SSI risk factors include the host factor of age. Older adults tend to be more susceptible to infection.[11] A study with patients undergoing orthopedic surgery found that patients older than 60 had a 2.216 times increased risk of SSI.[12] Another study showed that increased age increased the risk of SSI.[13] An increase in age affects the pathogen prevention system, starting from the skin, the first barrier. The skin becomes thinner with age, and the blood circulation to the skin reduces; hence, there is a greater possibility of infection when older adults are injured.[14] In addition, an increasing age affects innate immunity, particularly neutrophils and monocytes, which undergo changes, which, in turn, decrease the functioning of the immune system.[10] In fact, the number of cells does not reduce, but their functioning does as their efficiency reduces with age.[15] Thus, when the pathogen enters the body or the surgical site is contaminated, the body cannot respond by getting rid of the pathogen, thus causing SSI. In addition, an increase in age also means more susceptibility to chronic conditions, more likelihood to use multiple medications, more vulnerability, and physiological deterioration, hence slower recovery. The slower recovery, coupled with changes in the body's immune system and defense mechanisms, means that age can be considered a risk factor for SSI. In this study, age was counted using the birthdates of the patients for an entire year.

Having one comorbidity increases the chances of SSI by 1.58 times, and a higher number of comorbidities further escalates the risk of SSI.[16] Having comorbidity is expected among older persons, with hypertension and diabetes mellitus being the most prevalent at 58.3% and 19.4%, respectively. According to one study, 75.8% of older adults had at least one comorbidity.[17] Furthermore, it has been reported that diabetes mellitus is associated with the risk of SSI and increases the risk of SSI by 1.53 times.[18] In this study, comorbidity refers to the existence of more conditions or diseases within the health of older adults, such as diabetes mellitus, hypertension, chronic obstructive pulmonary disease, coronary artery disease, chronic kidney failure, etc. In this study, comorbidity was assessed by giving a count of 1 point to each condition or disease.

Obesity is at risk for SSI, including complexity and difficulty of surgery, oxygen supply to poor adipose tissue, and wound healing. Obesity increases surgical complexity and extended operative times due to sizeable adipose tissue, making the surgery more complex and longer lasting, which in turn increases the risk of SSI.[21] Obesity increases the risk of SSI by 1.1 to 4.4 times when compared between obese and non-obese, depending on the type of operation.[22] In terms of obesity and abdominal surgery, it was found that obesity increased the risk of SSI of clean wounds and clean-contaminated wounds with statistical significance in a study in which obesity was free from diabetes mellitus.[23] Therefore, it could be concluded that obesity without diabetes mellitus also increases the risk of SSI. In this study, obesity was considered the condition in which individuals have body weight and height more than the standard criterion by the World Health Organization (WHO). Body mass index (BMI) was used to determine obesity, as calculated using body weight in kilograms divided by height in meters to the second power and shown in kg/m^2. In general, the BMI of Asian people is as follows: a BMI of 25-29.9 kg/m^2 means level 1 of obesity and a BMI higher than 30 kg/m^2 means level 2 of obesity.[24]

The American Society of Anesthesiologists (ASA) classification evaluates a patient's physiological condition before surgery to assess clinical health problems. The assessment is done by considering health status, chronic illnesses, severity of chronic diseases, and sickness conditions.[19] An ASA classification greater than 3 has a higher incidence of SSI than an ASA classification less than 3.[20] However, some studies have found that the rate of SSIs in ASA class 1 and 2 (52.6%) is higher than in ASA class 3 and 4 (47.4%).[4] Therefore, further investigation was warranted to draw conclusive insights into these variables. In this study, a team of anesthetists used the ASA classification to assess the preoperative physical status of older adults.

Patients with malnutrition are 1.81 times more likely to develop SSI compared to those who do not have malnutrition.[25] It is generally accepted that supplementary diets, in addition to proteins, fats, carbohydrates, and amino acids, can help boost immunity and promote wound healing. A previous study found that preoperative nutritional supplementation can reduce the incidence of SSI.[26] Malnutrition refers to the condition in which the body receives inappropriate nutritional intake in quantity and quality. This study assessed malnutrition using the Nutrition Alert Form (NAF).[27] The scores were classified as follows:

NAF = A (normal-mild malnutrition), with a score of 0-5 points

NAF = B (moderate malnutrition), with a score of 6-10 points

NAF = C (severe malnutrition), with a score of 11 points or higher

Normal to mild malnutrition was at the 85th percentile, moderate malnutrition was at the 70th percentile, and severe malnutrition was at the 72nd (kappa statistic = 0.57). The reliability of the eight items was 0.561.[27]

Previous studies reported that emergency open abdominal surgery is associated with SSI[4] and increases the risk of SSI by 1.156 times.[23] It is deemed necessary that a study investigating factors related to SSI be carried out. In this study, the type of surgery referred to the urgency of the surgery. The data were collected from the participants' EMRs and categorized as emergency or elective surgery.

As for the environmental factors of surgical wounds, bacterial colonization on the patients' skin, gastrointestinal tract, and reproductive system can lead to SSI. Abdominal surgery results in a higher prevalence rate of SSI compared to other types of surgical procedures. Of SSIs, 70% to 95% are caused by endogenous pathogens of patients[28]—the microorganisms in the organ in the abdominal cavity, such as the gastrointestinal system. The gastrointestinal tract contains important microorganisms that play a role in maintaining immune balance and protecting the human body from pathogens.[29] Conversely, these microorganisms may transform into pathogens that cause post-operative wound infections. In general, pathogens found in the abdomen of patients who developed SSI included gram-negative bacteria, with enterobacteria being found in 53.84 % of cases, 39.56% *Escherichia coli*, 17.58% *Pseudomonas aeruginosa*, and 8.79% *Enterococcus*, while coagulase-negative included *Staphylococcus species* were found in 6.49% of the cases. In comparison, *Candida albicans* fungi were 3.3% of the cases.[30] These pathogens are causes of SSI and can be found in the body of the patients depending on the type and stages involved in the surgery.[31]

As for the pattern of infection, when a pathogen in the environment enters the body of the weak host, infection can occur. The cause of infection is the interaction between the agent and the host in an environment that promotes such an interaction. According to the epidemiology theory, this study included age, comorbidity, obesity, malnutrition, preoperative physical status determined by the ASA classification, and type of surgery to predict SSI.

Study Aims

This study aimed to investigate the SSI rate in older adults undergoing abdominal surgery and determine the predictive power of age, comorbidity, obesity, malnutrition, ASA classification, and type of surgery to predict SSIs in this patient cohort.

Methods

Design: This study was a retrospective cohort study of older adults undergoing abdominal surgery, which followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statements.

Population and Sample: The population of this study consisted of older adults aged ≥ 60 who underwent abdominal surgery at a university hospital in Bangkok, Thailand. The sample size appropriate for logistic regression analysis was calculated using the concept of Burmeister and Aitken[32] with the smallest possible sample size of 20 per variable under study. In this study, there were seven variables. The independent variables included age, comorbidity, obesity, malnutrition, ASA classification, and type of surgery, while the dependent variable was SSI. The ratio could be increased to ensure good predictive power of all selected independent variables in this study. Thus, the researchers increased the sample size to 50 per variable,[33] totaling six independent variables to determine the predictive power of the independent variables to predict SSI in older adults undergoing abdominal surgery. The final sample size required was 300. The sample was obtained following inclusion criteria: adults 60 years and older; had undergone open abdominal surgery with the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes; and had complete data available up to 30 days post-operation during the period January 1 to December 31, 2021. They were excluded if the required data in the EMR were incomplete, missing or not fully documented.

Research Instruments: This study administered a questionnaire comprising two sections: demographic characteristics and clinical data. The latter was composed of three instruments. Researchers developed the questionnaire and verified it by an ethical committee before collecting the data from EMRs.

The *Demographic Characteristics Form* consisted of seven items that sought participant data, which included age, gender, body weight, height, date of hospital admission, date of abdominal surgery, date of hospital discharge, and length of hospital stay.

Clinical data instruments:

The *Preoperative Clinical Characteristics Form* comprised five items: chronic illness, obesity, malnutrition, preoperative physical status, assessed using the ASA classification, and preoperative hospital stay.

The *Intraoperative Record Form* consisted of surgical procedures, antibiotic prophylaxis, type of anesthetics, evaluation of the surgical site skin, type of surgical wound, and type of surgery, all collected with response-type items. In contrast, data regarding the time of surgery, blood loss, and blood oxygen level during surgery were elicited using fill-in-the-blank type items. Data were collected from the medical records kept during the participants' hospitalization.

The *Post-operative Record Form* was used to collect data regarding the diagnosis of SSI within 30 days after the surgery, as diagnosed by the physician and recorded in the EMRs.

Data Collection: The researchers contacted the relevant department of the study hospital to identify the names of older adults aged 60 years and older, totaling 459 participants. After receiving the name list, 300 eligible participants were conveniently selected using the inclusion and exclusion criteria. The researchers collected data in the EMRs by themselves and examined the completion and accuracy of the data before data analysis.

Ethical Considerations: The study received approval No. COA.MURA2022/90 from the Institutional Review Board on Research Involving Human Subjects of the Faculty of Medicine Ramathibodi Hospital, Mahidol University, where the research team belongs. After approval was granted, the researchers collected data without having anything to do with the care and treatment given to the participants. The data collected from the EMRs were kept confidential and reported only as group data without any information to identify the study participants.

Data Analysis: The collected data were analyzed using SPSS (version 21). Descriptive statistics was used to analyze the demographic characteristics. Factors predicting SSI in older adults undergoing abdominal surgery, including age, comorbidity, obesity, malnutrition, ASA classification, and type of surgery, were analyzed using logistic regression analysis with the significance level set at .05. The assumptions of multicollinearity and autocorrelation were tested, with the dependent variable of the study being SSI with two values of 0, meaning no SSI, and 1, meaning SSI. The independent variables were not interrelated, there was no multicollinearity problem, and the correlation coefficient was not higher than .85.

Results

In this study, data were collected from the medical records of 300 patients undergoing open abdominal surgery, with the code of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), at a university hospital located in Bangkok, Thailand, between January and December 2021. Of these 36 participants with SSI, 22 (13%) were female. Of those who had SSI, 15 participants (14.2%) were between 70 and 79 years old, and 34 (12.7%) had comorbidity, with 28 (13.2%) and 17 participants (19.1%) having hypertension and diabetes mellitus, respectively. While 264 participants who had no SSI, 130 participants (91.5%) were between 60-69 years, 233 (87.3%) had comorbidity, with 184 (86.8%) and 72 (80.9%) had hypertension and diabetes mellitus, respectively.

When considering the comorbidity of the participants who developed SSI, most had three comorbidities. While the participants had no SSI, most had two comorbidities. Thirteen participants with SSI (15.5%) were classified under obesity class 1 (BMI 25.0-29.9 kg/m^2), and 8 (28.6%) were classified as obesity class 2 (BMI ≥ 30.0 kg/m^2). Ninety-six participants with no SSI (94.1%) had a normal BMI (18.5-22.9 kg/m^2), while 13 (14.4%) had moderate malnutrition, and seven (28%) had severe malnutrition. In contrast, 77 (85.6%) with no SSI had moderate malnutrition, and 18 (72%) had severe malnutrition. Furthermore, seven participants with SSI (31.8%) had ASA class 4 preoperative physical status, while 15 participants with no SSI (68.2%) had ASA class 4 preoperative physical status. Finally, of the participants who developed SSI, 16 (19.8%) underwent emergency surgery, and 32 (13%) had a clean-contaminated surgical wound classification. In comparison, of the participants who had no SSI, 65 (80.2%) and underwent emergency surgery, 215 (87%) were classified as clean-contaminated surgical wounds classification, as shown in **Table 1**.

Table 1. Demographic characteristics of participants with surgical site infection (SSI) and non-surgical site infection (N = 300)

Demographic characteristics	Surgical site infection	
	No (%) (n = 264)	**Yes (%) (n = 36)**
Gender		
Female	147 (87.0)	22 (13.0)
Male	117 (89.3)	14 (10.7)

Table 1. Demographic characteristics of participants with surgical site infection (SSI) and non-surgical site infection (N = 300) **(Cont.)**

Demographic characteristics	Surgical site infection	
	No (%) (n = 264)	**Yes (%) (n = 36)**
Age (years), Median (IQR) = 70 (65-77)		
Young-old (60-69)	130 (91.5)	12 (8.5)
Middle-old (70-79)	91 (85.8)	15 (14.2)
Old-old (≥80)	43 (82.7)	9 (17.3)
Comorbidity*		
No	31 (93.9)	2 (6.1)
Yes	233 (87.3)	34 (12.7)
Hypertension	184 (86.8)	28 (13.2)
Diabetes mellitus	72 (80.9)	17 (19.1)
Dyslipidemia	102 (85.7)	17 (14.3)
Chronic kidney disease	22 (71.0)	9 (29.0)
Cardiovascular disease	21 (75.0)	7 (25.0)
Cancer	12 (75.0)	4 (25.0)
Obstructive sleep apnea	5 (71.4)	2 (28.6)
Number of comorbidities		
Median (IQR) = 2 (1-3), Mean (SD) = 1.91 (1.14)		
No comorbidities	31 (93.9)	2 (6.1)
1	67 (93.1)	5 (6.9)
2	103 (92.0)	9 (8.0)
3	50 (83.3)	10 (16.7)
4	12 (66.7)	6 (33.3)
5	1 (25.0)	3 (75.0)
6	0 (0)	1 (100)
Body mass index (kg/m^2)		
Median (IQR) = 23.77 (20.93- 26.78)		
< 18.5 (Underweight)	25 (92.6)	2 (7.4)
18.5-22.9 (Normal)	96 (94.1)	6 (5.9)
23.0-24.9 (Overweight)	52 (88.1)	7 (11.9)
25.0-29.9 (Obese class1)	71 (84.5)	13 (15.5)
≥ 30.0 (Obese class2)	20 (71.4)	8 (28.6)
Malnutrition		
Normal to mild malnutrition	169 (91.4)	16 (8.6)
Moderate malnutrition	77 (85.6)	13 (14.4)
Severe malnutrition	18 (72.0)	7 (28.0)
ASA Classification		
ASA class 1	4 (80.0)	1 (20.0)
ASA class 2	100 (92.6)	8 (7.4)
ASA class 3	145 (87.9)	20 (12.1)
ASA class 4	15 (68.2)	7 (31.8)

Table 1. Demographic characteristics of participants with surgical site infection (SSI) and non-surgical site infection (N = 300) **(Cont.)**

Demographic characteristics	Surgical site infection	
	No (%) (n = 264)	**Yes (%) (n = 36)**
Type of surgery		
Elective surgery	199 (90.9)	20 (9.1)
Emergency surgery	65 (80.2)	16 (19.8)
Surgical wound classification		
Clean	41 (91.1)	4 (8.9)
Clean contaminated	215 (87.0)	32 (13.0)
Contaminated	7 (100)	0 (0)
Dirty	1 (100)	0 (0)

Note. *One participant could have more than one congenital disease.

Thirty-six participants had SSIs, with the rate ranging from 0.33% to 5.66%, depending on the surgical procedures. As displayed in **Table 2**, 17 participants (5.66%) had colon surgery, five (1.66%) had an abdominal hysterectomy, and four (1.33%) had gallbladder surgery.

Table 2. Surgical site infection rates by the type of surgical procedures (N = 300)

Surgical Procedures data	Surgical site infection		SSI rate
	No (%) (n = 264)	**Yes (%) (n = 36)**	
Surgical procedures*			
Colon surgery	78 (82.1)	17 (17.9)	5.66
Abdominal hysterectomy	54 (91.5)	5 (8.5)	1.66
Gallbladder surgery	13 (76.5)	4 (23.5)	1.33
Bile duct liver or pancreatic surgery	54 (94.7)	3 (5.3)	1.00
Appendix surgery	24 (88.9)	3 (11.1)	1.00
Gastric surgery	15 (88.2)	2 (11.8)	0.66
Small bowel surgery	11 (91.7)	1 (8.3)	0.33
Rectal surgery	7 (87.5)	1 (12.5)	0.33
Ovarian surgery	8 (100)	0	0

Note. *Surgical procedures = open abdominal surgery

The independent variables that could predict SSI with statistical significance at a .05 level were comorbidity, obesity, and physical status based on ASA classification. To further explain, with one additional comorbidity, the risk of SSI increased by 1.83 times with statistical significance ($p < .05$) (OR = 1.825, 95% CI = 1.210-2.753, p = .004). Older patients who had obesity class 2 (BMI ≥ 30.0 kg/m^2) had 5.72 higher chances of developing SSI with statistical significance when compared with those who were not obese ($p < .05$) (OR = 5.717, 95%CI = 1.918-17.040, p = .002). Moreover, those with ASA class 2 were 91.8% less likely to develop SSI with statistical significance compared to those with ASA class 1 ($p < .05$) (OR = .082, 95% CI = .007-.993, p = .049) and those with ASA class 3 were 93.7% less likely to suffer from SSI compared to those with ASA class 1 with statistical significance ($p < .05$) (OR = .063, 95% CI = .005-.827, p = .035). Finally, this study discovered that age, malnutrition, and type of surgery could predict SSI with no statistical significance, as displayed in **Table 3**.

Table 3. Binary logistic regression analysis of factors predicting abdominal surgical site infection in older adults undergoing abdominal surgery (N = 300)

Prediction factor	B	S.E.	df	p-value	Exp(B)/OR	95%CI	
						Lower	Upper
Age	.026	.026	1	.314	1.026	.976	1.079
Comorbidities	.602	.210	1	.004	1.825	1.210	2.753
No obesity			2	.007		Reference	
Obese class 1	.671	.450	1	.136	1.956	.809	4.728
Obese class 2	1.744	.557	1	.002	5.717	1.918	17.040
N. nutrition			2	.263		Reference	
M. malnutrition	.419	.444	1	.345	1.521	.637	3.633
S. malnutrition	.930	.590	1	.115	2.535	.797	8.062
ASA class 1			3	.173		Reference	
ASA class 2	-2.505	1.275	1	.049	.082	.007	.993
ASA class 3	-2.758	1.310	1	.035	.063	.005	.827
ASA class 4	2.337	1.459	1	.109	.097	.006	1.687
Emergency surgery	.627	.423	1	.138	1.872	.817	4.288
Constant	-3.573	1.976	1	.071	.028		

Note. -2 Log likelihood = 181.492; Nagelkerke R^2 = .233

Homer and Lemeshow test: $p > .05$

Abbreviations: OR = Odds ratio; CI = Confidence interval, Comorbidities = Number of comorbidities, N. nutrition = Normal nutrition, M. malnutrition = Moderate malnutrition, S. malnutrition = Severe malnutrition

Discussion

We found that the SSI rate was 12 per 100 surgical patients. The SSI rate in nine surgical procedures ranges from 0.33% to 5.66%. The highest rate of infection was found in colon surgery; the operations were in the gastrointestinal tract, which generally involves higher rates of SSI compared to clean surgical wounds.[31] These findings were consistent with a study where the incidence of SSI in patients undergoing colon surgery was the highest, accounting for 9.3%.[34] The three main components of infection could explain this. Colon surgery is associated with an increased risk of SSI due to the large number of microorganisms present. These microorganisms are essential in the digestive system and protect against other pathogens to maintain the balance of the gastrointestinal tract.[29] At the same time, during intraoperative, these microorganisms from the intestinal tract can potentially transform into infectious agents that contribute to post-operative wound infections when contamination occurs during the surgical process. In addition, the participants in this study were older than 60. An older age affects the length of time required for recovery and rehabilitation[15] as well as the lower immunity of the body to fight the pathogen,[14] hence increasing the likelihood of SSIs occurring.

Most participants who developed SSIs were in the middle-old age range (70-79 years). Infections are more common in older adults because age-related changes in immunity also occur. Even though the number of immune systems in the body cells does not decline, their functioning and efficiency are affected.[15] Surgical wound infection can occur when the body has a surgical wound and pathogens are present. In addition, an increase in age means physical changes related to protection from the pathogen. For example, age-related changes in the structure of the skin cause it to become sensitive, the size of the cutaneous blood vessels become smaller, resulting in impaired immunity, and loss of collagen in the dermis causes the skin to become thinner, which, when coupled with loss of excretions, make older adults more susceptible to infections.[14] For these reasons, the skin at the surgical site may be easily infected. Besides this, older adults tend to have multiple comorbidities, take different kinds of medication, may be increasingly vulnerable, or have deteriorated immunity, all of which increase their risk of SSI.[9]

Our findings demonstrate that the personal factors of older adults undergoing abdominal surgery predict SSI, including comorbidities, obesity, and ASA classification, all of which could predict SSI with statistical significance. As regards the number of comorbidities, an increase in one disease increased the chance of SSI by 1.83 times. The participants who suffered from SSI were more likely to have co-morbidities. Of the 36 participants who developed SSI, 34 had more than one comorbidity, such as hypertension, diabetes mellitus, and dyslipidemia. The relationship between comorbidity and SSI was similar to another study[17] that investigated SSI in patients undergoing surgery for spinal tumors and found a 1.68-time increased risk of SSI as a result of an increase in the number of comorbidities. Their comorbidities were consistent with the disease, which increases the risk of SSI.

A study on hypertension and SSI showed that hypertension could increase the risk of surgical infection by 1.4 times.[35] Hypertension is commonly found in older adults; thus, the blood vessel walls are more brittle, causing them to lose more blood during surgery. The blood circulation to the skin and tissues may also be poor, and surgical wound healing takes longer.[36] For these reasons, hypertension is a significant risk factor for SSI. A previous study reported that patients with diabetes were 1.53 times more likely to develop SSI because of poor blood circulation to different tissues in surgical sites, hence a delay in wound healing.[18] Moreover, a high plasma glucose level affects the immune system,[37] which works to get rid of pathogens in the body, increasing susceptibility to infection. Diabetes mellitus is a crucial factor in SSI and wound healing. One of the measures to prevent SSI is to control the plasma glucose level to keep it within the normal range. A study reported that the most common comorbidity found in patients with general SSI was diabetes mellitus.[11] Diabetes mellitus is considered a significant risk factor for SSI, so patients with diabetes need to control their plasma glucose levels to prevent SSI.

However, older adults have different comorbidities that require medication intake and which affect their physical health status and functioning. Also, dyslipidemia is a major cause of cardiovascular disease,[36] which may delay wound healing. Delayed wound healing can lead to SSI. Therefore, it could be concluded that even though different comorbidities increase the chances of SSI differently, depending on severity and association with infection, an increase in comorbidities can increase the risk of SSI. Based on such findings, patients with multiple comorbidities should be assessed before surgery to estimate the risk of SSI so that necessary observation and monitoring can be done to prevent the onset of SSI. However, having other comorbidities can also weaken the patients' health. Furthermore, when patients take numerous medications, particularly immunosuppressant drugs, before the surgery, the mechanism to prevent infection will be affected, and the patients are more susceptible to bacterial infection.

Obesity is another factor affecting SSI. In this study, it was found that patients with level 2 obesity ($BMI \geq 30.0$ kg/m^2) were 5.72 times more likely to suffer from SSI. Likewise, a previous study found that obesity increased the risk of surgical infection in patients undergoing abdominal hysterectomy and major bowel surgery by 1.4 to 4.4 times.[22] Thus, obesity is a significant factor influencing SSI, particularly in abdominal surgery with a large surgical wound because of thicker abdominal wall, thicker fat deposit, and higher surface tension, which delay the healing process of the tissues. SSI after undergoing colorectal surgery was most commonly found, with patients with BMI ≥ 30 kg/m^2 having 1.5 times higher risks of surgical infection compared to those with BMI < 30 k/m.[2] Also, patients with BMI 25-29.9 kg/m^2 had 1.2 times higher risks of SSI compared to those with BMI < 25 kg/sqm.[38]

Obesity is considered a risk factor that may both directly and indirectly increase the risk of SSI as it affects the immune system and the body's inflammatory responses. In addition, obesity causes impaired immunity. The adipose tissues produce cytokines, leptin, and adiponectin, which are necessary for producing immunity. In obese persons, both innate and adaptive immune systems will be reduced.[21] Moreover, when patients have diabetes mellitus or narrowed blood vessels, surgical wound healing will be delayed. If the patients are obese, oxygen transportation to the tissues may not be adequate, and obesity may make it necessary to increase the dosage of antibiotics to eliminate the pathogen that has caused the problems. Furthermore, as the surgical wounds of obese patients may be larger with more surface tension, it is likely that the sutures may not hold, resulting in wound dehiscence.

In this study, there were participants classified as class 1 obese (28%) and class 2 obese (9.3%), and 19.7% of them were overweight. Presently, in Thailand, maintaining one's BMI within the normal criteria is well recognized to prevent possible health problems and ensure the quality of life of older adults. In addition to physiological risk, patients with obesity tend to have diabetes and atherosclerosis, hence poor blood circulation to the tissues.[21] This results in delayed wound healing. Even though diabetes is a significant comorbidity that increases the risk of SSI, having obesity without diabetes can also increase the risk. A previous study found that obese (BMI = 30-39.9 kg/m^2) but non-diabetic patients undergoing abdominal surgery had 1.23 times higher risk of SSI compared to those with average weight (BMI = 18.5-24.9 kg/m^2).[23] Therefore, obesity is a significant factor in SSI due to poor blood circulation, which may result in gangrene. Care provided to patients with obesity needs to involve the promotion of wound healing to reduce or prevent SSI.

This study found that ASA class 2 and 3 are protective factors. Likewise, previous research found that SSI rates in ASA class 1 and 2 are higher than in class 3 and 4.[4] ASA classification evaluates the overall physical condition of patients before the surgery, including the risk of mortality when anesthetics are administered. However, even though patients may be classified as ASA class 1, they may have a comorbidity that has never been diagnosed before the surgery, and their health status may change after the surgery. In this study, most participants had ASA class 3. They were older than 60 years old and had at least one comorbidity.

The ASA classification was devised to inform preoperative, intraoperative, and postoperative care plans. Those with an ASA class 2 or higher need to be closely monitored to prevent postoperative complications. Physical rehabilitation is also supported, hence a lower incidence of SSI, and healthcare providers need to provide the knowledge for older adults to reduce the risk of postoperative complications and improve the quality of care.

However, a previous study investigating SSI risk factors showed that patients with ASA class 2 or higher were 1.782 times more likely to have SSI than those with ASA class 1.[39] Similarly, a previous study found that an ASA class greater than 3 has a higher incidence of SSI than an ASA class less than 3.[20] Poor health status or frail health with severe comorbidity delays the patients' rehabilitation and increases their risk of postoperative complications. Conversely, the participants evaluated to be healthy might have an underlying disease or experienced undetected abnormal health conditions. When the body undergoes surgery or stress response, it results in atypical symptoms.[1] This study focused on older adults, who typically undergo immune system decline and slower physical recovery compared to younger participants who were assessed to have poor health conditions before the surgery and might have received close monitoring and post-operative rehabilitation, resulting in reduced post-operative complications.

In conclusion, we found that the highest rate of SSI was in colon surgery when considering the three significant components of host, agent, and environment. In this study, the host referred to older adults undergoing abdominal surgery. Older adults are considered vulnerable individuals who may endure age-related physical deterioration and tend to have comorbidities. Environmental factors include intestinal tract surgery, which involves an organ crucial for the body due to its essential microorganisms. At the same time, these microorganisms become contaminated during surgery; they may become pathogens and cause surgical wound infections.

However, additional laboratory culture tests may be necessary to understand the cause of SSI definitively. The findings of this study indicated that the number of comorbidities and obesity class 2 are significant risk factors predicting SSI. At the same time, ASA class 2 and ASA class 3 were identified as protective factors. These factors could be determined before the surgery. When older adults have elective surgery and there are appropriate care plans to prevent SSI, the incidence of SSI could be reduced.

Limitations

This study was a retrospective cohort study that collected secondary data recorded in EMR; therefore, the completeness and accuracy of data in this study are based on the data recorded.

Implications for Nursing Practice and Research

The results of this study have direct and practical implications for daily practice, equipping healthcare professionals with the knowledge to manage SSI better. These findings provide a powerful tool to screen patients at risk of surgical site infection in nursing practice, particularly with older adults undergoing colon surgery, and to prevent surgical site infection. While ASA class 2 and ASA class 3 were identified as protective factors, nurses could design and implement preventive measures for the high-risk group. Further research studies should explore ways to prevent SSIs in older adults undergoing abdominal surgery, such as how to utilize knowledge to better manage surgical site infection and how to monitor SSI at preoperative, intraoperative, and postoperative phases.

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ปัจจัยทำนายการติดเชื้อตำแหน่งแผลผ่าตัดช่องท้องในผู้สูงอายุ : การศึกษาจากเหตุไปหาผลแบบย้อนหลัง

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บทคัดย่อ: การติดเชื้อตำแหน่งแผลผ่าตัดเป็นปัญหาทางสุขภาพที่สำคัญของการติดเชื้อในโรงพยาบาลซึ่งนำเป็นสู่การเสียชีวิตหลังผ่าตัดในผู้สูงอายุที่ได้รับการผ่าตัด การระบุปัจจัยเสี่ยงจึงเป็นสิ่งสำคัญในคุณภาพของการดูแลภายหลังได้รับการผ่าตัดเพื่อป้องกันการติดเชื้อตำแหน่งแผลผ่าตัด การศึกษาเชิงวิเคราะห์แบบย้อนหลังนี้มีวัตถุประสงค์เพื่อศึกษาอัตราการติดเชื้อแผลผ่าตัดและปัจจัยทำนายการติดเชื้อตำแหน่งแผลผ่าตัดช่องท้องในผู้สูงอายุ กลุ่มตัวอย่างได้รับการคัดเลือกตามความสะดวก จำนวน 300 ราย เป็นผู้ป่วยที่ได้รับการผ่าตัดช่องท้องตามรหัส ICD-9 ที่โรงพยาบาลระดับมหาวิทยาลัย 1 แห่ง กรุงเทพมหานคร ระหว่างเดือน 1 มกราคม ถึง 31 ธันวาคม พ.ศ. 2563 และการบันทึกข้อมูลอิเล็กทรอนิกส์ทางการแพทย์มีความสมบูรณ์ของข้อมูลที่ศึกษา เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูลเป็นแบบบันทึกข้อมูลต่าง ๆ ได้แก่ ข้อมูลส่วนบุคคล ข้อมูลทางคลินิกก่อนการผ่าตัด ระหว่างผ่าตัด และหลังการผ่าตัด วิเคราะห์ข้อมูลโดยใช้สถิติเชิงบรรยาย และวิเคราะห์ปัจจัยทำนายการเกิดการติดเชื้อตำแหน่งแผลผ่าตัดช่องท้องในผู้สูงอายุ โดยใช้สถิติการวิเคราะห์การถดถอยโลจิสติกแบบไบนารี

ผลการวิจัยพบว่ากลุ่มตัวอย่างเป็นเพศหญิงร้อยละ 63.25 อายุเฉลี่ย 74.50 ปี พบอัตราการติดเชื้อตำแหน่งแผลผ่าตัดของกลุ่มตัวอย่างคิดเป็น 12 ต่อผู้ป่วยที่ผ่าตัด 100 ราย โดยพบอัตราการติดเชื้อตำแหน่งแผลผ่าตัดแตกต่างกันไปตามตำแหน่งของอวัยวะที่ผ่าตัดและหัตถการของการผ่าตัด ระหว่างร้อยละ 0.33 ถึง 5.66 โดยพบจากการผ่าตัดลำไส้มากที่สุด ปัจจัยเสี่ยงที่สามารถทำนายการติดเชื้อตำแหน่งแผลผ่าตัดอย่างมีนัยสำคัญ ได้แก่ การมีโรคร่วม และภาวะอ้วนระดับ 2 ส่วนปัจจัยป้องกัน ได้แก่ การประเมินความเสี่ยงก่อนผ่าตัดตามเกณฑ์ของสมาคมวิสัญญีแพทย์อเมริกา ระดับ 2 (ASA class 2) และ ระดับ 3 (ASA class 3) ผลการศึกษาสามารถนำไปใช้คัดกรองผู้ป่วยที่มีความเสี่ยงต่อการเกิดการติดเชื้อตำแหน่งแผลผ่าตัด ได้แก่ ผู้ที่มีโรคร่วม และมีภาวะอ้วนระดับ 2 ก่อนการผ่าตัดโดยเฉพาะในผู้สูงอายุที่เข้ารับการผ่าตัดลำไส้ใหญ่ เพื่อป้องกันการเกิดการติดเชื้อที่แผลผ่าตัด

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คำสำคัญ: ผ่าตัดช่องท้อง โรคร่วม ภาวะอ้วน ผู้สูงอายุ การติดเชื้อตำแหน่งแผลผ่าตัด

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