# Risk factors for surgical-site infections after radical gastrectomy for gastric cancer: a study in China

**Yong-Qi Qiao[1], Li Zheng[2], Bei Jia[1], Wei-Hua Wang[1], Xiao-Hao Zheng[3], Lin-Lin Fan[1], Yi-Bin Xie[3], Yan-Tao Tian[3]**

[1]Department of Pharmacy, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China;

[2]Department of General Surgery, Beijing Dongcheng First People's Hospital, Beijing 100075, China;

[3]Department of Pancreatic and Gastric Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China.

**Abstract**

**Background:** About 10% of patients get a surgical-site infection (SSI) after radical gastrectomy for gastric cancer, but SSI remains controversial among surgeons. The aim of this study was to explore the risk factors for SSIs after radical gastrectomy in patients with gastric cancer to guide clinical therapies and reduce the incidence of SSI.

**Methods:** The study was a retrospective cohort study in patients who underwent radical gastrectomy for gastric cancer. SSI was defined in accordance with the National Nosocomial Infection Surveillance System. We evaluated patient-related and peri-operative variables that could be risk factors for SSIs. The Chi-squared test and logistic regression analysis were used to assess the association between these risk factors and SSI.

**Results:** Among the 590 patients, 386 were men and 204 were women. The mean age was 56.6 (28–82) years and 14.2% (84/590) of these patients had an SSI. Among them, incisional SSI was observed in 23 patients (3.9%) and organ/space SSI in 61 patients (10.3%). Multivariate logistic regression analysis identified sex (odds ratios [ORs] = 2.548, and 95% confidence interval [CI]: 1.268–5.122, $P = 0.009$), total gastrectomy (OR = 2.327, 95% CI: 1.352–4.004, $P = 0.002$), albumin level (day 3 after surgery) <30 g/L (OR = 1.868, 95% CI: 1.066–3.274, $P = 0.029$), and post-operative total parenteral nutrition (OR = 2.318, 95% CI: 1.026–5.237, $P = 0.043$) as independent risk factors for SSI.

**Conclusions:** SSI was common among patients after radical gastrectomy for gastric cancer. The method supporting post-operative nutrition and the duration of prophylactic antibiotics may be important modifiable influencing factors for SSI.

**Keywords:** Radical gastrectomy; Gastric cancer; Risk factor; Surgical-site infection

## Introduction

Gastric cancer (GC) is one of the most common malignancies and leading causes of cancer-related death in East Asia.[1,2] Radical resection is the method of first choice for the treatment of GC.[3-5] However, about 10% of patients worldwide get a surgical-site infection (SSI) after radical gastrectomy for GC,[6,7] which prolongs hospitalization, increases medical costs, reduces patients' quality of life, and even causes death.[8] Thus, to date, SSI remains controversial among surgeons.

Several studies investigated the factors that influence SSI after radical gastrectomy. Tu *et al*[9] found that body mass index (BMI) ≥25 kg/m$^2$, intraoperative blood loss ≥75 mL, surgical time ≥240 min, and peri-operative transfusion were adversely associated with organ/space SSIs. A similar study from Japan[10] showed that male sex, chronic liver disease, total gastrectomy (TG), and surgical time ≥320 min were independently associated with SSI. However, the factors mentioned above cannot be easily altered. The patients' sex and BMI also cannot be changed before surgery, and these factors would not make much difference in lowering the incidence of SSI even if they were adverse factors. Therefore, the aim of the present study was to identify factors that can be modified to help prevent SSI after radical gastrectomy in a consecutive cohort of patients over 1 year at our center.

| Access this article online | |
|---|---|
| Quick Response Code: | Website: www.cmj.org |
| | DOI: 10.1097/CM9.0000000000000860 |

Yong-Qi Qiao and Li Zheng contributed equally to this research.

**Correspondence to:** Yi-Bin Xie, Department of Pancreatic and Gastric Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China
E-Mail: yibinxie_2003@163.com



Chinese Medical Journal 2020;133(13)
**Received:** 25-12-2019 **Edited by:** Xiu-Yuan Hao

## Methods

### Study design

The study was a retrospective analysis of a prospectively documented database comprising 590 patients who underwent radical gastrectomy for primary gastric cancer at the Department of Pancreatic and Gastric Surgery of National Cancer Center (NCC)/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College from November 2017 to December 2018. The exclusion criteria were as follows: (1) pre-operative identification of infectious disease or febrile status within 24 h before surgery; (2) T4b stage or palliative resection; (3) American Society of Anesthesiologists (ASA) score ≥4; or (4) presence of post-operative anastomotic fistula that was diagnosed using gastroscopy, upper digestive tract radiography, or methylene blue trial. Risk factors for SSIs after radical gastrectomy for gastric cancer were determined based on other published studies, such as pre-operative and intra-operative factors. Several new factors were also included, such as albumin level on day 3 after surgery, prophylactic antibiotics duration, and nutrition support methods within 24 to 48 h after surgery.

### Data collection

The required information was gathered from hospital records and through patient interviews. The potential risk factors for SSI included age, sex, co-morbidities, BMI, smoking, alcohol use, hemoglobin concentration, lymphocyte count, tumor stage, pre-operative chemo- or radiotherapy, surgical duration, surgery mode (laparoscopic-assisted/open), TG, bleeding, albumin level on day 3 after surgery, prophylactic antibiotics duration, and nutrition support methods at the early post-operative stage. All surgeries were performed by experienced senior surgeons and the surgical incision classification was clean-contaminated or contaminated.

The primary outcome was SSI. SSI is defined as an infection that occurs at an incisional site within 30 days after the incision is made, or within 1 year if a prosthesis is implanted, based on the Committee of Disease Control guidelines.[8] SSI has been classified into the following three categories: (1) superficial incisional (involving only the skin and subcutaneous tissue at the site of the incision); (2) deep incisional (involving fascial and muscle layers); and (3) organ/space (involving a body cavity or visceral organs, diagnosis was made by surgeons).

### Data analysis

Statistical analysis was performed using SPSS version 19.0 software (SPSS, Chicago, IL, USA). Categorical data are presented as the percentage. Chi-squared test and analysis of variance were used to screen the categorical factors that were associated with SSIs. Variables that showed a statistically significant difference in the univariate analysis were included in the subsequent multivariate analysis. The univariate analysis results were described by Chi-squared and $P$ values, and multivariable analysis results were described using odds ratios (ORs) and 95% confidence intervals (CIs). $P < 0.05$ was considered statistically significant.

## Results

### SSI incidence and characteristics

Among the 590 patients, 65.4% (386/590) were men and 34.6% (204/590) were women. The mean age was 56.6 (28–82) years. The patients' mean BMI was 23.8 (14.0–34.9) kg/m$^2$. Based on the Union for International Cancer Control (UICC) tumor-node-metastasis (TNM) Classification of Malignant Tumors, 8th Edition, 56.8% of patients (335/590) were classified as stage I-II and 43.2% (255/590) were classified as stage III. Additionally, 14.6% (86/590) of the patients received neoadjuvant chemotherapy and 22.7% (134/590) had co-morbidities. The mean pre-operative hemoglobin was 135.9 (range, 61–196) g/L and the mean surgical duration was 2.99 ± 0.88 h. The average blood loss was 117.6 (range, 10–2500) mL. Additionally, 18.3% (108/590) of the patients underwent TG and 48.8% (288/590) underwent laparoscopic gastrectomy.

Among the 590 patients, 84 (14.2%) had an SSI, including 23 incision SSIs and 61 organ/space SSIs. Among the 61 organ/space SSI patients, 41 presented with pleural effusion, 16 had intra-abdominal abscesses, and four had blood infection.

The most frequent antibiotic prescribed was latamoxef (441/590, 74.7%), followed by cefminox (135/590, 22.9%). In other patients, levornidazole, clindamycin, cefoselis, and meropenem were administrated because of cephalosporin allergy. The prophylactic antibiotic for each patient was administered 30 min to 1 h before the skin incision, and an additional dose was administered every 3 h during surgery. The prophylactic antibiotics duration in 41.7% (246/590) of patients was less than 48 h. Table 1 presents additional characteristics of the study patients.

### Analysis of factors associated with SSI

Tables 2–4 show the univariate analysis results of pre-, intra-, and post-operative factors, respectively. Sex ($P = 0.001$) and smoking ($P = 0.039$) were the two pre-operative factors that were significantly associated with SSI, while TG was the only intra-operative factor with statistical significance ($P = 0.001$). For post-operative factors, we found that the prophylactic antibiotics duration ($P = 0.029$) and post-operative nutrition supporting methods ($P = 0.007$) were significantly associated with SSI. Age ($P = 0.067$) and serum albumin (day 3 after surgery) <30 g/L ($P = 0.074$) were two factors with a $P$ value lower than 0.1 and were also included in multivariable logistic regression analysis. The multivariate analysis revealed that male sex (OR = 2.548, 95% CI: 1.268–5.122, $P = 0.009$), TG (OR = 2.327, 95% CI: 1.352–4.004, $P = 0.009$), serum albumin (day 3 after surgery) <30 g/L (OR = 1.868, 95% CI: 1.066–3.274, $P = 0.029$), and post-operative total parenteral nutrition (TPN) (OR = 2.318, 95% CI: 1.026–5.237, $P = 0.043$) were the adverse risk factors for SSI [Tables 5 and 6].

**Table 1: Patient and surgical characteristics of 590 patients with gastric cancer.**

| Characteristics | Value |
|---|---|
| Mean age (years) | 56.6 (10.2) |
| Sex | |
| Male | 386 (65.4%) |
| Female | 204 (34.6%) |
| Body mass index (kg/m$^2$) | 23.8 (14.0–34.9) |
| Smoker | 255 (43.2%) |
| Alcohol consumer | 210 (35.6%) |
| Co-morbidities* | 134 (22.7%) |
| Tumor stage | |
| I–II | 335 (56.8%) |
| III–IV | 255 (43.2%) |
| Pre-operative chemo- or radio-therapy | 86 (14.6%) |
| Pre-operative hemoglobin (g/L) | 135.9 (61–196) |
| Absolute lymphocyte count ($\times 10^9$/L) | 1.78 (0.44–4.84) |
| Duration of surgery (hours) | 2.99 (0.88) |
| Bleeding (mL) | 117.6 (10–2500) |
| Mode of surgery | |
| Laparoscopic assisted | 288 (48.8%) |
| Open | 302 (51.2%) |
| Total gastrectomy | 108 (18.3%) |
| Infections | 84 (14.2%) |

Data are expressed as mean (standard deviation), mean (range) or *n* (%).
* Co-morbidities include diabetes mellitus, chronic kidney disease, chronic obstructive pulmonary disease, chronic liver disease, congestive heart failure, and human immunodeficiency virus infection/acquired immune deficiency syndrome and other immunocompromised states.

## Discussion

SSIs have been a global challenge for a long time. In 2002, a project was conducted by the Committee of Disease Control to decrease the incidence of SSIs, and for decades, tremendous efforts were made, but the incidence of SSIs showed only a small decrease. To date, the overall incidence of SSIs is about 10% to 20%, and infections account for nearly half of the causes of death after major abdominal surgery.[6,7,11-14] It is crucially important to determine all the SSI risk factors, especially those factors that are modifiable so that SSIs can be prevented.

An anastomotic leakage space/organ SSI is almost inevitable. Anastomotic leakage is an independent influencing factor of SSI and the SSI treatment methods are different if there is an anastomotic leakage. Several studies investigated the factors that influence anastomotic leakage, including ischemia, low pre-operative serum albumin, anemia, malnutrition, and SSI.[15-18] Thus, SSI can also be a reason for an anastomotic leakage, and the relationship between SSI and anastomotic leakage is complex. In this research, we excluded patients with SSIs and anastomotic leakage and determine the precise influencing factors that are associated with SSI.

Several studies have reported risk factors for SSIs after gastrectomy, including male sex, chronic liver disease, longer surgical time, advanced age, a BMI of 25 kg/m$^2$ or higher, diabetes mellitus, blood loss, TG, and combined resection procedures.[6,7,9,10,19] Similarly, male sex and TG were also risk factors in our study. However, other factors did not show a statistically significant difference. For the longer surgical time factor, other studies defined a longer surgical time as longer than 240 or 320 min, but in our study, nearly all the surgical time was less than 240 min. We set a surgical time cut-off of 180 min for the analysis, and thus, the results were different compared with the other studies. A BMI of 25 kg/m$^2$ or higher is usually a risk factor for SSI,[19,20] but we defined a BMI of less than 18 kg/m$^2$ as malnutrition, which might also influence the incidence of SSI. Thus, we combined patients with a BMI of less than 18 kg/m$^2$ or greater than 24 kg/m$^2$ into a group, so our results were also different compared with these studies. In this study, few patients had accompanying diabetes mellitus or underwent combined resection procedures, so these two factors were excluded.

Anti-microbial prophylaxis (AMP) can effectively prevent SSI in gastric cancer surgery. A single dose of AMP was recommended in the current research,[21-23] but prolonged post-operative use of prophylactic antibiotics after gastric cancer surgery remains common in Asia.[24] In the guidelines for clinical application of antibiotics in China, it is recommended that AMP can be extended for up to 48 h after gastrointestinal surgery. A prophylactic antibiotic duration of more than 48 h was thought to be a factor that was associated with SSI, which is supported by the results of this study.

Based on the guidelines for enhanced recovery after surgery,[25,26] TPN is not recommended as a method of nutritional support after upper gastrointestinal surgery. The existing routine of nil-by-mouth for upper gastrointestinal surgery remains unchallenged. Recently, we conducted a study comparing food-at-will and TPN after gastrectomy, and the results showed that the incidence of infectious complications with TPN was much higher compared with food-at-will. Additionally, the study by Lassen *et al*[27] showed that the infectious incidence associated with allowing food-at-will was lower compared with an enteral tube feeding. These results showed that a relatively low number of calories within the first 3 to 5 post-operative days were associated with fewer infectious complications. Eating food, especially through the activation of normal digestive reflexes, has an important impact on overall recovery after gastrointestinal surgery. As an influencing factor for SSI, it is modifiable and can be easily controlled by each surgeon.

Data collection in our study showed that pre-operative albumin levels among all the patients was above 35 g/L, which reflects a good nutrition status in the patients before surgery. Numerous studies have shown that post-operative hypoalbuminemia is a risk factor for complications after surgery.[28-31] Exudate after surgery is necessary for wound healing, but it causes a decrease in serum albumin. However, systemic inflammatory response syndrome or SSI may cause higher levels of exudate, which will lead to a low serum albumin level.[32] Post-operative serum albumin was mainly considered to be an acute-phase protein. We found that serum albumin that was lower than 30 g/L on day 3 after surgery was significantly associated with SSI, and this factor might be used as an indicator of SSI.

**Table 2: Pre-operative factors associated with surgical site infections in 590 patients with gastric cancer.**

| Factors | Total, *n* | SSI, *n* Yes *N* = 84 | SSI, *n* No *N* = 506 | Incidence (%) | $\chi^2$ | *P* |
|---|---|---|---|---|---|---|
| Sex | | | | | | |
| Male | 386 | 68 | 318 | 17.6 | 10.441 | 0.001 |
| Female | 204 | 16 | 188 | 7.8 | | |
| Age | | | | | | |
| ≥60 years | 255 | 44 | 211 | 17.3 | 3.349 | 0.067 |
| <60 years | 335 | 40 | 295 | 11.9 | | |
| Tumor stage | | | | | | |
| I–II | 335 | 44 | 291 | 13.1 | 0.772 | 0.380 |
| III–IV | 255 | 40 | 215 | 15.7 | | |
| Pre-operative chemo- or radio-therapy | | | | | | |
| Yes | 86 | 10 | 76 | 11.6 | 0.561 | 0.454 |
| No | 504 | 74 | 430 | 14.7 | | |
| Smoker | | | | | | |
| Yes | 255 | 45 | 210 | 17.6 | 4.276 | 0.039 |
| No | 335 | 39 | 296 | 11.6 | | |
| Alcohol consumer | | | | | | |
| Yes | 210 | 30 | 180 | 14.3 | 0.001 | 0.980 |
| No | 380 | 54 | 326 | 14.2 | | |
| Co-morbidities | | | | | | |
| Yes | 134 | 17 | 117 | 12.7 | 0.341 | 0.559 |
| No | 456 | 67 | 389 | 14.7 | | |
| BMI | | | | | | |
| >24 or <18.5 kg/m$^2$ | 288 | 38 | 250 | 13.2 | 0.501 | 0.479 |
| 18.5 ≤ BMI ≤ 24 kg/m$^2$ | 302 | 46 | 256 | 15.2 | | |
| Pre-operative hemoglobin | | | | | | |
| ≥120 g/L | 464 | 67 | 397 | 14.4 | 0.073 | 0.787 |
| <120 g/L | 126 | 17 | 109 | 13.5 | | |
| Absolute lymphocyte count | | | | | | |
| <1 × 10$^9$/m$^3$ | 553 | 76 | 477 | 13.7 | 1.763 | 0.184 |
| ≥1 × 10$^9$/m$^3$ | 37 | 8 | 29 | 21.6 | | |

SSI: Surgical-site infection; BMI: Body mass index.

**Table 3: Intra-operative factors associated with surgical site infections in 590 patients with gastric cancer.**

| Factors | Total, *n* | SSI, *n* Yes *N* = 84 | SSI, *n* No *N* = 506 | Incidence (%) | $\chi^2$ | *P* |
|---|---|---|---|---|---|---|
| Duration of surgery | | | | | | |
| ≥3 h | 279 | 45 | 234 | 16.1 | 1.551 | 0.213 |
| <3 h | 311 | 39 | 272 | 12.5 | | |
| Mode of surgery | | | | | | |
| Laparoscopic-assisted | 288 | 40 | 248 | 13.9 | 0.056 | 0.813 |
| Open | 302 | 44 | 258 | 14.6 | | |
| Total gastrectomy | | | | | | |
| Yes | 108 | 26 | 82 | 24.1 | 10.476 | 0.001 |
| No | 482 | 58 | 424 | 12.0 | | |
| Bleeding | | | | | | |
| ≥200 mL | 126 | 17 | 109 | 13.5 | 0.073 | 0.787 |
| <200 mL | 464 | 67 | 397 | 14.4 | | |

SSI: Surgical-site infection.

**Table 4: Post-operative factors associated with surgical site infections in 590 patients with gastric cancer.**

| Factors | Total, *n* | SSI, *n* | | Incidence (%) | $\chi^2$ | *P* |
|---|---|---|---|---|---|---|
| | | Yes $N = 84$ | No $N = 506$ | | | |
| Albumin (the third day after surgery) | | | | | | |
| ≥30 g/L | 465 | 60 | 405 | 12.9 | 3.199 | 0.074 |
| <30 g/L | 125 | 24 | 101 | 19.2 | | |
| Duration of prophylactic antibiotics | | | | | | |
| ≤2 days | 352 | 41 | 311 | 11.6 | 4.792 | 0.029 |
| >2 days | 238 | 43 | 195 | 18.1 | | |
| Post-operative parenteral nutrition | | | | | | |
| Yes | 469 | 76 | 393 | 16.2 | 7.249 | 0.007 |
| No | 121 | 8 | 113 | 6.6 | | |

SSI: Surgical-site infection.

**Table 5: Multivariable logistic regression analysis of factors associated with surgical site infection in 590 patients with gastric cancer.**

| Predictor variables | $\chi^2$ | *P* | OR | 95% CI |
|---|---|---|---|---|
| Male | 6.896 | 0.009 | 2.548 | 1.268-5.122 |
| Age ≥60 years | 1.196 | 0.274 | 1.314 | 0.805–2.145 |
| Smoker | 0.289 | 0.591 | 1.168 | 0.663–2.058 |
| Total gastrectomy | 9.301 | 0.002 | 2.327 | 1.352–4.004 |
| Albumin (the third day after surgery) <30 g/L | 4.764 | 0.029 | 1.868 | 1.066–3.274 |
| Duration of prophylactic antibiotics >2 days | 1.823 | 0.177 | 1.420 | 0.854–2.362 |
| Post-operative parenteral nutrition | 4.085 | 0.043 | 2.318 | 1.026–5.237 |

OR: Odds ratio; CI: Confidence interval.

**Table 6: Culture isolates in cases of surgical site infection in 590 patients with gastric cancer.**

| Organism | *n* |
|---|---|
| *Staphylococcus saprophyticus* | 2 |
| *Staphylococcus epidermidis* | 1 |
| *Staphylococcus aureus* | 1 |
| *Staphylococcus capitis* | 1 |
| *Enterococcus faecalis* | 1 |
| *Enterobacter cloacae* | 1 |
| *Streptococcus salivarius* | 1 |
| *Burkholderia cepacia* | 1 |
| *Pseudomonas aeruginosa* + *Enterococcus avium* | 1 |
| *Enterococcus faecalis* + *Acinetobacter baumannii* | 1 |
| *Enterococcus faecalis* + *Klebsiella pneumoniae* | 2 |
| α-Hemolytic streptococcus + *Klebsiella pneumoniae* | 1 |
| *Pseudomonas aeruginosa* + *Klebsiella pneumoniae* | 1 |

There were some limitations in this study. First, in this retrospective study, we gave the patients high-caloric sip-feeds instead of normal food, and the optimal number of calories was not investigated. Second, there was selection bias, and some important risk factors were not included. Finally, more data on SSI treatment should be included in this study.

In addition to male sex, TG, and lower serum albumin level on day 3 after surgery, this study showed that routine TPN after gastrectomy was an adverse risk factor of SSI compared with food-by-mouth in the first 3 to 5 days after surgery. Univariate analysis showed that a prophylactic antibiotic duration more than 48 h was significantly associated with SSI. These findings will provide direction for subsequent clinical trials to reduce the incidence of SSI after radical gastrectomy.


## Acknowledgements

The authors thank Jodi Smith, PhD, from Liwen Bianji, Edanz Editing China (www.liwenbianji.cn/ac), for editing the English text of a draft of this manuscript.

## Funding

Supportive foundations: Medical and Health Science and Technology Innovation Project of Chinese Academy of Medical Sciences (No. 2016-12M-1-007), China International Medical Exchange Foundation Xiansheng Anti-Tumor Therapy Special Research Fund (No. cimf-f-h001-314).


Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at yibinxie_2003@163.com. No additional data are available.

## Conflicts of interest

None.

## References


1. Lei PR, Liao JW, Ruan Y, Yang XF, Hu KP, Liu JP, *et al*. Risk factors analysis for surgical site infection following elective colorectal resection: a retrospective regression analysis. Chin Med J (Engl) 2020;133:571–576. doi: 10.1097/CM9.0000000000000670.
2. Zhao J, Wang G, Jiang ZW, Jiang CW, Liu J, Xia CC, *et al*. Patients administered neoadjuvant chemotherapy could be enrolled into an enhanced recovery after surgery program for locally advanced gastric cancer. Chin Med J (Engl) 2018;131:413–419. doi: 10.4103/0366-6999.225047.
3. Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM. Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. Int J Cancer 2010;127:2893–2917. doi: 10.1002/ijc.25516.
4. Sano T, Sasako M, Yamamoto S, Nashimoto A, Kurita A, Hiratsuka M, *et al*. Gastric cancer surgery: morbidity and mortality results from a prospective randomized controlled trial comparing D2 and extended para-aortic lymphadenectomy-Japan Clinical Oncology Group study 9501. J Clin Oncol 2004;22:2767–2773. doi: 10.1200/JCO.2004.10.184.
5. Yonemura Y, Wu CC, Fukushima N, Honda I, Bandou E, Kawamura T, *et al*. Operative morbidity and mortality after D2 and D4 extended dissection for advanced gastric cancer: a prospective randomized trial conducted by Asian surgeons. Hepatogastroenterology 2006;53: 389–394.
6. Migita K, Takayama T, Matsumoto S, Wakatsuki K, Enomoto K, Tanaka T, *et al*. Risk factors for surgical site infections after elective gastrectomy. J Gastrointest Surg 2012;16:1107–1115. doi: 10.1007/s11605-012-1838-1.
7. Ushiku H, Hosoda K, Yamashita K, Katada N, Kikuchi S, Tsuruta H, *et al*. A risk model for surgical site infection in the gastric cancer surgery using data of 790 patients. Dig Surg 2015;32:472–479. doi: 10.1159/000440703.
8. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Hospital Infection Control Practices Advisory Committee. Infect Control Hosp Epidemiol 1999;20:250–278. doi: 10.1086/501620.
9. Tu RH, Huang CM, Lin JX, Chen QY, Zheng CH, Li P, *et al*. A scoring system to predict the risk of organ/space surgical site infections after laparoscopic gastrectomy for gastric cancer based on a large-scale retrospective study. Surg Endosc 2016;30:3026–3034. doi: 10.1007/s00464-015-4594-y.
10. Kosuga T, Ichikawa D, Komatsu S, Kubota T, Okamoto K, Konishi H, *et al*. Clinical and surgical factors associated with organ/space surgical site infection after laparoscopic gastrectomy for gastric cancer. Surg Endosc 2017;31:1667–1674. doi: 10.1007/s00464-016-5156-7.
11. Jeong SJ, Ann HW, Kim JK, Choi H, Kim CO, Han SH, *et al*. Incidence and risk factors for surgical site infection after gastric surgery: a multicenter prospective cohort study. Infect Chemother 2013;45:422–430. doi: 10.3947/ic.2013.45.4.422.
12. Morikane K, Honda H, Suzuki S. Factors associated with surgical site infection following gastric surgery in Japan. Infect Control Hosp Epidemiol 2016;37:1167–1172. doi: 10.1017/ice.2016.155.
13. Fukuda H. Patient-related risk factors for surgical site infection following eight types of gastrointestinal surgery. J Hosp Infect 2016;93:347–354. doi: 10.1016/j.jhin.2016.04.005.
14. Özmen T, Javadov M, Yeğen CS. Factors affecting surgical site infection rate after elective gastric cancer surgery. Ulus Cerrahi Derg 2015;32:178–184. doi: 10.5152/UCD.2015.3135.
15. Kawada K, Sakai Y. Preoperative, intraoperative and postoperative risk factors for anastomotic leakage after laparoscopic low anterior resection with double stapling technique anastomosis. World J Gastroenterol 2016;22:5718–5727. doi: 10.3748/wjg.v22.i25.5718.
16. Sciuto A, Merola G, De Palma GD, Sodo M, Pirozzi F, Bracale UM, *et al*. Predictive factors for anastomotic leakage after laparoscopic colorectal surgery. World J Gastroenterol 2018;24:2247–2260. doi: 10.3748/wjg.v24. i21. 2247.
17. Choudhuri AH, Uppal R, Kumar M. Influence of non-surgical risk factors on anastomotic leakage after major gastrointestinal surgery: Audit from a tertiary care teaching institute. Int J Crit Illn Inj Sci 2013;3:246–249. doi: 10.4103/2229-5151.124117.
18. Oshi M, Kunisaki C, Miyamoto H, Kosaka T, Akiyama H, Endo I. Risk factors for anastomotic leakage of esophagojejunostomy after laparoscopy-assisted total gastrectomy for gastric cancer. Dig Surg 2018;35:28–34. doi: 10.1159/000464357.
19. Hirao M, Tsujinaka T, Imamura H, Kurokawa Y, Inoue K, Kimura Y, *et al*. Overweight is a risk factor for surgical site infection following distal gastrectomy for gastric cancer. Gastric Cancer 2013;16:239–244. doi: 10.1007/s10120-012-0174-1.
20. Nishigori T, Tsunoda S, Okabe H, Tanaka E, Hisamori S, Hosogi H, *et al*. Impact of sarcopenic obesity on surgical site infection after laparoscopic total gastrectomy. Ann Surg Oncol 2016;23:524–531. doi: 10.1245/s10434-016-5385-y.
21. Han JH, Jeong O, Ryu SY, Jung MR, Park YK. Efficacy of single-dose antimicrobial prophylaxis for preventing surgical site infection in radical gastrectomy for gastric carcinoma. J Gastric Cancer 2014;14:156–163. doi: 10.5230/jgc.2014.14.3.156.
22. Imamura H, Kurokawa Y, Tsujinaka T, Inoue K, Kimura Y, Iijima S, *et al*. Intraoperative versus extended antimicrobial prophylaxis after gastric cancer surgery: a phase 3, open-label, randomised controlled, non-inferiority trial. Lancet Infect Dis 2012;12:381–387. doi: 10.1016/S1473-3099 (11)70370-X.
23. Mohri Y, Tonouchi H, Kobayashi M, Nakai K, Kusunoki M. Mie Surgical Infection Research Group. Randomized clinical trial of single- versus multiple-dose antimicrobial prophylaxis in gastric cancer surgery. Br J Surg 2007;94:683–688. doi: 10.1002/bjs.5837.
24. Ahn HS, Yook JH, Park CH, Park YK, Yu W, Lee MS, *et al*. General perioperative management of gastric cancer patients at high-volume centers. Gastric Cancer 2011;14:178–182. doi: 10.1007/s10120-011-0012-x.
25. Mortensen K, Nilsson M, Slim K, Schäfer M, Mariette C, Braga M, *et al*. Consensus guidelines for enhanced recovery after gastrectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Br J Surg 2014;101:1209–1229. doi: 10.1002/bjs.9582.
26. Yamagata Y, Yoshikawa T, Yura M, Otsuki S, Morita S, Katai H, *et al*. Current status of the "enhanced recovery after surgery" program in gastric cancer surgery. Ann Gastroenterol Surg 2019;3: 231–238. doi: 10.1002 /ags3.12232.
27. Lassen K, Kjaeve J, Fetveit T, Tranø G, Sigurdsson HK, Horn A, *et al*. Allowing normal food at will after major upper gastrointestinal surgery does not increase morbidity: a randomized multicenter trial. Ann Surg 2008;247:721–729. doi: 10.1097/SLA.0b013e31815cca68.
28. Liu ZJ, Ge XL, Ai SC, Wang HK, Sun F, Chen L, *et al*. Postoperative decrease of serum albumin predicts short-term complications in patients undergoing gastric cancer resection. World J Gastroenterol 2017;23:4978–4985. doi: 10.3748/wjg.v23.i27.4978.
29. Labgaa I, Joliat GR, Kefleyesus A, Mantziari S, Schäfer M, Demartines N, *et al*. Is postoperative decrease of serum albumin an early predictor of complications after major abdominal surgery? A prospective cohort study in a European centre. BMJ Open 2017;7: e013966. doi: 10.1136/bmjopen-2016-013966.
30. Kang SC, Kim HI, Kim MG. Low serum albumin level, male sex, and total gastrectomy are risk factors of severe postoperative complications in elderly gastric cancer patients. J Gastric Cancer 2016;16:43–50. doi: 10.5230/jgc.2016.16.1.43.
31. Lee JI, Kwon M, Roh JL, Choi JW, Choi SH, Nam SY, *et al*. Postoperative hypoalbuminemia as a risk factor for surgical site infection after oral cancer surgery. Oral Dis 2015;21:178–184. doi: 10.1111/odi.12232.
32. Fleck A, Raines G, Hawker F, Trotter J, Wallace PI, Ledingham IM, *et al*. Increased vascular permeability: a major cause of hypoalbuminaemia in disease and injury. Lancet 1985;1:781–784. doi: 10.1016/s0140-6736(85)91447-3.


**How to cite this article:** Qiao YQ, Zheng L, Jia B, Wang WH, Zheng XH, Fan LL, Xie YB, Tian YT. Risk factors for surgical-site infections after radical gastrectomy for gastric cancer: a study in China. Chin Med J 2020;133:1540–1545. doi: 10.1097/CM9.0000000000000860