Original Article

Establishment of a prediction model of postoperative infection complications in patients with gastric cancer and its impact on prognosis

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Background: Postoperative infection delays postoperative adjuvant therapy and can lead to poor prognosis in gastric cancer patients. Therefore, accurately identifying patients at high risk of postoperative infection in patients with gastric cancer is critical. We therefore conducted a study to analyze the impact of postoperative infection complications on long-term prognosis.

Methods: From January 2014 to December 2017, we retrospectively collected the data of 571 patients with gastric cancer admitted to the Affiliated People's Hospital of Ningbo University. The patients were divided into an infection group (n=81) and control group (n=490) according to whether the patients experienced postoperative infection. The clinical characteristics of the 2 groups were compared, and the risk factors of postoperative infection complications in patients with gastric cancer were analyzed. Finally, the prediction model of postoperative infection complications was established.

Results: There were significant differences in age, diabetes, preoperative anemia, preoperative albumin, preoperative gastrointestinal obstruction, and surgical methods between the 2 groups (P<0.05). Compared with that in the control group, the mortality rate of patients in the infection group at 5 years after surgery was significantly increased (39.51% *vs.* 26.12%; P=0.013). Multivariate logistics regression analysis showed that age >65 years, preoperative anemia, albumin <30 g/L, and gastrointestinal obstruction were risk factors of postoperative infection in patients with gastric cancer (P<0.05). The data set was randomly divided into a training set and validation set; the sample size of the training set was 286 while the sample size of the validation set was 285. In terms of the predictive model's value in predicting postoperative infection in patients with gastric cancer, the area under the curve of the receiver operating characteristic (ROC) curve in the training set was 0.788 (95% confidence interval: 0.711–0.864), and the area under the curve of the ROC curve in the validation set was 0.779 (95% confidence interval: 0.703–0.855). In the validation set, the model was evaluated with the Hosmer-Lemeshow goodness-of-fit test, resulting in a chi-squared value of 5.589 and a P value of 0.693.

Conclusions: The present model can effectively identify patient as high risk of postoperative infection.

Keywords: Gastric cancer; infection complications; predictive models; prognosis

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Introduction

Gastric cancer is one of the most common malignant tumors of the digestive tract, second only to colorectal cancer (1). Surgery is the main treatment of gastric cancer, but the incidence of postoperative infection complications is high. One retrospectively clinical study showed that the incidence of postoperative infection complications in patients with gastric cancer was as high as 6.8% (2), another reported a higher incidence of 12.6% (3), and still another reported a postoperative lung infection rate as high as 14.7% (4). Current studies have confirmed that postoperative infection is associated with lower long-term overall survival in patients with gastric cancer (2,5,6). Therefore, the prevention and treatment of postoperative infection in patients with gastric cancer is a difficult but crucial challenge. The key to preventing postoperative infection is to identify high-risk factors and high-risk patients for postoperative infection in gastric cancer, and a small number of researchers have discussed the relevant factors of postoperative infection in this patient group. In one study, overweight status was shown to be a risk factor for incision infection after radical gastric resection (7). It was also found that patients with hypertension, combined organ resection, history of abdominal surgery, and long duration of surgery were more likely to develop intra-abdominal infection (8). Different research indicated that myopenia, tumor size, pathology, and multiple organ resection were independent contributing factors to intra-abdominal infection (9). Moreover, it has been reported that open surgery, chronic obstructive pulmonary disease, intraoperative blood transfusion, and long operation time were risk factors of postoperative lung infection in patients with gastric cancer (10). However, the ability of individual biological indicators to identify patients with gastric cancer at high-risk for postoperative infection is limited. We thus aimed to develop and evaluated a nomogram-based prediction model capable of identifying those patients with gastric cancer at high risk of postoperative infection. We present this article in accordance with the TRIPOD reporting checklist (available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-231/rc).

Highlight box

Key findings

- Age >65 years, preoperative anemia, albumin <30 g/L, and gastrointestinal obstruction were risk factors of postoperative infection in patients with gastric cancer (P<0.05).

What is known and what is new?

- Patients with gastric cancer have a higher incidence of postoperatively infection complications.
- This model can effectively identify patients with high-risk gastric cancer and postoperative infection.

What is the implication, and what should change now?

- Strengthening interventions in patients at high risk of postoperative infection may be beneficial in reducing the incidence of infection complications and ultimately improving patient outcomes.

Methods

General information

From January 2014 to December 2017, we retrospectively collected the data from 571 patients with gastric cancer admitted to the Affiliated People's Hospital of Ningbo University, and the patients were divided into an infection group (n=81) and control group (n=490) according to whether or not the patients experienced infection after surgery. The inclusion criteria were the following: (I) gastric cancer, (II) surgical treatment in the Affiliated People's Hospital of Ningbo University, (III) age ≥18 years old, and (IV) completed data available. Meanwhile, the exclusion criteria were the following: (I) gastric stromal tumor, (II) infectious diseases before surgery, (III) presence of other malignant tumors, (IV) remote metastasis required multi-visceral resections, and (V) loss of patient in follow-up. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Ethics Committee of the Affiliated People's Hospital of Ningbo University (No. 202200147) and individual consent for this retrospective analysis was waived.

Treatment

All patients completed the related examinations. After contraindications to surgery were considered, radical gastrectomy for gastric cancer (mainly including radical distal gastrectomy, radical gastrectomy, and total gastrectomy) was performed. Preventive antibiotic treatment was given at 30 minutes before the surgery (prophylactic antibiotic use time was 48 hours). After surgery, symptomatic supportive treatment, such as early ambulation and maintaining the water-electrolyte balance, was given. When the patient's gastrointestinal function was restored, the diet was gradually resumed. After surgery,

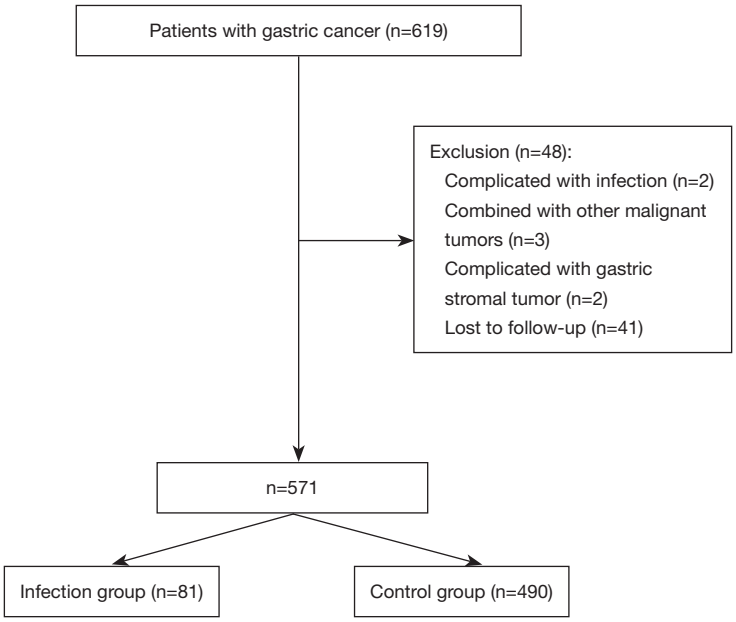

Figure 1 Flowchart of inclusion of patients with gastric cancer.

according to the pathological results, the postoperative adjuvant treatment plan was decided.

Data collection

Information related to age, sex, body mass index, smoking history, history of alcoholism, hypertension, diabetes, hyperlipidemia, preoperative anemia, blood transfusion, serum albumin, preoperative gastrointestinal obstruction, lesion size, surgical method, surgical resection range, dissected lymph node count, lymph node metastasis, tumor cell differentiation, operation time, intraoperative blood loss, and mortality rate at 5 years after surgery was collected. Postoperative follow-up was carried out via outpatient visits at least once a year for 5 years.

Statistical analysis

SPSS2 6.0 software (IBM Corp.) was used to complete the data analysis, and a P value <0.05 was considered to be statistically significant (2-tailed). The measurement data of the 2 groups were expressed as mean ± standard deviation, with the differences between the 2 groups being analyzed with the independent samples *t* test. The count data of the 2 groups are expressed as numbers and percentages, with the chi-squared test being used to analyze the differences between the 2 groups. Multivariate regression was used to analyze risk factors of postoperative infection complications in patients with gastric cancer. R 4.0.3 statistical software (The R Foundation for Statistical Computing) was used to establish a prediction model for postoperative infection complications in patients with gastric cancer.

Results

Comparison of clinical features between the 2 groups

The flowchart of patients with gastric cancer included is shown in *Figure 1*. There were statistically significant differences in age, diabetes, preoperative anemia, preoperative albumin, preoperative gastrointestinal obstruction, and surgical method between the 2 groups (P<0.05). Compared with that in the control group, the mortality rate at 5 years after surgery was significantly increased in the infection group (39.51% *vs.* 26.12%; P=0.013; *Table 1*).

Risk factors for postoperative infection in patients with gastric cancer

Multivariate logistics regression analysis showed that age >65 years, preoperative anemia, albumin <30 g/L, and gastrointestinal obstruction were risk factors of postoperative infection in patients with gastric cancer

Table 1 Comparison of clinical features of the 2 groups

Variable	Infection group (n=81)	Control group (n=490)	t/χ^2 value	P value
Age (years)			3.395	0.065
Mean ± SD	64.80±8.79	60.32±10.24	3.721	0.000
>65 years	36 (44.44)	166 (33.88)		
≤65 years	45 (55.56)	324 (66.12)		
Gender			0.397	0.529
Male	48 (59.26)	272 (55.51)		
Female	33 (40.74)	218 (44.49)		
Body mass index (kg/m^2)	25.73±3.85	25.24±3.69	1.101	0.271
History of smoking	6 (7.41)	32 (6.53)	0.086	0.768
History of alcoholism	3 (3.70)	15 (3.06)	0.094	0.759
Hypertension	5 (6.17)	34 (6.94)	0.064	0.800
Diabetes	10 (12.35)	17 (3.47)	12.157	0.000
Hyperlipidemia	12 (14.81)	67 (13.67)	0.076	0.783
Preoperative anemia	8 (9.88)	13 (2.65)	10.238	0.001
Blood transfusion	4 (4.94%)	11 (2.24%)	1.971	0.160
Preoperative albumin (g/L)			42.469	0.000
Mean ± SD	31.96±5.30	36.64±4.89	7.880	0.000
<30 g/L	28 (34.57)	43 (8.78)		
≥30 g/L	53 (65.43)	447 (91.22)		
Preoperative gastrointestinal obstruction	10 (12.35)	20 (4.08)	9.536	0.002
Surgical method			4.532	0.033
Open surgery	4 (4.94)	7 (1.43)		
Minimally invasive surgery	77 (95.06)	483 (98.57)		
Surgical resection range			2.587	0.274
Radical distal gastrectomy	32 (39.51)	155 (31.63)		
Proximal radical gastric resection	12 (14.81)	65 (13.27)		
Total gastrectomy	37 (45.68)	270 (55.10)		
Dissected lymph node count	20.47±3.85	20.92±3.92	0.959	0.338
Lymph node metastases	37 (45.68)	211 (43.06)	0.194	0.660
Tumor cell differentiation			0.051	0.822
Poorly differentiated or undifferentiated	12 (14.81)	68 (13.88)		
Medium to high differentiation	69 (85.19)	422 (86.12)		
Lesion size (cm)	4.12±2.10	4.39±2.09	1.074	0.283
Duration of surgery (min)	204.28±27.89	201.61±28.74	0.778	0.437
Amount of intraoperative bleeding (mL)	165.91±60.49	172.04±58.49	0.869	0.385
Mortality at 5 years postoperatively	32 (39.51)	128 (26.12)	6.173	0.013

Data are shown as n (%) or mean ± standard deviation.

Table 2 Risk factors of postoperative infection in patients with gastric cancer

Variables	B value	Standard error	Wald value	P value	Relative risk (95% CI)
Age >65 years	0.567	0.263	4.641	0.031	1.763 (1.052–2.954)
Diabetes	0.836	0.490	2.909	0.088	2.306 (0.883–6.025)
Preoperative anemia	1.452	0.499	8.465	0.004	4.272 (1.606–11.360)
Albumin <30 g/L	1.778	0.302	34.677	0.000	5.919 (3.275–10.696)
Gastrointestinal obstruction	1.362	0.448	9.239	0.002	3.902 (1.622–9.389)
Open surgery	0.839	0.771	1.184	0.276	2.315 (0.511–10.498)
Constant	–11.035	2.278	23.473	0.000	0.000

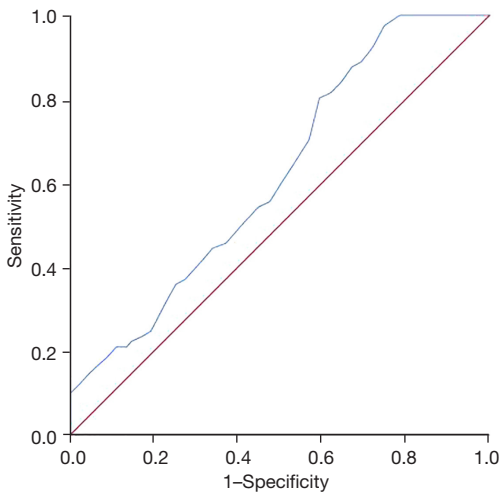

Figure 2 The value of age in predicting postoperative infection in patients with gastric cancer.

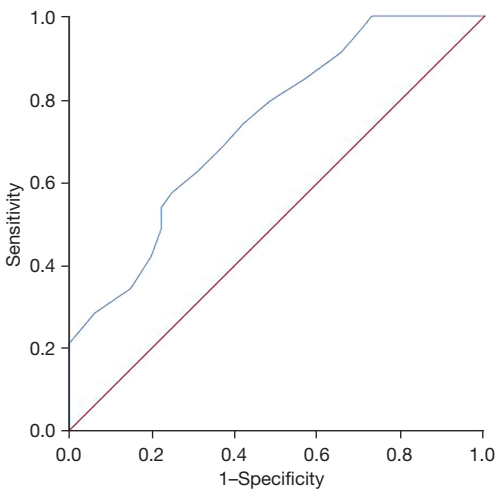

Figure 3 The value of albumin in predicting the absence of postoperative infection in patients with gastric cancer.

(P<0.05; *Table 2*).

The value of age in predicting postoperative infection in patients with gastric cancer

Age was valuable in predicting the postoperative infection in patients with gastric cancer, and the area under the curve was 0.620 (95% confidence interval: 0.560–0.679; P=0.030; *Figure 2*).

The value of albumin in predicting the absence of postoperative infection in patients with gastric cancer

Albumin exhibited value in predicting the absence of postoperative infection in patients with gastric cancer, and the area under the curve was 0.736 (95% confidence interval: 0.676–0.795; P<0.001; *Figure 3*).

Establishment and validation of a postoperative infection complication prediction model for patients with gastric cancer

The R 4.0.3 statistical software was used to randomly divide the dataset into a training set and validation set. The sample size of the training set was 286, and the sample size of the validation set was 285. In terms of the predictive model's value in predicting postoperative infection in patients with gastric cancer, the area under the receiver operating characteristic (ROC) curve in the training set was 0.788 (95% confidence interval: 0.711–0.864), and the area under the ROC curve in the validation set was 0.779 (95% confidence interval: 0.703–0.855). In the validation set, the model was evaluated with the Hosmer-Lemeshow goodness-of-fit test, resulting in a chi-squared value of 5.589 and a P value of 0.693 (*Figures 4-7*).

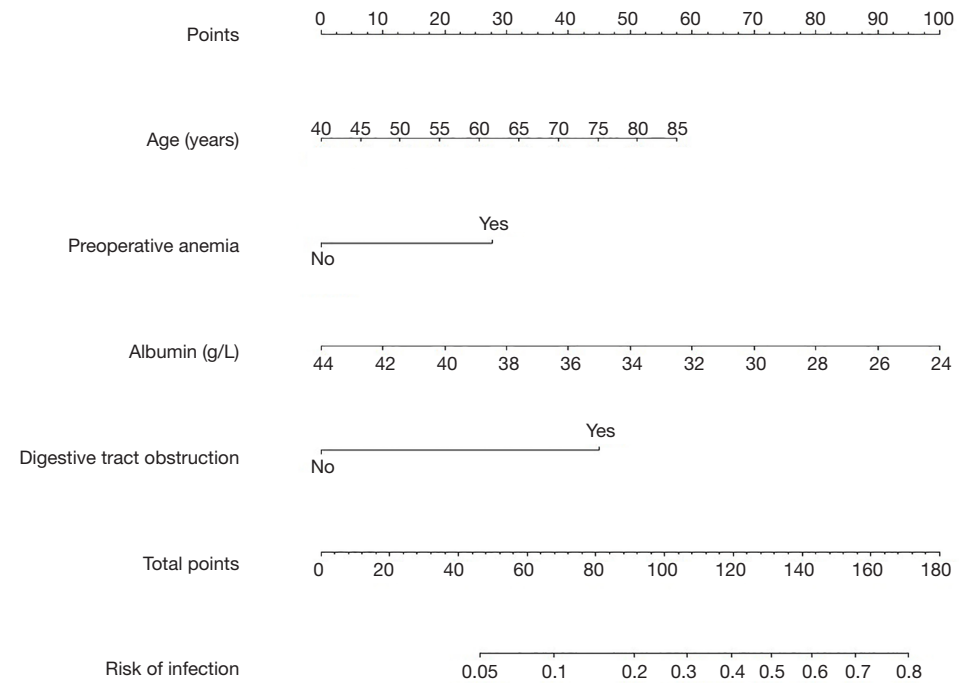

Figure 4 Nomogram of the postoperative infection complication prediction model in patients with gastric cancer.

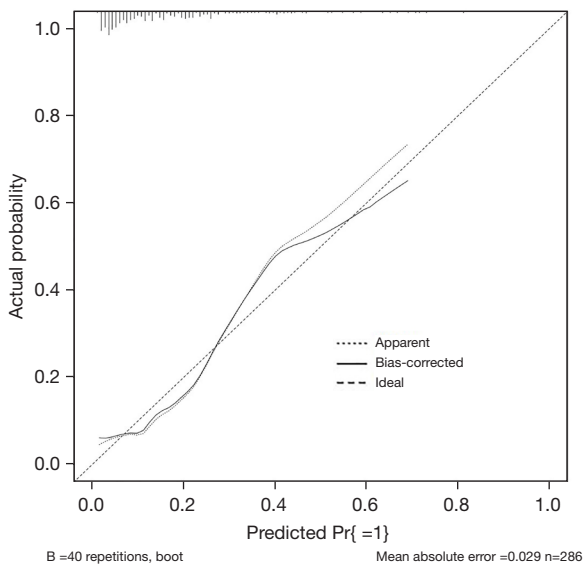

Figure 5 Calibration curve of postoperative infectious complication prediction model in patients with gastric cancer.

Types of postoperative infection complications in patients with gastric cancer

Postoperative infection in patients with gastric cancer mainly included lung infection, abdominal infection, and incision infection (*Table 3*).

Discussion

Surgery is one of the main methods for treating gastric cancer, but the infection rate after surgery is high, and the main infection sites include the abdomen, incision, and lung, among others. Postoperative infection can lead to delayed postoperative adjuvant therapy. Moreover, infection will lead to further immune dysfunction, so it may lead to the poor prognosis of patients, and current studies have confirmed that postoperative infection is associated with reduced postoperative survival (2). The present study also showed there to be a significant increase

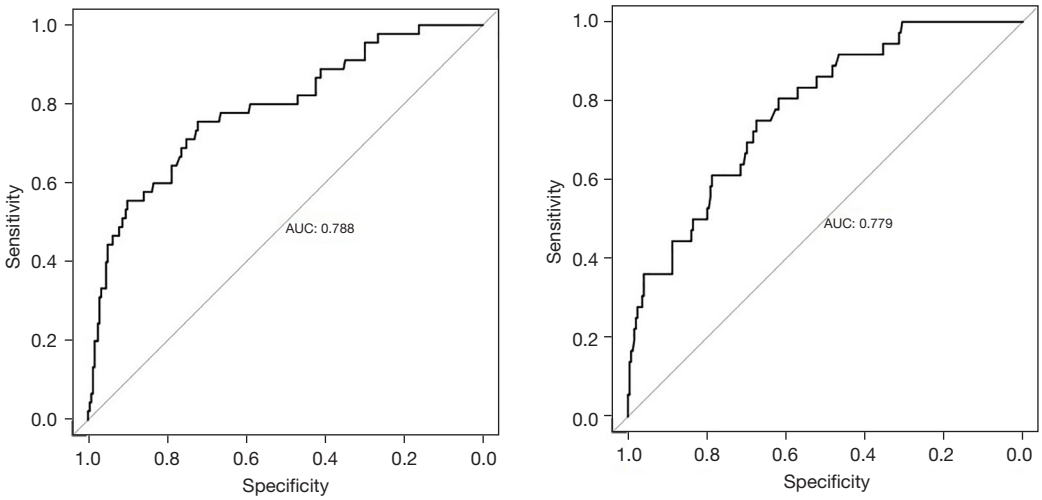

Figure 6 The value of the predictive model in predicting postoperative infection complications in patients with gastric cancer (left: training set; right: validation set).

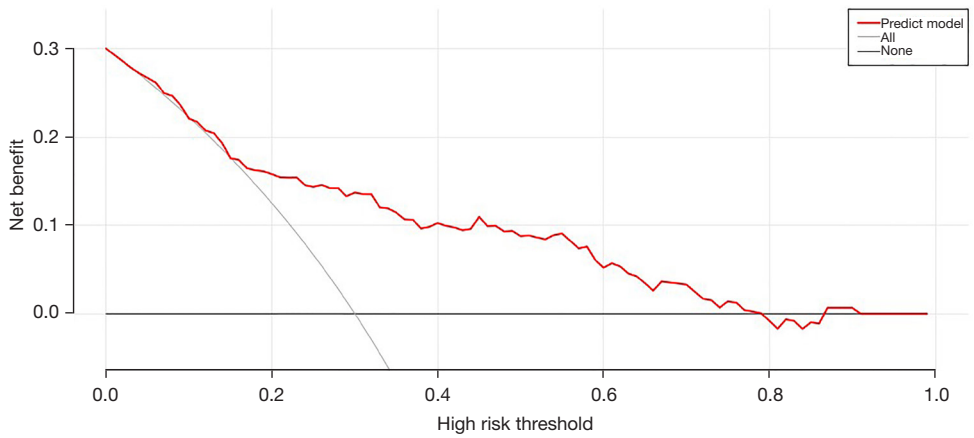

Figure 7 Clinical decision curve of the postoperative infection complication prediction model in patients with gastric cancer.

Table 3 Distribution of postoperative infection complications in patients with gastric cancer

Variable	Value, n (%)
Abdominal infection	28 (34.57)
Incision infection	13 (16.05)
Lung infections	38 (46.91)
Urinary tract infections	2 (2.47)

in mortality at 5 years in the infection group. Therefore, the prevention and treatment of postoperative infection in patients with gastric cancer is a challenging but crucial issue. In this study, the factors related to postoperative infection in patients with gastric cancer were examined. It was found that age >65 years, preoperative anemia, albumin <30 g/L, and gastrointestinal obstruction were risk factors for postoperative infection in patients with gastric cancer (P<0.05).

Gastric cancer is more likely to occur in middle-aged and older adult individuals. In older adult patients, the body's immune function decreases and the susceptibility to bacteria increases. Moreover, older adult patients are more likely to develop pneumonitis, so increasing age is a risk factor of postoperative infection (11,12), which is consistent with the results of the present study. In the

state of anemia, the blood flow to all organs in the body is insufficient, and surgery will further aggravate the anemic state, resulting in a decrease in immune function. At the same time, anemia leads to delayed healing of the incision and anastomosis, causing an increased risk of infection (13). Albumin is the most important protein in human plasma and is synthesized by the liver. Albumin is an important nutrient in the human body and can maintain plasma osmolality and reflect the nutritional status of the body, with studies confirming decreased albumin to be a risk factor of postoperative infection (14-16). Gastrointestinal obstruction refers to a narrowing or atresia that occurs anywhere from the mouth to the anus, either alone or in combination with other structural malformations. There are many causes of gastrointestinal obstruction. Patients with gastrointestinal obstruction may have abdominal distension, abdominal pain, nausea, vomiting, and other symptoms, and gastrointestinal obstruction can lead to gastrointestinal edema, increased gastrointestinal permeability, and ultimately abdominal infection (17,18). Preoperative correction of these risk factors may be beneficial to reducing the risk of postoperative infection in patients with gastric cancer, ultimately improving patient outcomes.

Furthermore, in order to better identify patients with gastric cancer at high risk of postoperative infection, we established a nomogram prediction model based on the relevant risk factors. This predictive model could intuitively reflect the risk of postoperative infection in patients with gastric cancer. A study in patients with gastric cancer also showed that the predictive nomogram model could better assess the risk of postoperative lung infection (10). The predictive nomogram model established in the present study exhibited good value in predicting postoperative infection in patients with gastric cancer. Strengthening the intervention in such high-risk patients may be beneficial to reducing the rate of postoperative infection rate in these patients and improving prognosis.

Limitations

The number of patients with infection was relatively low. Therefore, we failed to study the complications according to the Clavien-Dindo III-IV complications. And due to the limitations of this retrospective study, we failed to study some data in the present study.

Conclusions

At present, the relevant biological indicators of the prognosis of various diseases are the focus of researches (13,19). The present study found that the incidence of postoperative infection complications in patients with gastric cancer was high, and our model could effectively identify patients with gastric cancer at high risk of postoperative infection.

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Footnote

Reporting Checklist: The authors have completed the TRIPOD reporting checklist. Available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-231/rc

Data Sharing Statement: Available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-231/dss

Peer Review File: Available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-231/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jgo.amegroups.com/article/view/10.21037/jgo-23-231/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by Ethics Committee of the Affiliated People's Hospital of Ningbo University (No. 202200147) and individual consent for this retrospective analysis was waived.

References

1. Siegel RL, Miller KD, Wagle NS, et al. Cancer statistics, 2023. CA Cancer J Clin 2023;73:17-48.
2. Xiao Y, Wei G, Ma M, et al. Association among prognostic nutritional index, post-operative infection and prognosis of stage II/III gastric cancer patients following radical gastrectomy. Eur J Clin Nutr 2022;76:1449-56.
3. Zhang Y, Li S, Yan C, et al. Perioperative Use of Glucocorticoids and Intraoperative Hypotension May Affect the Incidence of Postoperative Infection in Patients with Gastric Cancer: A Retrospective Cohort Study. Cancer Manag Res 2021;13:7723-34.
4. Meng Y, Zhao P, Yong R. Modified Frailty Index Independently Predicts Postoperative Pulmonary Infection in Elderly Patients Undergoing Radical Gastrectomy for Gastric Cancer. Cancer Manag Res 2021;13:9117-26.
5. Liu M, Zhang L, Zhou Q, et al. The Distinct Impact of TAM Infiltration on the Prognosis of Patients With Cardia and Non-Cardia Gastric Cancer and Its Association With H. pylori Infection. Front Oncol 2021;11:737061.
6. Nie S, Wang A, Yuan Y. Comparison of clinicopathological parameters, prognosis, micro-ecological environment and metabolic function of Gastric Cancer with or without Fusobacterium sp. Infection. J Cancer 2021;12:1023-32.
7. Hirao M, Tsujinaka T, Imamura H, et al. Overweight is a risk factor for surgical site infection following distal gastrectomy for gastric cancer. Gastric Cancer 2013;16:239-44.
8. Zhang Y, Wang Z, Basharat Z, et al. Nomogram of intra-abdominal infection after surgery in patients with gastric cancer: A retrospective study. Front Oncol 2022;12:982807.
9. Mao CC, Chen XD, Lin J, et al. A Novel Nomogram for Predicting Postsurgical Intra-abdominal Infection in Gastric Cancer Patients: a Prospective Study. J Gastrointest Surg 2018;22:421-9.
10. Xiao H, Zhou H, Liu K, et al. Development and validation of a prognostic nomogram for predicting post-operative pulmonary infection in gastric cancer patients following radical gastrectomy. Sci Rep 2019;9:14587.
11. Ashrafi-Asgarabad A, Safiri S. Age and dressing type as independent predictors of post-operative infection in patients with acute compartment syndrome of the lower leg. Methodological issues. Int Orthop 2018;42:221-2.
12. Campbell L, Sammon J, Rahbar H, et al. Postoperative urinary retention in men is common after carotid endarterectomy and is associated with advanced age and prior urinary tract infection. J Vasc Surg 2016;63:355-61.
13. Jericó Alba C, M Ramírez-Rodríguez J, Ripollés-Melchor J, et al. Transfusion and/or anemia as risk factors for infection in rectal surgery: Association or causality?. Cir Esp (Engl Ed). 2019;97(4):242-243.
14. Fahmy MD, Hechler BL, Carlson ER, et al. Preoperative Serum Albumin Predicts Wound Dehiscence but Not Infection After Surgery for Oral Squamous Cell Carcinoma. J Oral Maxillofac Surg 2021;79:1355-63.
15. Zhang F, Liu X, Tan Z, et al. Effect of postoperative hypoalbuminemia and supplement of human serum albumin on the development of surgical site infection following spinal fusion surgery: a retrospective study. Eur Spine J 2020;29:1483-9.
16. Lu PH, Wei MX, Shen W, et al. Is preoperative serum albumin enough to ensure nutritional status in the development of surgical site infection following gastrointestinal surgery? Ann Surg 2011;254:663-4; author reply 664.
17. Zhu Y, Liu R, Geng X, et al. Serum homocysteine is a valuable marker for predicting aggravation of infection in intestinal obstruction patients. Exp Biol Med (Maywood) 2023;248:36-43.
18. Aonzo P, Santoro D, Serventi A. Small intestinal obstruction caused by parasitic infection. Tech Coloproctol 2022. [Epub ahead of print]. doi: 10.1007/s10151-022-02738-2.
19. Teng D, Xia S, Hu S, et al. miR-887-3p Inhibits the Progression of Colorectal Cancer via Downregulating DNMT1 Expression and Regulating P53 Expression. Comput Intell Neurosci 2022;2022:7179733.

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