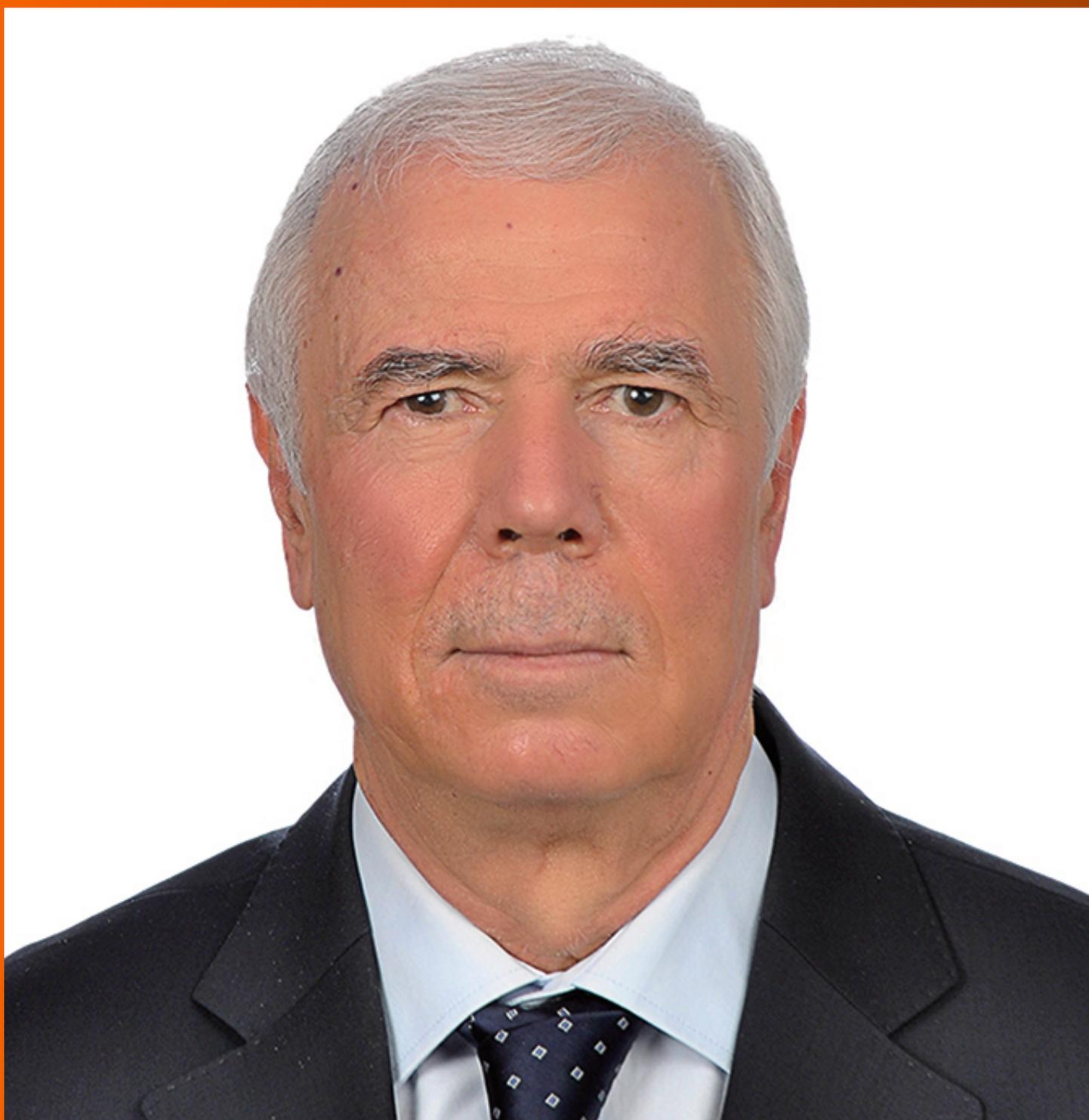


# World Journal of *Gastrointestinal Surgery*

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*WJGS* mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

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## Case Control Study

## Nomogram for predicting chylous ascites after right colectomy

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**Author contributions:** Zheng HD collected the clinical data and prepared the manuscript; Zheng HD, Liu YR, Chen ZZ, and Xu CH designed the study and supervised the statistical data; Zheng HD and Sun YF contributed to the analyses; Xu JH provided clinical advice, reviewed the manuscript and gave final approval of the version of the article to be published.

**Institutional review board statement:** This study was approved by the Ethics Committee of the Second Affiliated Hospital of Fujian Medical University (approval No. 2021-0227).

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## Abstract

## BACKGROUND

Chylous ascites following right colectomy has a high incidence which is a critical challenge. At present, there are few studies on the factors affecting chylous ascites after right colectomy and especially after D3 Lymphadenectomy. A predictive model for chylous ascites has not yet been established. Therefore, we created the first nomogram to predict the incidence of chylous ascites after right hemicolectomy.

## AIM

To analyze the risk factors for chylous ascites after right colectomy and establish a nomogram to predict the incidence of chylous ascites.

## METHODS

We retrospectively collected patients who underwent right hemicolectomy between January 2012 and May 2021 and were pathologically diagnosed with cancer. Multivariate logistic regression was used to analyze the influencing factors of chylous ascites and a nomogram was established. The predictive ability was assessed by the area under the receiver operating characteristic (ROC) curve.

## RESULTS

Operative time, the type of operation (standard or extended), the number of lymph nodes retrieved, and somatostatin administration were considered important risk factors. Multivariate logistic regression and nomograms can be used to accurately predict whether chylous ascites occurs. The area under the ROC curve of the model is 0.770. The C-statistic of this model is 0.770 which indicates that it has a relatively moderate ability to predict the risk of chylous ascites.

## CONCLUSION

We found a novel set of risk factors, created a nomogram, and validated it. The

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nomogram had a relatively accurate forecasting ability for chylous ascites after right hemicolectomy and can be used as a reference for risk assessment of chylous ascites and whether to prevent it after surgery.

**Key Words:** Nomogram; Right colectomy; Chylous ascites; Risk factors

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**Core Tip:** The article retrospectively analyzed the incidence of chylous ascites after right colectomy, and through multivariate analysis, the operative time, the type of operation (standard or extended), and the number of lymph nodes retrieved were identified as risk factors, while the administration of somatostatin or synthetic analogs after surgery was a protective factor. Based on these factors, we created a nomogram with moderate ability to predict the risk of chylous ascites.

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## INTRODUCTION

Colorectal cancer is the second most common cause of cancer-related death worldwide [1]. At present, although there are many treatment methods, surgical treatment is still the most important approach. Recent studies have shown that the incidence of colon cancer or rectal cancer on the left has remained stable or decreased and the survival rate of right-sided colon cancer is significantly lower than that of left colon cancer [2]. Moreover, there are differences in the incidence of complications, especially the incidence of chylous ascites.

Chylous ascites (CA) is defined as milky or milky peritoneal fluid that is rich in triglycerides [3]. It is generally believed that the main reason for the occurrence of CA is direct damage to the chylous duct, chylous branches or lymph nodes caused by surgery [4]. Complete mesocolic excision with D3 Lymph node dissection is regarded as a priority choice for right colectomy as more lymph nodes can be removed [5]. In clinical work and literature review, we were surprised to discover that the incidence of CA after right colectomy was significantly higher than that after other colorectal surgeries. Baek Se-Jin conducted a retrospective analysis of 779 patients after colorectal surgery and found that the incidence of CA after right colectomy was as high as 10.5%, which was significantly higher than the incidences of 5.75% after left colectomy and 4.6% of chyle leakage after rectal surgery [6]. Professor Chipan analyzed CA after colorectal surgery and the results showed that the incidence of CA following right hemicolectomy could be as high as 13.3% [7]. Therefore, according to the existing research, CA has become a complication that cannot be ignored after right colectomy. Because chyle drainage fluid contains many nutrients, CA may cause malnutrition, dehydration, electrolyte disorders, and delayed healing of incisions. In addition, CA contains lymph fluid that is enriched in lymphocytes and immunoglobulins; therefore, severe and long-term CA may lead to weakened immunity, which can cause severe infection and even death due to sepsis [8].

Thus, it is very important to establish a predictive model of CA after right hemicolectomy and to determine the risk reduction factors in a controllable strategy. At present, there are few studies evaluating the risk factors for CA after colorectal cancer surgery. The few existing studies suggested that the possible risk factors for CA were age, tumor location, preoperative albumin level, number of lymph nodes retrieved, operative time, intraoperative blood loss, D3 Lymphadenectomy, and surgeon [6,7,9,10]. However, no one has established a predictive model for CA that made sense in terms of preventive decision-making and risk assessment. This study aims to construct a nomogram to predict the incidence of CA after right hemicolectomy. Clinicians can eventually personalize the management of patients and take effective preventive measures through the nomogram and improve the prognosis

and quality of life while reducing the length of hospitalization and costs.

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## MATERIALS AND METHODS

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### Patients

This retrospective study was approved by the Ethics Committee. We collected 516 consecutive patients who underwent right hemicolectomy in the Second Affiliated Hospital of Fujian Medical University from January 2012 to May 2021. The inclusion criteria were pathologically confirmed right colon adenocarcinoma and right colectomy. The exclusion criterion was that the operation was an emergency operation. Ultimately, we collected a total of 516 patients. We divided patients into two groups: CA and without CA.

All operations were performed by clinical colorectal surgeons with extensive experience. D3 Lymphadenectomy is defined as the removal of the main lymph nodes at the roots of the blood vessels (ileocolonic vessels and the middle colon artery or the right branch of the middle colon artery) and then ligation of the blood vessels at the origin site. Tumor staging was reidentified according to the eighth edition of the American Joint Committee on Cancer staging system (AJCC).

All patients completed the necessary preoperative examinations, including colonoscopy with biopsy, to confirm the diagnosis. The perioperative treatments were essentially the same. Some patients were administered somatostatin or its synthetic analogs for 3 d after surgery in the collected data. In the following, the term somatostatin includes its synthetic analogs, such as octreotide.

### Definition of CA and Follow-Up

CA is defined as milky or milky white ascites without infectious exudation in the drainage tube, with a volume of  $\geq 200$  mL/d and a triglyceride (TG) level of  $\geq 110$  mg/dL. When CA occurs, there should be no signs of fever, peritonitis, or other signs of infection to rule out the possibility of anastomotic leakage or other abdominal infections[6,7,9,10]. All patients with CA were cured after conservative treatment, avoiding a second operation.

### Variables

Variables analyzed as risk factors for CA included age, sex, body mass index, history of abdominal surgery, neoadjuvant therapy, ASA score, combined organ resection, type of surgery, surgical approach, blood loss, operative time, number of positive lymph nodes (LNs), number of lymph nodes retrieved, tumor diameter (cm), preoperative albumin, preoperative CEA, pathological T stage, pathological N stage, metastasis, differentiation, vascular invasion, perineural invasion, and somatostatin administration.

### Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics 22.0. Continuous variables are presented as the mean  $\pm$  SD and were compared using the Mann-Whitney *U* test (2-tailed). Categorical variables were represented by numbers (percentage), which were compared by using the  $\chi^2$  test or Fisher's exact test. Potential univariate and multivariate factors were analyzed by logistic regressions. Variables with a *P* value  $< 0.1$  were included in the multivariate model.

We used R (version 4.0.5) to build a nomogram, and bootstraps with 1000 resamples were used to validate the internal nomogram. The coordination statistic (C-statistic) was used to measure the performance of the nomogram. A calibration curve was used to express the relationship between the observed frequency and the predicted probability, which was assessed by the area under the receiver operating characteristic (ROC) curve (AUC). The differences were considered statistically significant when the *P* value  $< 0.05$ .

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## RESULTS

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### Patients

After reviewing all included data, 29 patients were diagnosed with CA. Table 1 summarizes the characteristics of patients. A long operative time ( $P = 0.032$ ), number of LNs retrieved ( $P = 0.005$ ), standard or extended surgery ( $P = 0.012$ ), and

Table 1 Patient characteristics

Variables	No CA (n = 487)	CA (n = 29)	P value
Age (yr)	64.3 ± 11.5	66.0 ± 10.3	0.436
Sex			0.384
Male	245 (93.5%)	17 (6.5%)	
Female	242 (95.3%)	12 (4.7%)	
BMI (kg/m <sup>2</sup> )			0.122
≤ 25	337 (93.4%)	24 (6.6%)	
> 25	150 (96.8%)	5 (3.2%)	
History of abdominal surgery			0.406
Yes	70 (97.2%)	2 (2.8%)	
No	417 (93.9%)	27 (6.1%)	
Neoadjuvant therapy			0.142
Yes	10 (83.3%)	2 (16.7%)	
No	477 (94.6%)	27 (5.4%)	
ASA score			0.565
1 or 2	363 (94.0%)	23 (6.0%)	
≥ 3	124 (95.4%)	6 (4.6%)	
Combined organ resection			0.495
Yes	38 (92.7%)	3 (7.3%)	
No	449 (94.5%)	26 (5.5%)	
Type of surgery			0.012
Standard	357 (96.0%)	15 (4.0%)	
Extended	130 (90.3%)	14 (9.7%)	
Surgical approach			0.094
Open	94 (97.9%)	2 (2.1%)	
Laparoscopy	391 (93.5%)	27 (6.5%)	
Blood loss (mL)	83.8 ± 81.5	94.5 ± 64.2	0.252
Operative time (min)	155.0 ± 21.5	164.1 ± 19.3	0.032
Number of positive LNs	2.79 ± 5.3	2.3 ± 7.0	0.668
Number of LNs retrieved	25.69 ± 8.7	29.79 ± 6.6	0.005
Tumor diameter (cm)	5.4 ± 2.4	5.6 ± 1.9	0.377
Preoperative albumin	38.5 ± 5.5	39.7 ± 4.1	0.163
Preoperative CEA	22.3 ± 81.7	5.0 ± 4.0	0.110
Pathological T stage			0.220
T0-T2	50 (90.9%)	5 (9.1%)	
T3-T4	437 (94.8%)	24 (5.2%)	
Pathological N stage			0.101
N0	226 (92.6%)	18 (7.4%)	
N1-N2	261 (96.0%)	11 (4%)	
Metastasis			0.749
Yes	46 (93.9%)	3 (6.1%)	
No	441 (94.4%)	26 (5.6%)	

Differentiation			0.299
w/d, m/d	302 (93.5%)	21 (6.5%)	
p/d	30 (100.0%)	0 (0.0%)	
Lymphovascular Invasion			0.098
Negative	259 (92.8%)	20 (7.2%)	
Positive	228 (96.2%)	9 (3.8%)	
Perineural invasion			0.665
Negative	369 (94.1%)	23 (5.9%)	
Positive	118 (95.2%)	6 (4.8%)	
Somatostatin administration			0.039
Yes	156 (97.5%)	4 (2.5%)	
No	331 (93.0%)	25 (7.0%)	

CA: Chylous ascites; BMI: Body mass index; ASA: American Society of Anesthesiologists; LNs: Lymph nodes; CEA: Carcinoembryonic antigen.

somatostatin administration ( $P = 0.039$ ) were related to CA. However, intraoperative blood loss and open or laparoscopic surgery seemed not to be significantly related to the occurrence of CA.

### Univariate and multivariate analyses

As shown in [Table 2](#), after univariate logistic regression analysis, a long operative time, number of LNs retrieved, type of surgery (standard or extended surgery), somatostatin administration and preoperative CEA were associated with CA. Multivariate analysis showed that a long operative time (OR = 1.019, 95%CI: 1.001-1.037;  $P = 0.041$ ), number of LNs retrieved (OR = 1.058, 95%CI: 1.015-1.103;  $P = 0.008$ ), type of surgery (OR = 2.493, 95%CI: 1.097-5.669;  $P = 0.029$ ), and somatostatin administration (OR = 0.240, 95%CI: 0.078-0.744;  $P = 0.013$ ) were independent influencing factors of CA. According to these results, a forest plot was established ([Figure 1](#)).

### Nomogram for CA

According to the multivariate logistic regression analysis, we established a nomogram to predict the risk of CA after right hemicolectomy and showed that operative time, number of LNs retrieved, type of surgery, and somatostatin had greater impacts on CA ([Figure 2](#)). The higher the total points assigned based on each factor in the nomogram, the higher the risk of CA. For example, a patient with a long operative time (160 min), a D3 type of operation, extended lymphadenectomy, with 30 LNs retrieved and without somatostatin administration postoperatively would have a total of 157.5 points (37.5 points for operative time, 30 points for type of operation, 45 points for number of LNs retrieved, and 45 points for without somatostatin administration postoperatively), for a predicted risk of CA of 15%. According to ROC analysis, the AUC of the model was 0.770. Because it was a binary variable model, the C-statistic of the model was 0.770, indicating that the model had considerable predictive potential ([Figure 3A](#)). The calibration curve showed that there was optimal agreement between the results predicted by the nomogram and actual observations, indicating good calibration ([Figure 3B](#)).

## DISCUSSION

To the best of our knowledge, few articles have specifically studied the occurrence of CA after right colectomy and no one has established a nomogram to predict the occurrence of CA. At present, no auxiliary examination that can accurately predict CA has been proposed. This study analyzed the possible risk factors for CA after right colectomy in 516 cases and created a nomogram to predict the incidence of CA. We observed that the probability of CA after right colectomy was 5.6%. A long operative time, number of lymph nodes retrieved, and type of surgery (standard or extended surgery) were independent risk factors for CA after right colectomy, and somatostatin

Table 2 Univariate and multivariate logistic regression models for risk factors of chylous ascites

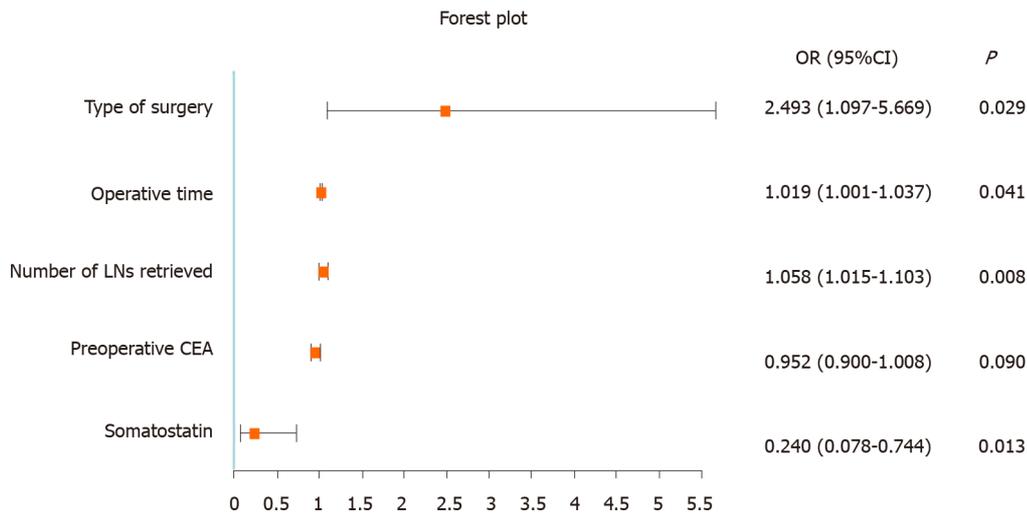
		Univariate	Multivariate	
		P value	OR (95% CI)	P value
Age (yr)		0.449		
Sex	Male or female	0.386		
BMI (kg/m <sup>2</sup> )	> 25 vs ≤ 25	0.130		
History of abdominal surgery	Absent vs present	0.272		
Neoadjuvant therapy	Absent vs present	0.114		
ASA score	1 or 2 vs ≥ 3	0.566		
Combined organ resection	Absent vs present	0.624		
Type of surgery	Standard vs extended	0.015	2.493 (1.097-5.669)	0.029
Surgical approach	Open vs laparoscopy	0.112		
Blood loss (mL)		0.492		
Operative time (min)		0.028	1.019 (1.001-1.037)	0.041
Number of positive LNs		0.668		
Number of LNs retrieved		0.014	1.058 (1.015-1.103)	0.008
Tumor diameter (cm)		0.199		
Preoperative albumin		0.228		
Preoperative CEA		0.087	0.952 (0.900-1.008)	0.090
Pathological T stage	T0-T2 vs T3-T4	0.243		
Pathological N stage	N0 vs N1-N2	0.106		
Metastasis	Absent vs present	0.873		
Differentiation	w/d, m/d vs p/d	0.784		
Lymphovascular Invasion	Absent vs present	0.103		
Perineural invasion	Absent vs present	0.665		
Administration of somatostatin	Absent vs present	0.048	0.240 (0.078-0.744)	0.013

CA: Chylous ascites; BMI: Body mass index; ASA: American Society of Anesthesiologists; LNs: Lymph nodes; CEA: Carcinoembryonic antigen.

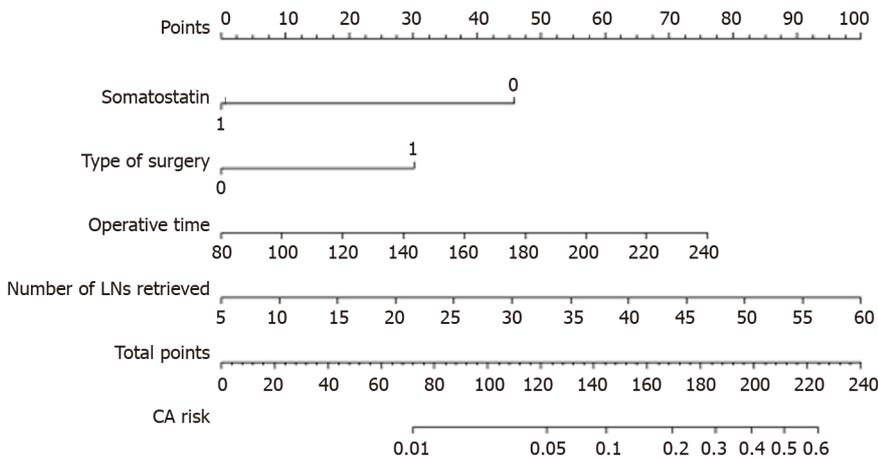
administration was a protective factor. All patients with CA were cured by conservative treatment and the short- and long-term survival results of patients were not affected by CA[9].

Looking back at previous research reports, the incidence of CA after major abdominal surgery ranges from 0.2% to 11.0%[11]. In our data, the incidence of CA fell in that range. However, because of the protective effect of somatostatin after surgery, the incidence was low compared to other studies. After we removed patients who were administered somatostatin after surgery, the incidence of CA was 7.0%. Why the incidence of CA after right colectomy with D3 Lymphadenectomy was so high, even as high as 13.3%, is closely associated with the anatomy of the region[6]. It is generally believed that the chyle cistern is located on the right side of the aorta, the anterior side of the first or second lumbar vertebrae has abundant lymphatic branches nearby, and it is closely related to the surgical area of D3 dissection[12]. In the process of D3 Lymph node dissection, the retroperitoneal lymph vessels and fat were removed, which resulted in the cutting and interruption of lymphatic drainage[13,14]. As the area for lymph node dissection expands, the number of lymph nodes retrieved increases, and the incidence of CA increases, which is consistent with previous reports on the risk factors for CA[6,7,9-11].

A previous study stated that CA occurrence was affected by various factors. For patients who have undergone right colectomy, there are few large-scale studies to provide risk factors for CA. We found that a long operative time, number of LNs retrieved, type of surgery (standard or extended surgery), and somatostatin adminis-

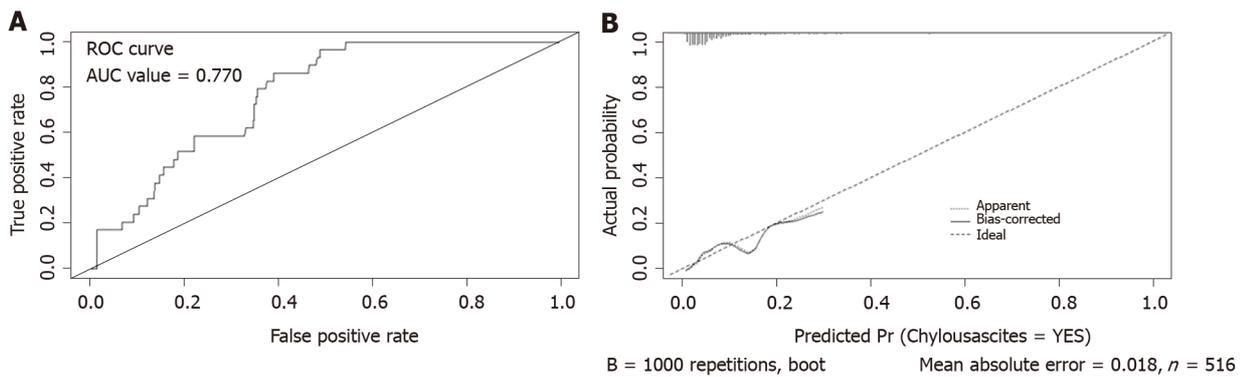


**Figure 1 Forest plot.** LNs: Lymph nodes; CEA: Carcinoembryonic antigen.



**Figure 2 Nomogram for predicting chylous ascites after right colectomy.** The nomogram to predict the incidence of chylous ascites (CA) was created based on four independent risk factors, including somatostatin administration, type of surgery, operative time and number of lymph nodes retrieved. The “Nomogram for CA” section of the article provides a detailed description of the nomogram. LNs: Lymph nodes; CA: Chylous ascites.

tration were independent influencing factors. The operative time was related to many factors including the surgeon, the operation method, and whether the abdominal cavity had adhesions. The differences in the skills of the surgeon would cause differences in the operative time. If surgeons had not mastered a comprehensive understanding of vascular anatomy or advanced laparoscopic techniques[15] or if the abdominal cavity was severely adhered[16], the surgeon may enter the wrong anatomy level, leading to the destruction of a larger area of the lymphatic network and lymphatic vessels, prolonging the operative time, and increasing the incidence of CA, which was inconsistent with previous reports that considered short operative times; additionally, the occurrence of CA may be caused by incomplete sealing of lymphatic vessels and energy devices due to insufficient sealing time during laparoscopic surgery[6,9]. However, laparoscopy was not a risk factor in our study ( $P > 0.05$ ). The increase in the incidence of postoperative CA may be directly related to more extensive and more detailed lymph node dissection; thus, the number of LNs retrieved can be explained as an independent risk factor. As the principle of D3 Lymphadenectomy is to remove more LNs in the mesenteric root, the number of LNs retrieved was quite large, but it was still less than in the study by Liang *et al*[17] ( $25.9 \pm 8.7$  vs  $34.4 \pm 8.4$ ,  $P < 0.05$ ). Due to the larger area of lymph node removal in D3 extended mesenterectomy, CA was more likely to occur, which was confirmed in Agustsdottir EES’s study that the incidence of CA after D3 extended mesenterectomy was 41.0% [18], which was higher than our data (41.0% vs 9.7%). Somatostatin, or its synthetic analog octreotide, which can reduce the absorption of triglycerides and inhibits



**Figure 3 Validation of the nomogram.** A: receiver operating characteristic (ROC) curve for the nomogram. C statistic/ area under the receiver operating characteristic curve (AUC) = 0.770 (95%CI: 0.706-0.834); B: Nomogram calibration curve. The y-axis represents the actual probability of chylous ascites. The x-axis represents estimated probability. The ideal line represents a perfect prediction model. The apparent line represents the performance of the nomogram, and a close fit to the ideal line represents a good prediction.

visceral circulation and gastrointestinal motility, thereby reducing the concentration of triglycerides in the thoracic duct and reducing the lymphatic flow of the main lymphatic vessels[19]. It can provide valuable time for the healing of damaged lymphatic vessels and can thus play a preventive role.

There are few articles in the literature addressing the prevention of CA. At present, the main methods of prevention are that the injured lymphatics must be controlled and ligated intraoperatively during the operation[20], and the diet must be controlled. The surgical habit of our center was to use a slow range and double cauterization of the ultrasonic scalpel when performing laparoscopic lymphadenectomy, especially in the root of the main artery, and follow the integrity principle of lymphadenectomy to avoid partial lymphadenectomy. In open surgery, the use of an electro-surgical scalpel should be minimized for thicker lymphatic ducts or lymph nodes near the lymphatic trunk, and silk suture or ligation should be used. This may be part of the reason why our incidence of CA was lower than that in other studies. The study by Agustsdottir *et al*[18] considered that a routine fat-reduced diet (FRD) had a prophylactic effect and prevented the lymphatic vessels from collapsing, thereby reducing the occurrence of CA. According to our study, somatostatin played a protective role, indicating that somatostatin administration can reduce the occurrence of CA, but there is currently no relevant research to confirm this hypothesis. In our study, the average time for CA to occur was 3.9 d, and it often appeared after eating. However, Lizaola *et al*[21] believed that CA may occur in the early period (approximately 1 wk) after abdominal surgery because of the rupture of lymphatic vessels. In our study, the reason for the earlier appearance of CA was the accelerated rehabilitation surgery (ERAS) we implemented, which led to the patient eating earlier. Therefore, early intervention in the occurrence of CA is significant.

There are two modalities for the conservative treatment of CA: nutritional support and the use of somatostatin. Pan *et al*[22] revealed that in treating CA, enteral nutrition (EN) + medium-chain triglyceride (MCT) instead of total parenteral nutrition (TPN) was the best nutritional support and somatostatin should be used immediately. Aalami *et al*[23] published a large review of 156 cases and concluded that the resolution rate of conservative treatment was 67% while the remaining 33% of patients required surgical intervention such as lymphangiography and embolization[24]. The patients with CA that we included in this study were all cured by conservative treatment, such as diet control and the administration of somatostatin or its synthetic derivatives but the hospital stay was significantly prolonged with an average length of stay of 15.7 d, leading to a significant increase in hospital costs and was not conducive to the turnover rate of hospital beds.

We focused on patients after right colectomy who were reported to have a high risk of CA. According to the data of multiple logistic regression analysis, we established a nomogram that included operative time, type of surgery, number of LNs retrieved, and somatostatin administration. The nomogram can provide clinicians with an accurate approximation of CA risk after right colectomy because it is composed of data throughout the perioperative period which will make it convenient and feasible for doctors to better control the occurrence of CA and surgeons will be able to judge whether a patient is at high risk through our model so that the patient can take preventive measures. Considering that the cost of an extra day of hospitalization far

exceeds the cost of somatostatin or octreotide administration, and there are potential economic effects of low risk, high benefit, and shortening the length of hospitalization [11]. For patients who are assessed as high-risk for CA by nomogram, it is recommended to start administering somatostatin or octreotide for 3 d immediately after the operation and to implement a 3-d fat-reduced diet at the same time[18].

The advantage of our study was that it focused on the high incidence of CA after right hemicolectomy, which has rarely been reported. We analyzed multiple factors that may be related to CA and created a nomogram that can provide a valuable prediction of the risk of CA after surgery. However, the study has several limitations. First, this is a retrospective, single-center study with a small sample size. Second, the mechanisms of most of the risk factors for CA we discussed were hypothetical and have not been confirmed on a scientific basis. For example, whether somatostatin can truly prevent CA has not been reported in the previous literature; carefully designed prospective clinical trials will be needed to confirm our results. Finally, it is currently uncertain whether the nomogram we created can be used by all surgeons because its effectiveness has not been evaluated in another study cohort. We expect to conduct forward-looking, large-sample, multicenter research to improve the reliability and value of the prediction model in future research.

## CONCLUSION

In our study, the risk factors for CA after right hemicolectomy were screened by multivariate analysis and a nomogram was constructed to predict the possibility of CA. The nomogram had a good predictive ability for CA which can provide a reference for whether preventive measures need to be taken after the operation.

## ARTICLE HIGHLIGHTS

### **Research background**

Chylous ascites is a relatively rare postoperative complication but its incidence in patients after right hemicolectomy is relatively high.

### **Research motivation**

If it is possible to assess which postoperative patients are at high risk for chylous ascites, appropriate preventive measures can be taken which will greatly speed up the recovery of patients and reduce hospitalization costs.

### **Research objectives**

To identify the risk factors for chylous ascites and to establish a novel nomogram for predicting chylous ascites after right colectomy.

### **Research methods**

A hospital-based retrospective study was conducted. Multivariate logistic regression was used to analyze the risk factors for chylous ascites and a novel nomogram was created. We used the receiver operating characteristic curve to assess the predictive ability of the model.

### **Research results**

Operative time, the type of operation (standard or extended), and the number of lymph nodes retrieved were risk factors and somatostatin administration was considered a protective factor. Multivariate logistic regression and nomogram had relatively moderate abilities to predict the risk of chylous ascites.

### **Research conclusions**

The nomogram had a relatively accurate predictive ability for chylous ascites. Thus, we can use this model to assess the risk of patients for developing chylous ascites.

### **Research perspectives**

A multicenter prospective study should be performed to improve the practicality of the model.

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