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The incidence and risk factors for surgical site infection in older adults after gastric cancer surgery

A STROBE-compliant retrospective study

Jung Ho Kim, MD[a,b,c], Jinnam Kim, MD[a], Woon Ji Lee, MD[a], Hye Seong, MD[a,c], Heun Choi, MD[a,c], Jin Young Ahn, MD[a,c], Su Jin Jeong, MD, PhD[a,c], Nam Su Ku, MD, PhD[a,c,*], Taeil Son, MD[d,*], Hyoung-Il Kim, MD[d], Sang Hoon Han, MD, PhD[a,c], Jun Yong Choi, MD, PhD[a,c], Chang Oh Kim, MD, PhD[a], Joon-Sup Yeom, MD, PhD[a,c], Woo Jin Hyung, MD, PhD[d], Young Goo Song, MD, PhD[a,c], Sung Hoon Noh, MD, PhD[d], June Myung Kim, MD, PhD[a,c]

Abstract

Surgical site infection (SSI) is a well-known complication in older adults. However, there have been no studies on SSI after gastrectomy in older adults. Therefore, we aimed to investigate the incidence, risk factors, and outcomes of SSIs after gastrectomy in older adults.

We performed a retrospective cohort study of older adults, aged 65 years or older, who underwent gastrectomy between January 2015 and December 2015 at the Severance Hospital in Seoul, Korea. The incidence and outcomes of SSIs after gastrectomy were evaluated, and the risk factors for SSI were identified using multivariate analyses.

We identified 353 older adults who underwent gastrectomy. Of these, 25 patients (7.1%) developed an SSI. Multivariate analysis indicated that open surgery (odds ratio, 2.71; 95% confidence interval, 1.13–6.51; $P = .03$) and a longer operation time (odds ratio, 1.01; 95% confidence interval, 1.00–1.01; $P = .04$) were independent risk factors for SSI after gastrectomy. In the SSI group, the incidence of postoperative fever (84.0% vs 51.8%; $P < .001$), length of postoperative hospital stay (13 days vs 6 days; $P < .001$), and re-admission rates within 30 days postoperatively (32.0% vs 3.4%; $P < .001$) were significantly higher than those in the non-SSI group.

The risk factors for SSI in older adults after gastrectomy were open surgery and a longer operation time. When an SSI occurred, the postoperative hospital stay was prolonged and the chances of having a postoperative fever and being re-admitted within 30 days increased.

Abbreviations: ASA = American Society of Anesthesiologists, BMI = body mass index, CAOD = coronary artery occlusive disease, CHF = congestive heart failure, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, CTx = chemotherapy, CVA = cerebrovascular accident, DM = diabetes mellitus, ICH = intracranial hemorrhage, IRB = Institutional Review Board, LND = lymph node dissection, SSI = surgical site infection.

Keywords: gastrectomy, gastric cancer, gastric cancer surgery, older adults, surgical site infection

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[a] Department of Internal Medicine, [b] Graduate School, [c] AIDS Research Institute, [d] Department of Surgery, Yonsei University College of Medicine, Seoul 03722, Republic of Korea.

[*] Correspondence: Nam Su Ku, Department of Internal Medicine, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea (e-mail: smileboy9@yuhs.ac) and Taeil Son, Department of Surgery, Yonsei University College of Medicine, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea (e-mail: tison@yuhs.ac).

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1. Introduction

According to the worldwide data for 2015, gastric cancer is the fifth most common malignancy in the world and the third leading cause of cancer-related death.[1] Gastrectomy is one of the main treatment methods for gastric cancer and among the most common surgical procedures carried out in South Korea. Although advances in surgical techniques and improvements in surgical devices have resulted in reduced mortality after gastrectomy, postoperative complications remain a clinically significant problem.[2]

One of the most common postoperative complications is surgical site infection (SSI). SSI is associated with prolonged hospitalization, decreased quality of life for patients, increased treatment costs, and increased mortality.[3–5] In older adults, 11% of all nosocomial infections are SSIs.[6] Moreover, the number of older adults is steadily increasing; according to 1 study, it is expected to double by 2030.[7] The importance of studying SSIs in older adults is related not only to the increase in the number of older adults, but also to the fact that older adults have various comorbidities, such as diabetes mellitus, poor nutrition, chronic hypoalbuminemia, and decreased body fat, which are known predictors of SSIs.[8] Nevertheless, despite the frequency of SSIs and the adverse effects it has on older adults' clinical outcomes, there are limited data pertaining to the risk factors for SSI in older adults.[9] Furthermore, to the best of our knowledge, there have been no studies on the incidence and risk factors of SSIs after gastric cancer surgery in older adults. Therefore, it is important to study the incidence and risk factors of SSIs after gastric cancer surgery in the population of older adults with a high incidence of gastric cancer in South Korea. The purpose of this study was to investigate the incidence, risk factors, and outcomes of SSIs after gastric cancer surgery in older adults.

2. Materials and methods

2.1. Study design and population

A retrospective cohort study was conducted to investigate the incidence and risk factors for SSIs in older adults with gastric cancer who underwent gastrectomy. Between January 1, 2015 and December 31, 2015, a total of 1067 patients underwent gastric cancer surgery in the Severance Hospital in Seoul, Korea. We excluded the patients who required an emergency surgery, those who underwent an additional surgery for another disease at the time of gastrectomy, as well as the patients with active infections, massive ascites, mental disease, and severe cardiopulmonary disease. Finally, we enrolled 353 patients, aged 65 years or older, who underwent gastric cancer surgery and did not qualify for exclusion. The patients of age 65 years or older were considered older adults based on the age criteria established in the Journal of the American Geriatrics Society.[10] The study was approved by the Institutional Review Board (IRB) of Yonsei University Health System Clinical Trial Center (4-2017-1252). Since the study was retrospective and the study subjects were anonymized, the IRB waived the requirement for patients' written consent.

2.2. Definition of SSI

Surgeons checked for SSIs every day during the hospital stay and at every outpatient clinic visit until 30 days post-surgery.[11] A SSI was defined based on the 1999 Centers for Disease Control and Prevention National Nosocomial Infection Surveillance System manual.[3] The definition included an incisional SSI and organ/space SSI. Incisional SSI was diagnosed if at least 1 of the following criteria was met:

1. purulent drainage from the incision site, with or without laboratory confirmation of an infection;
2. organisms isolated from an aseptically obtained culture of fluid or tissue from the incision;
3. at least 1 sign or symptom of an infection (pain, tenderness, localized swelling, redness, or local heat), in addition to the incision being deliberately opened by the surgeon, unless the incision was culture negative; or
4. diagnosis of incisional SSI by the surgeon or attending physician.[11]

Briefly, incisional SSI was diagnosed when the infection was confined to the incisional site, involving the skin, subcutaneous tissue, fascial, and muscular layers.[12] Organ/space SSI was diagnosed in the presence of at least 1 of the following criteria:

(1) purulent drainage from a drain placed through a stab wound into an organ/space;
(2) organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space;
(3) an abscess or other evidence of an infection involving the organ/space that is found upon examination, during reoperation, or by histopathologic or radiologic examination; or
(4) diagnosis of organ/space SSI made by a surgeon or an attending physician.

2.3. Surgical procedures and perioperative management

The typical surgical procedures for open, laparoscopic, and robotic gastrectomy have been previously described in detail.[13–16] First-generation cephalosporins were administered to all study population within an hour of skin incision according to Centers for Disease Control guidelines.[17] Most surgical procedures were performed in a similar manner among the surgeons. The da Vinci System (Intuitive Surgical, Sunnyvale, CA) was used to perform robotic surgeries. Depending on the location of the tumors, a total or partial gastrectomy was performed. Lymph node dissection, D1, D1+, or D2 was performed according to the 2014 Japanese gastric cancer treatment guidelines.[18] The reconstruction type (Roux-en-Y esophagojejunostomy, gastroduodenostomy, gastrojejunostomy or double tract reconstruction), and method (intra- or extracorporeal) were selected according to the surgeons' preferences.[19]

2.4. Clinical and surgical outcomes

We reviewed the patients' medical records and collected the following information: age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, smoking history, comorbidities (hypertension, diabetes mellitus, cerebrovascular disease, cardiovascular disease, pulmonary disease, chronic kidney disease, and thyroid disease), presence of anemia and hypoalbuminemia, type of gastrectomy, extent of lymph node dissection (LND), and operation time. Cerebrovascular disease included a past history of intracranial hemorrhage or brain infarction. Cardiovascular disease included a coronary artery occlusive disease treated by catheter interventions,

arrhythmia, and congestive heart failure. Chronic kidney disease was defined as a glomerular filtration rate of <60 ml/minute/1.73 m^2 for >3 months, irrespective of the presence of other signs of kidney damage.[20] Hypoalbuminemia was defined as a serum albumin concentration of <3.5 g/dl.[21] Anemia was defined according to the World Health Organization criteria (<13 g/dl in males and <12 g/dl in females).[21] Tumor stages were determined according to the 7th Tumor, Node, Metastasis classification of the American Joint Committee on Cancer/International Union Against Cancer.[22] Body temperatures were measured by a thermometer through the tympanic route.[23] Postoperative fever was defined as a temperature >100°F (38°C) on 2 consecutive postoperative days, or >102.2°F (39°C) on any 1 postoperative day.[24–26] Hospital re-admission was defined according to the Centers for Medicare and Medicaid Services guidelines.[27] Data regarding mortality, postoperative fever, length of the postoperative hospital stay, re-admission within 30 days, incidence of SSI, and type of SSI were also collected as clinical outcomes of interest.

2.5. Statistical analysis

Patients were divided into 2 groups according to the occurrence of SSIs. In order to verify the normality of the continuous variables, Kolmogorov–Smirnov test and Shapiro–Wilk test were conducted, and Mann–Whitney *U* test was used to compare the continuous variables between the 2 groups. Chi-Squared or Fisher exact tests were used to compare the categorical variables. In analyses of risk factors for SSI, all variables with $P < .05$ in the univariate analyses were entered into the multivariate logistic regression model to identify the independent risk factors for SSI. These variables were stage III and IV gastric cancer ($P = .02$), total gastrectomy ($P = .03$), open surgery ($P = .02$), and a longer operation time ($P = .04$). Along with these variables, male gender, generally considered risk factor for SSIs after gastric cancer surgery,[28] was selected as variable of multivariate logistic regression analysis. *P* values of <.05 were considered statistically significant. All statistical analyses were performed using the Statistical Package for Social Sciences software, version 23.0 (IBM, Armonk, NY, USA).

3. Results

3.1. Clinical characteristics of older adults with an SSI after gastrectomy

The clinical and surgical characteristics of the 353 patients who had undergone gastrectomy for stomach cancer are shown in Table 1. The differences in age, sex, obesity, and smoking status between the SSI- and non-SSI groups were not statistically significant. There was no statistically significant difference in the comorbidities, including diabetes mellitus, between the 2 groups. In addition, there was no statistically significant difference between the 2 groups in the ASA score, presence of anemia, presence of hypoalbuminemia, and neoadjuvant chemotherapy, conditions which may affect a patient's condition before surgery.

3.2. Incidence, type, and treatment outcomes of SSIs

Table 2 shows the incidence, type, and treatment outcomes of the SSIs. Among the 353 patients who underwent gastrectomy, 25 (7.1%) developed an SSI. The incidence rates of SSIs in older adults were higher than younger adults but not statistically significant (7.1% vs 4.8%, respectively; $P = .09$). Of the 25 patients in the SSI group, 5 were diagnosed with an incisional SSI, and 20 were diagnosed with an organ/space SSI. In the SSI group, the frequency of postoperative fever was significantly higher than that in the non-SSI group (84.0% vs 51.8%, respectively; $P < .001$). The length of the postoperative hospital stay was significantly longer in the SSI group than in the non-SSI group (13 days vs 6 days, respectively; $P < .001$). The rate of re-admission within 30 days was also significantly higher in the SSI group than in the non-SSI group (32.0% vs 3.4%, respectively; $P < .001$). Of the 8 re-hospitalized patients in SSI group, 4 were re-admitted due to anastomosis site leakage and 4 were re-admitted with intra-abdominal fluid collection. In cases of the 11 re-hospitalized patients in the non-SSI group, 6 were re-admitted with delayed gastric emptying, 3 were re-admitted with upper gastrointestinal

Table 1

Clinical characteristics of older adults with surgical site infection after gastric cancer surgery.

	Total (n = 353)	SSI (−) (n = 328)	SSI (+) (n = 25)	*P* value
Age	71 (67–75)	71 (67.25–75)	70 (66–72.5)	.18
Sex				.85
Male	232 (65.7)	216 (65.9)	16 (64.0)	
Female	121 (34.3)	112 (34.1)	9 (36.0)	
BMI > 25	99 (28.0)	91 (27.7)	8 (32.0)	.65
Smoking	193 (54.7)	178 (54.3)	15 (60.0)	.58
ASA score				.92
3≤	201 (56.9)	187 (57.0)	14 (56.0)	
3>	152 (43.1)	141 (43.0)	11 (44.0)	
Hypertension	188 (53.3)	176 (53.7)	12 (48.0)	.59
DM	77 (21.8)	72 (22.0)	5 (20.0)	.82
ICH	3 (0.8)	3 (0.9)	0 (0.0)	>.99
CVA	22 (6.2)	21 (6.4)	1 (4.0)	>.99
Arrhythmia	9 (2.5)	9 (2.7)	0 (0.0)	>.99
CHF	11 (3.1)	11 (3.4)	0 (0.0)	>.99
CAOD	26 (7.4)	24 (7.3)	2 (8.0)	.71
Asthma	10 (2.8)	10 (3.0)	0 (0.0)	>.99
COPD	8 (2.3)	8 (2.4)	0 (0.0)	>.99
CKD	28 (7.9)	26 (7.9)	2 (8.0)	>.99
Thyroid disease	17 (4.8)	17 (5.2)	0 (0.0)	.62
Anemia	13 (3.7)	13 (4.0)	0 (0.0)	.61
Hypoalbuminemia	19 (5.4)	16 (4.9)	3 (12.0)	.14
Neoadjuvant CTx	13 (3.7)	12 (3.7)	1 (4.0)	>.99
Pathological stage				.02
Stage I, II	266 (75.4)	252 (76.8)	14 (56.0)	
Stage III, IV	87 (24.6)	76 (23.2)	11 (44.0)	
Extent of surgery				.03
Total gastrectomy	79 (22.4)	69 (21.0)	10 (40.0)	
Partial gastrectomy	274 (77.6)	259 (79.0)	15 (60.0)	
Surgical approach				.02
Open	160 (45.3)	143 (43.6)	17 (68.0)	
Minimally invasive	193 (54.7)	185 (56.4)	8 (32.0)	
Lymph node dissection				.67
D1, D1+	127 (36.0)	119 (36.3)	8 (32.0)	
D2 or more	226 (64.0)	209 (63.7)	17 (68.0)	
Combined resection	55 (15.6)	52 (15.9)	3 (12.0)	.78
Operation time (min)	181 (149–214)	178 (147.5–213)	205 (171–244.5)	.01
Estimated blood loss (mL)	100 (52.5–175)	95 (50.3–150)	122 (52.5–210)	.48

Data are presented as median (IQR) or number (%) of patients, unless otherwise indicated.
ASA = American Society of Anesthesiologists, BMI = body mass index, CAOD = coronary artery occlusive disease, CHF = congestive heart failure, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease, CTx = chemotherapy, CVA = Cerebrovascular accident, DM = diabetes mellitus, ICH = intracranial hemorrhage, IQR = interquartile range, SSI = surgical site infection.

Table 2

Treatment outcomes of surgical site infection in older adults after gastric cancer surgery.

	Total (n = 353)	SSI (−) (n = 328)	SSI (+) (n = 25)	*P* value
Type of SSI				
Incisional	5 (1.4)	N/A	5 (20.0)	
Organ/space	20 (5.7)	N/A	20 (80.0)	
Postoperative fever	191 (54.1)	170 (51.8)	21 (84.0)	<.001
Postoperative hospital stay (days)	6 (5–8.5)	6 (5 – 8)	13 (9.5–26)	<.001
Re-admission within 30 days	19 (5.4)	11 (3.4)	8 (32.0)	<.001
Mortality	2 (0.6)	2 (0.6)	0 (0.0)	>.99

Data are presented as median (IQR) or number (%) of patients, unless otherwise indicated.
IQR = interquartile range, N/A = not applicable, SSI = surgical site infection.

bleeding, and 2 were re-admitted due to intestinal obstruction. However, there was no significant difference in the mortality rate between the 2 groups (0.0% vs 0.6%, respectively, $P > .99$).

3.3. Risk factors for SSI

The results of the univariate analysis indicated that the following factors were significantly associated with the incidence of SSIs after gastrectomy: stage III and IV gastric cancer ($P = .02$), total gastrectomy ($P = .03$), open surgery ($P = .02$), and a longer operation time ($P = .04$). The results of the multivariate analysis revealed that an open surgery (odds ratio, 2.71; 95% confidence interval, 1.13–6.51; $P = .03$) and a longer operation time (odds ratio, 1.01; 95% confidence interval, 1.00–1.01; $P = .04$) were the independent risk factors for SSI in older adults after gastric cancer surgery (Table 3).

4. Discussion

In the present study, the incidence of SSIs after gastric cancer surgery in older adults was 7.1%. Open surgery and a longer operation time were risk factors for the development of an SSI. In the SSI group, the length of the postoperative hospital stay was longer, and the incidence of the postoperative fever as well as the rate of re-admission within 30 days were also higher than those in the non-SSI group.

It is well known that SSIs occur more frequently in older adults, and the related risk factors have been investigated in many studies.[8,9,29,30] In addition, SSIs for specific surgeries in older adults have also been studied.[31,32] However, to the best of our knowledge, there are no existing studies on the incidence of SSIs in older adults who have undergone gastrectomy for gastric cancer.

In general, risk factors for SSIs after gastric cancer surgery have been determined through various studies, and there have also been studies on the risk factors for SSIs according to the surgical method used.[11,28,33] The range of possible surgical procedures, especially in the field of stomach cancer surgery, has been further widened by the availability of various options, such as laparoscopic and robotic surgery.[19,34,35] In general, minimally invasive surgery is known to have fewer postoperative complications than the open surgery; however, the results have not been confirmed in older adults.[36,37] Therefore, it is useful to identify the incidence and risk factors of SSIs after gastric cancer surgery in older adults.

In this study, the incidence of SSIs in older adults was 7.1% (25/353). The incidence of SSIs in minimally invasive surgery was 4.2% (8/193), and that in open surgery was 10.6% (17/160). These results demonstrated that the incidence of SSIs in minimally invasive surgery, such as laparoscopic or robotic surgery, was significantly lower than that in the open surgery ($P = .02$). Advances in minimally invasive surgery have benefited patients with stomach cancer. Although the indications for laparoscopy or robotic surgery remain controversial, many studies have shown that in comparison to open gastrectomy, minimally invasive surgery is associated with less postoperative pain, faster return of gastrointestinal function, better pulmonary function, decreased stress response, shorter hospital stay, and better postoperative quality of life.[38,39] In addition, as identified in this study, the risk of SSIs in older adults is also lower in minimally invasive surgery; therefore, this type of surgery could be recommended in older adults even in terms of postoperative infection prevention. And it remained robust after comparing open surgery with minimally invasive surgery in some variables like age, BMI, ASA score and pathological stage. The age, BMI, and ASA score of the patients were not different between 2 groups. Rather, in advanced stage gastric cancer, minimally invasive surgery was performed more than open surgery. Thus, if open gastrectomy is unavoidable, greater attention should be paid to the prevention of SSIs.

Another risk factor for SSI identified in the multivariate logistic regression was a longer operating time. Kurmann et al reported that the operation time was a risk factor for SSI in sigmoid colon resection.[40] As this has been verified in older adults who have undergone gastrectomy, surgeons will need to make efforts to reduce the operating time in order to prevent SSIs. Conversely, a BMI of >25 and male sex, which are known risk factors for SSI after gastric cancer surgery, as presented in previous studies, were not significant in this study.[12,41]

In this study, there was no increase in the mortality rate in the SSI group. However, the postoperative hospital stay length and re-admission rate within 30 days were significantly higher in the SSI group than in the non-SSI group. Therefore, surgeons are advised to select minimally invasive surgery, such as laparoscopic or robotic gastrectomy, rather than open gastrectomy, when choosing an operative method. In addition, if fever occurs after surgery, the possibility of a surgical site infection should be considered.

This study had some limitations. First, it was a nonrandomized, retrospective study. Therefore, patient characteristics among the groups might be biased because the patients with relatively advanced-stage gastric cancer were not considered

Table 3

Multivariate logistic regression analysis to identify independent risk factors for surgical site infection in older adults after gastric cancer surgery.

	Multivariate analysis	
	OR (95% CI)	*P* value
Male gender	0.89 (0.37–2.12)	.79
Stage III and IV	1.66 (0.67–4.14)	.28
Total gastrectomy	1.56 (0.62–3.89)	.34
Open surgery	2.71 (1.13–6.51)	.03
Operation time (min)	1.01 (1.00–1.01)	.04

CI = confidence interval, OR = odds ratio.

candidates for minimally invasive surgery at our institution during the study period.[36] However, open gastrectomy still remained an independent risk factor because the stage III and IV gastric cancers were not found to be independent risk factors in the multivariate analysis. Second, the sample size of the SSI group was particularly small because the study was limited to older adults over 65 years of age. Third, since this study was conducted in an institution where advanced surgical techniques, such as laparoscopy and robotic surgery, are routinely used in gastric cancer operations, it might be difficult to generalize the findings to other institutions.

5. Conclusions

Open surgery and a longer operation time were determined to be the risk factors for SSI in older adults after gastrectomy. When SSIs occurred, the duration of the patient's postoperative hospital stay was prolonged, and the chances of experiencing postoperative fever and being re-admitted within 30 days also increased. Therefore, surgeons should consider these findings when planning gastric cancer surgery in older adults.

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Author contributions

Conceptualization: Jung Ho Kim, Heun Choi, Jin Young Ahn, Nam Su Ku, Taeil Son, Jun Yong Choi, Woo Jin Hyung, Young Goo Song, June Myung Kim.
Data curation: Jung Ho Kim, Jinnam Kim, Woon Ji Lee, Hye Seong.
Formal analysis: Jinnam Kim, Hye Seong, Woo Jin Hyung.
Funding acquisition: Nam Su Ku.
Investigation: Jung Ho Kim, Woon Ji Lee, Hye Seong, Heun Choi, Jin Young Ahn, Taeil Son, Jun Yong Choi.
Methodology: Jung Ho Kim, Heun Choi, Jin Young Ahn, Taeil Son, Sang Hoon Han, Joon-Sup Yeom, Young Goo Song, June Myung Kim.
Project administration: Jung Ho Kim, Nam Su Ku.
Resources: Jinnam Kim, Taeil Son, Hyoung-Il Kim, Sang Hoon Han, Jun Yong Choi, Chang Oh Kim, Joon-Sup Yeom, Woo Jin Hyung, Sung Hoon Noh, June Myung Kim.
Supervision: Nam Su Ku, Taeil Son.
Validation: Jin Young Ahn, Taeil Son, Hyoung-Il Kim, Young Goo Song.
Visualization: Jung Ho Kim, Su Jin Jeong.
Writing – original draft: Jung Ho Kim.
Writing – review & editing: Jung Ho Kim.

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