Am J Cancer Res 2026;16(8):3516-3525
www.ajcr.us /ISSN:2156-6976/ajcr0174776

Original Article

Serum inflammatory markers and influencing factors in patients with colorectal adenomas

Linjin Chen[1,2], Haiyan Zhong[3], Zijie Wang[1], Xingxing Zhang[4], Yan Li[1]

[1]Department of Gastrointestinal Surgery, The Fourth People's Hospital of Changzhou, Changzhou 213000, Jiangsu, China; [2]Department of General Surgery, Fuzhou University Affiliated Provincial Hospital, Fuzhou 350001, Fujian, China; [3]Department of Gastroenterology, Changzhou Fourth People's Hospital, Changzhou 213000, Jiangsu, China; [4]Department of Urology, Fuzhou University Affiliated Provincial Hospital, Fuzhou 350001, Fujian, China

Received June 15, 2026; Accepted July 27, 2026; Epub August 15, 2026; Published August 30, 2026

Abstract: This study aimed to investigate the expression patterns of serum inflammatory markers (SIMs) in patients with colorectal adenomas (CRAs) and identify the associated influencing factors. A total of 420 patients who underwent colonoscopy between January 2020 and December 2025 were included in this study. Patients with colonoscopy-identified CRAs were assigned to the CRA group (n=285), whereas individuals without obvious endoscopic abnormalities served as the control group (n=135). SIMs, including high-sensitivity C-reactive protein (hs-CRP), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α), as well as blood lipids, including total cholesterol (TC), triglyceride (TG), and high-/low-density lipoprotein cholesterol (HDL-C/LDL-C), were measured and compared between the two groups. CRA patients presented with higher TG levels, lower HDL-C levels, and elevated SIM levels compared with controls ($P<0.05$). Univariate analysis revealed significant between-group differences in age, smoking history, drinking history, hepatic steatosis, cholecystic polyps, gallstones, TG, and HDL-C. Logistic regression analysis demonstrated that older age, smoking, hypertriglyceridemia, low HDL-C levels, and elevated inflammatory marker levels were independent risk factors for CRAs. In conclusion, smoking, dyslipidemia, and chronic inflammation are independent factors associated with CRA development. In addition to lifestyle modification and lipid management, dynamic monitoring of inflammatory markers may have important clinical value for improving the early identification of individuals at high risk of CRAs.

Keywords: Colorectal adenoma, blood lipids, inflammatory factors, influencing factors

Introduction

Colorectal cancer (CRC) is a malignancy that poses a serious threat to global health [1]. CRC ranks among the leading cancers in terms of incidence and mortality in China, according to the latest global cancer statistics and reports released by the National Cancer Center in China. Moreover, CRC shows an obvious trend toward urbanization and younger ages at onset [2]. During the pathological progression of CRC, about 80%-95% of sporadic CRCs originate from benign adenomas [3]. Hence, identifying epidemiological risk factors associated with colorectal adenomas (CRAs) holds profound implications for early risk assessment and prevention in high-risk populations.

Although colonoscopy is recognized as the golden standard for adenoma diagnosis [4], its widespread application in China is constrained by the uneven distribution of endoscopic resources, and limited patient acceptance of invasive procedures. Consequently, the identification of highly sensitive and non-invasive serological predictors has become an important focus of clinical epidemiological research. In recent years, accumulating epidemiological evidence has demonstrated close associations between lifestyle factors (e.g., smoking), dyslipidemia (e.g., hypertriglyceridemia), obesity, and adenoma development [5, 6]. However, traditional risk factors alone cannot fully explain inter-individual variations in disease susceptibility, prompting increasing attention toward

https://doi.org/10.62347/PPEI1509

the role of inflammatory microenvironment regulation.

In recent years, the concept of synergistic effects between chronic inflammation and metabolic disorders in promoting tumorigenesis has garnered considerable interest [7]. Clinical observations have indicated that long-term chronic inflammation in the intestinal mucosa may induce persistent oxidative stress and cellular injury [8]. However, the specific biological mechanisms by which systemic inflammatory microenvironments contribute to adenoma development remain incompletely understood. Serum inflammatory markers (SIMs), including C-reactive protein (CRP), tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6), are key indicators of systemic inflammation and are considered to play important roles in regulating the proliferation, apoptosis, and immune escape of intestinal epithelial cells [9]. Although previous studies have linked inflammatory markers with intestinal lesions, the factors influencing CRA development remain to be elucidated. Accordingly, this study aimed to analyze the clinical characteristics and SIM levels of patients with CRAs and construct a logistic regression model to identify independent factors associated with CRAs.

Materials and methods

Research participants

A retrospective review was conducted among patients who underwent colonoscopy at The Fourth People's Hospital of Changzhou between January 2020 and December 2025. According to colonoscopic and histopathological findings, patients with colorectal polyps identified by colonoscopy and subsequently confirmed as CRAs by histopathological examination were assigned to the CRA group (n=285), whereas individuals without obvious endoscopic abnormalities were included as the control group (n=135).

Inclusion criteria: (1) adults aged ≥18 years; (2) adequate intestinal preparation (Boston Bowel Preparation Scale [BBPS] score ≥6), with successful cecal intubation and clear visualization of the intestinal mucosa; (3) for the CRA group, polyps confirmed histopathologically as adenomatous polyps (including tubular, villous, or tubulovillous adenomas) without high-grade intraepithelial neoplasia or malignant transformation; and (4) complete clinical medical records.

Exclusion criteria: (1) age <18 years; (2) previous history of CRC, inflammatory bowel disease (IBD; including Crohn's disease and ulcerative colitis), or familial adenomatous polyposis (FAP); (3) acute infection, trauma, or surgery within one month before colonoscopy; (4) use of non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, or immunosuppressants within 4 weeks before examination; (5) long-term use of health supplements, such as fish oil and soybean isoflavones, or the presence of other major chronic or systemic inflammatory diseases (including rheumatoid arthritis, chronic viral hepatitis, and chronic obstructive pulmonary disease) that could substantially affect serum lipid or inflammatory marker levels; (6) severe cardiac, pulmonary, hepatic, or renal insufficiency, autoimmune diseases, or malignant tumors; and (7) incomplete clinical data.

Before study initiation, ethical approval was obtained from the Institutional Ethics Committee of The Fourth People's Hospital of Changzhou. The study flow chart is presented in **Figure 1**.

Data acquisition

The data analyzed in this study were collected from the Electronic Medical Records System of The Fourth People's Hospital of Changzhou, including the Hospital Information Systems (HIS), Laboratory Information Systems (LIS), and Picture Archiving and Communication Systems (PACS).

(1) Demographic data and medical history: Demographic information included age, sex, body mass index (BMI), smoking history (defined as a cumulative smoking history of >100 cigarettes or smoking >1 cigarette/day consistently for at least 1 year), and drinking history (defined as an average drinking frequency of >3 times per week, with an equivalent alcohol intake of >30 g/d for men and >20 g/d for women, maintained for at least 1 year). Relevant medical history included appendectomy history, cholecystectomy history, underlying diseases (hypertension and diabetes), and the presence of hepatic steatosis, cholecystic pol-

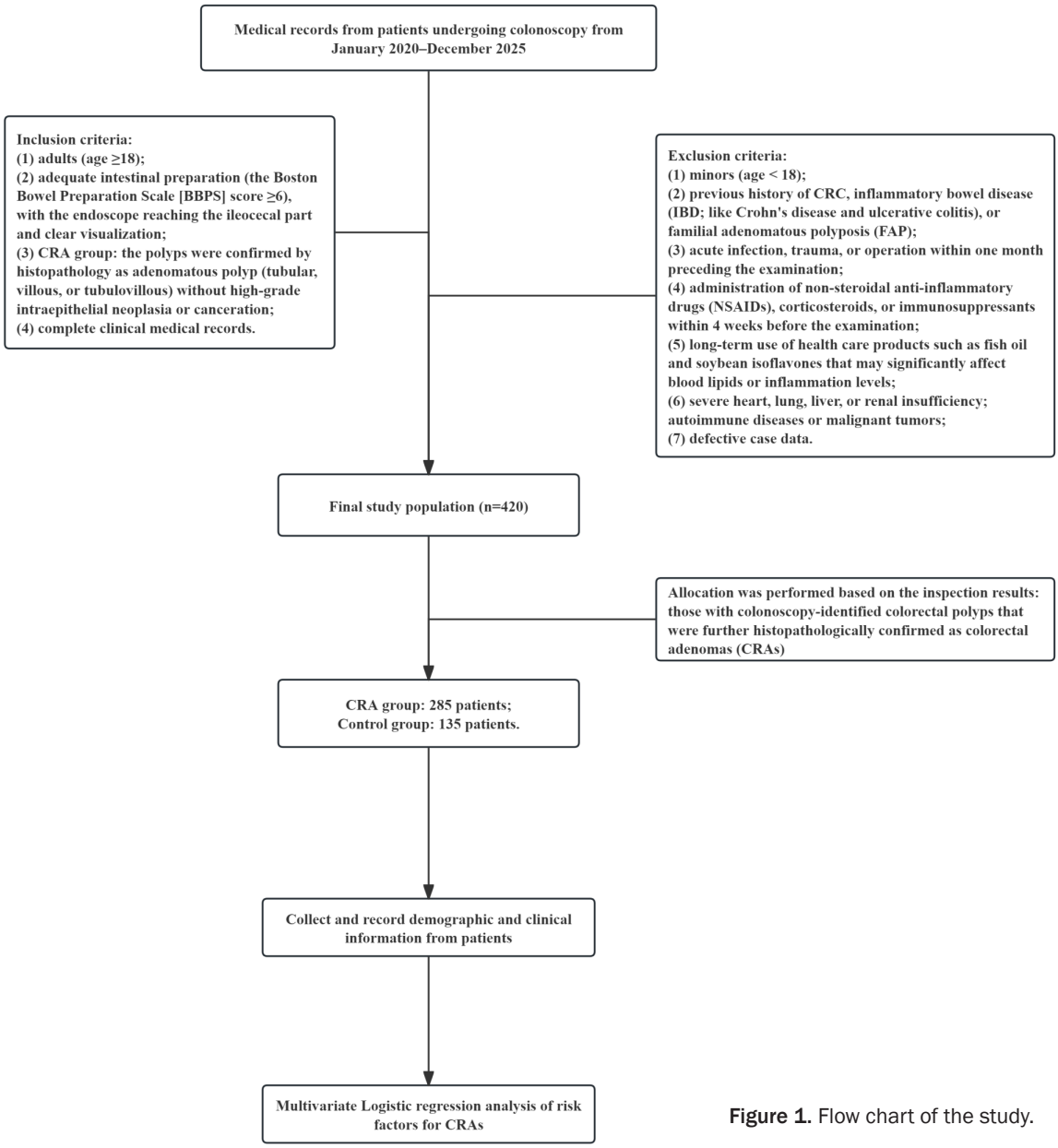

Figure 1. Flow chart of the study.

yps, and gallstones based on abdominal ultrasonography or computed tomography (CT) performed by experienced sonographers. Hepatic steatosis was evaluated according to the consensus criteria issued by the Chinese Medical Association Group for Non-alcoholic Fatty Liver Disease.

(2) Biochemical indices: Fasting venous blood samples were collected from all participants before colonoscopy. Total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) were measured using an automated biochemical analyzer.

(3) SIMs: High-sensitivity C-reactive protein (hs-CRP) levels were quantified using immunoturbidimetry with an automated biochemical analyzer. Serum IL-6 and TNF-α levels were detected using enzyme-linked immunosorbent assay (ELISA) kits, and all procedures were performed strictly following the manufactures' instructions.

Statistical analysis

Statistical analyses were performed using SPSS 26.0. All data were subjected to the Kolmogorov-Smirnov test for normal distribution and homogeneity of variance test. Con-

Table 1. Comparison of baseline characteristics between the two groups

	CRA group (n=285)	Control group (n=135)	χ^2/t	P
Sex			2.515	0.113
Male	167	68		
Female	118	67		
Age (years)	61.88±6.92	60.17±7.83	2.265	0.024
BMI (kg/m^2)	23.11±2.76	22.85±2.90	0.892	0.373
Smoking history			10.671	0.001
Yes	179	62		
No	106	73		
Drinking history			8.956	0.003
Yes	171	60		
No	114	75		
Hypertension			2.361	0.124
Yes	159	86		
No	126	49		
Diabetes			2.429	0.119
Yes	111	42		
No	174	93		
History of appendectomy			0.296	0.587
Yes	37	15		
No	248	120		
History of cholecystectomy			2.411	0.121
Yes	58	19		
No	227	116		
Hepatic steatosis			12.221	0.001
Yes	77	16		
No	208	119		
Cholecystic polypus			5.123	0.024
Yes	32	6		
No	253	129		
Gallstones			4.768	0.029
Yes	37	8		
No	248	127		

Note: CRA, colorectal adenoma.

tinuous variables with a normal distribution and has homogeneity of variance were expressed as mean ± standard deviation (SD) and were compared between groups using the independent-samples t-test. Data that do not conform to normal distribution or homogeneity of variance are represented by Median (P_{25}, P_{75}), and the comparison is conducted using the Mann-Whitney U test. Categorical variables were presented as percentages and were compared using the chi-square test. Binary logistic regression analysis was performed to identify independent factors associated with CRAs. The diagnostic performance of individual serum inflammatory markers and their joint prediction panel was evaluated using receiver operating characteristic (ROC) curve analysis. The combined predictive index was calculated based on the predicted probability (P) derived from the multivariable binary logistic regression model. A two-sided *P* value <0.05 was considered statistically significant.

Results

Comparison of general characteristics

As shown in **Table 1**, CRA patients and controls exhibited comparable distributions in sex,

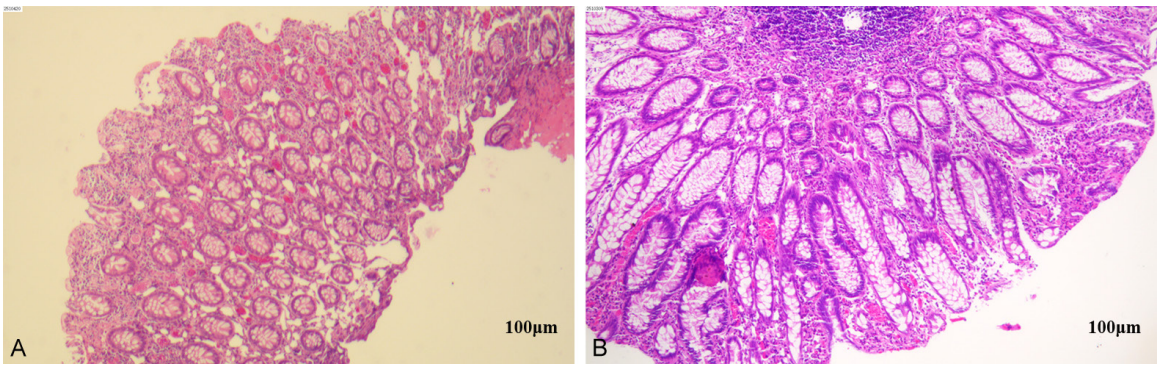

Figure 2. Representative H&E staining images of typical cases. A: Inflammatory polyps of the ascending colon mucosa; B: Hyperplastic polyps of the ascending colon.

Table 2. Comparison of lipid profiles between the two groups

	CRA group (n=285)	Control group (n=135)	t/Z	P
Total cholesterol (mmol/L)	4.80±0.82	4.85±0.90	0.608	0.544
Triglyceride (mmol/L)	1.82 (1.15, 2.47)	1.53 (1.09, 1.93)	-4.022	<0.0001
High-density lipoprotein cholesterol (mmol/L)	1.02 (0.81, 1.17)	134 (1.09, 1.63)	-8.331	<0.0001
Low-density lipoprotein cholesterol (mmol/L)	2.73±0.73	2.76±0.76	0.377	0.706

Note: CRA, colorectal adenoma.

Table 3. Comparison of metabolic abnormalities between the two groups

	CRA group (n=285)	Control group (n=135)	χ^2	P
Hypertriglyceridemia	157	52	10.061	0.002
Hypoalphalipoproteinemia	136	25	33.041	<0.0001

Note: CRA, colorectal adenoma.

hypertension, diabetes, cholecystectomy history, and appendectomy history (P>0.05). However, statistical significances were observed in age, smoking history, alcohol consumption history, hepatic steatosis, cholecystic polyps, and gallstones between the two groups (P<0.05). Age demonstrated a significant association with CRA development. In addition, representative histopathological staining images of typical cases are shown in **Figure 2**.

Serum lipid levels

Significant differences were observed in lipid profiles between the CRA and control groups. Patients in the CRA group exhibited significantly higher serum TG levels and lower HDL-C levels compared with the control group (P<0.05). No significant differences were found in TC and LDL-C levels between the two groups (P>0.05; **Table 2**).

Abnormalities in lipid metabolism

The CRA group had a significantly higher proportion of patients with lipid metabolism abnormalities, including hypertriglyceridemia (TG≥1.7 mmol/L) and hypoalphalipoproteinemia (HDL-C <1.0 mmol/L), compared with the control group (both P<0.05; **Table 3**).

SIM levels

The levels of hs-CRP, TNF-α, and IL-6 were significantly higher in CRA patients compared with the controls (P<0.05; **Table 4**).

Receiver operating characteristic (ROC) curve analysis of SIMs

As shown in **Figure 3**, ROC curve analysis demonstrated that the area under the curve (AUC) value was 0.840 for hs-CRP, 0.832 for TNF-α, and 0.845 for IL-6 in predicting CRAs. The cor-

Table 4. Comparison of serum inflammatory marker levels between the two groups

	CRA group (n=285)	Control group (n=135)	t/Z	P
hs-CRP (mg/L)	4.67 (3.72, 5.63)	2.60 (2.06, 3.30)	-11.273	<0.0001
TNF-α (pg/mL)	16.35 (12.91, 20.18)	10.46 (8.78, 12.55)	-11.004	<0.0001
IL-6 (pg/mL)	23.59 (17.70, 29.99)	13.09 (10.58, 15.98)	-11.440	<0.0001

Note: CRA, colorectal adenoma; hs-CRP, high-sensitivity C-reactive protein; IL-6, interleukin-6; TNF-α, tumor necrosis factor-α.

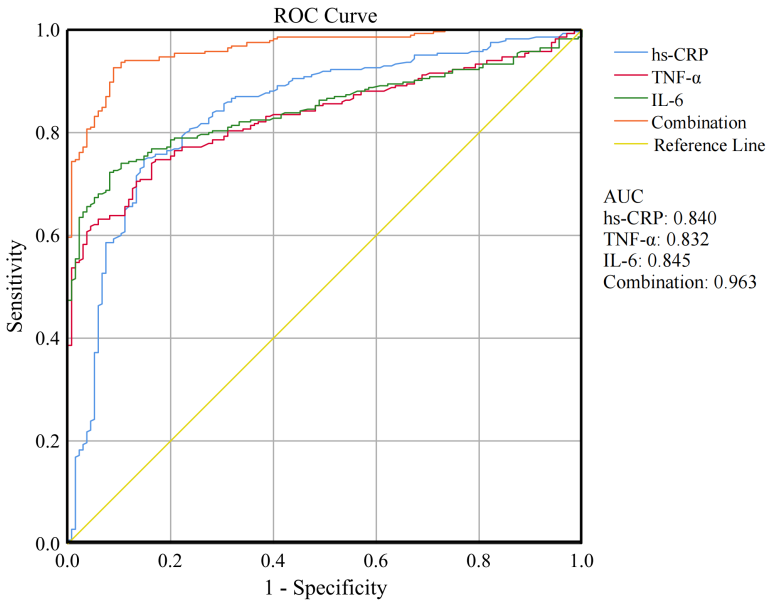

Figure 3. ROC curve analysis for inflammatory markers in predicting CRA. Note: ROC, receiver operating characteristic; hs-CRP, high-sensitivity C-reactive protein; IL-6, interleukin-6; TNF-α, tumor necrosis factor-α; CRA, colorectal adenomas. The combination curve is constructed from predicted probabilities automatically generated by a binary logistic regression model.

responding optimal cutoff values were 3.73 mg/L, 13.15 pg/mL, and 18.81 pg/mL, respectively. The combined curve was generated based on the predicted probabilities derived from the binary logistic regression model. When used in combination (hs-CRP+TNF-α+IL-6), the AUC increased to 0.963, indicating improved predictive performance compared with individual markers (**Figure 1** and **Table 5**). In addition, patients were grouped according to the optimal cut-off value of inflammatory marker levels. The results showed that the proportion of patients with elevated inflammatory marker levels was significantly higher in the CRA group than that in the control group (**Table 6**).

Independent factors associated with CRAs identified by multivariate logistic regression analysis

Binary logistic regression analysis was performed to identify independent predictors for CRAs, using the Forward Stepwise Selection method (Likelihood Ratio). Variables showing significant differences or statistical trends in univariate analysis were included in the multivariate logistic regression model. Age, smoking history, alcohol consumption history, hepatic steatosis, cholecystic polyps, and gallstones were classified and analyzed using binary Logistic regression. Following adjustment for potential confounding factors, hs-CRP (OR= 3.507, 95% CI: 2.401-5.121), TNF-α (OR=1.610, 95% CI: 1.395-1.857), and IL-6 (OR= 1.355, 95% CI: 1.243-1.478) remained independent predictors of CRA (P<0.05). Additionally, older age, smoking history, hypertriglyceridemia, and low HDL-C levels were significantly associated with an increased risk of CRA development (**Table 7**).

Discussion

CRC, with its increasing incidence and mortality rates, represents a global public health concern that warrants attention [10]. Since the majority of CRC cases arise from adenomas, early detection and resection of CRAs can effectively reduce CRC-associated mortality. Therefore, identifying factors associated with CRA development may facilitate the screening and prevention of CRC.

In this study, CRA patients exhibited significantly higher TG levels and lower HDL-C levels than the controls. Hypertriglyceridemia and hypoalphalipoproteinemia were identified to as factors associated with an increased likelihood of adenoma development. In recent years, improvements in living standards in China have

Table 5. ROC curve analysis for inflammatory markers in predicting CRA

	Cut-off	AUC	95% CI	Sensitivity (%)	Specificity (%)
hs-CRP (mg/L)	3.73	0.840	0.799-0.882	74.7	85.2
TNF-α (pg/mL)	13.15	0.832	0.795-0.870	74.0	83.7
IL-6 (pg/mL)	18.81	0.845	0.809-0.882	72.3	91.9
Combination	0.552	0.963	0.948-0.979	92.6	91.1

Note: ROC, receiver operating characteristic; AUC, area under the curve; hs-CRP, high-sensitivity C-reactive protein; IL-6, interleukin-6; TNF-α, tumor necrosis factor-α.

Table 6. Comparison of inflammatory status between the CRA and control groups

	CRA group (n=285)	Control group (n=135)	χ^2	P
hs-CRP (mg/L)			133.21	<0.0001
≤3.73	72	115		
>3.73	213	20		
TNF-α (pg/mL)			122.01	<0.0001
≤13.15	75	113		
>13.15	210	22		
IL-6 (pg/mL)			150.91	<0.0001
≤18.81	79	124		
>18.81	206	11		

Table 7. Binary logistic regression analysis of risk factors for colorectal adenomas

Variable	Assignment	β	SE	Wald	P	OR	95% CI
Constant		-20.846	2.946	50.061	0.000	0.000	-
Age	Continuous variable	0.068	0.029	5.274	0.022	1.070	1.010-1.133
Smoking history	0 = no, 1 = yes	1.598	0.456	12.276	0.000	4.943	2.022-12.085
Hypertriglyceridemia	0 = no, 1 = yes	1.030	0.436	5.581	0.018	2.801	1.192-6.583
Hypoalphalipoproteinemia	0 = no, 1 = yes	1.543	0.474	10.605	0.001	4.684	1.849-11.851
hs-CRP (mg/L)	Continuous variable	1.255	0.193	42.174	0.000	3.507	2.401-5.121
TNF-α (pg/mL)	Continuous variable	0.476	0.073	42.623	0.000	1.610	1.395-1.857
IL-6 (pg/mL)	Continuous variable	0.304	0.044	47.199	0.000	1.355	1.243-1.478

Note: hs-CRP, high-sensitivity C-reactive protein; IL-6, interleukin-6; TNF-α, tumor necrosis factor-α.

been accompanied by a shift toward Western dietary patterns, characterized by increased consumption of high-fat and low-fiber foods. Epidemiological data has also correlated hyperlipidemia, obesity, and metabolic syndrome with CRC onset [11, 12]. Multiple large-scale case-control and cohort studies have shown that elevated serum TG level are positively correlated with CRA risk [13]. In a study of patients with familial adenomatous polyposis (FAP), Mutoh et al. [14] reported that patients with colon cancer exhibited higher blood TG levels. Elevated circulating TG levels are often accompanied by increased free fatty acids (FFAs), which not only serve as cellular energy source but also function as endogenous ligands that activate the Toll-like receptor 4 (TLR4) pathway in intestinal epithelial cells [15]. This activation may initiate downstream pro-inflammatory cascades, induce oxidative stress in the intestinal microenvironment, and promote DNA damage, thereby accelerating adenoma formation [16].

In clinical epidemiology, HDL-C is generally considered "protective" cholesterol, with studies indicating an approximately 7% reduction in CRC risk per 0.2 mmol/L increase in HDL-C [17]. HDL not only participates in reverse cholesterol transport but also carries a variety of biologically active enzymes, such as paraoxonase-1 (PON1), which can degrade oxidized

phospholipids in the intestine and prevent inflammation of intestinal epithelial cells [18]. Therefore, decreased HDL-C may expose the intestinal mucosa to persistent low-level inflammation, thereby increasing the likelihood of adenoma development.

Furthermore, this study identified significantly elevated SIM levels in the CRA group compared with controls. Multivariate analysis further demonstrated a positive association between SIM levels and CRA risk, suggesting a potential continuous relationship. These findings further support the important role of systemic inflammatory microenvironments in intestinal precancerous lesions [19]. Within the intestinal microenvironment, pro-inflammatory cytokines (e.g., IL-6, TNF-α) may promote aberrant proliferation of intestinal epithelial cells and inhibit their apoptosis through activation of the STAT3 or NF-κB signaling pathways, thereby facilitating the formation of adenomas [20]. Epidemiological evidence has also indicated that IL-6 may induce epithelial-mesenchymal transition (EMT) in intestinal epithelial cells and enhance their migratory and invasive abilities [21]. TNF-α, a key TNF family member, can induce the expression of anti-apoptosis proteins through NF-κB axis activation, enabling damaged intestinal epithelial cells to escape programmed cell death [22]. As a non-specific marker of systemic inflammation, hs-CRP may reflect a state of persistent low-grade systemic inflammation [23]. This inflammatory state may precede detectable macroscopic pathological changes under colonoscopy. By up-regulating the expression of adhesion molecules, hs-CRP-associated inflammatory responses may facilitate monocyte infiltration into the intestinal mucosa, thereby creating a microenvironment conducive to adenoma formation.

In obese individuals or patients with dyslipidemia, adipose tissue can produce increased amounts of TNF-α and IL-6 [24]. These inflammatory markers may further inhibit lipoprotein lipase (LPL) activity and further aggravate hypertriglyceridemia [25]. In most European and American studies, obesity is strongly associated with CRC [26]. In the Asian population, however, dyslipidemia and visceral fat accumulation may significantly increase CRA risk even among individuals with normal BMI [27]. In addition, smoking may contribute to CRA development by significantly increasing leukocyte counts and circulating inflammatory marker levels, consistent with the elevated hs-CRP levels observed in this study [28]. Moreover, beyond directly damaging intestinal mucosa through chemical carcinogens, smoking may also enhance lipid peroxidation and reduce HDL-C levels by inducing oxidative stress, thus exerting synergistic carcinogenic effects with metabolic disorders [29].

Several limitations of the current study should be acknowledged. First, as this study employed a retrospective, single-center case-control design, patients were enrolled based on clinical indications for colonoscopy rather than through randomized, community-based screening, which may have introduced potential referral and selection biases. Moreover, this design limits the ability to establish a definitive temporal or causal relationship between chronic inflammation, dyslipidemia, and the development of CRA. Second, although patients with major chronic systemic or autoimmune diseases were systematically excluded during initial cohort screening to minimize the influence of systemic inflammatory conditions, the inherent non-specificity of hs-CRP, IL-6, and TNF-α as inflammatory markers means that subclinical or undiagnosed low-grade inflammatory states may still have acted as potential confounders. Third, all adenomas identified during colonoscopy were analyzed as a single cohort without further stratification according to specific pathological characteristics, such as adenoma size, burden, histological subtype, or degree of dysplasia. This limitation restricted further exploration of the potential role of inflammatory markers across different stages of adenoma progression. Thus, future multicenter, prospective cohort studies incorporating rigorous baseline matching, detailed pathological stratification, and longitudinal follow-up are needed to elucidate the precise causal mechanisms and clinical applicability of these biomarkers in CRA development and progression.

Conclusion

CRAs development is likely influenced by the combined action of environmental exposure, metabolic dysregulation, and systemic inflammation. This study confirmed the potential independent association of SIMs with CRA risk when analyzed as continuous variables. However, a definitive temporal-causal relationship

between inflammatory status and adenoma development cannot be established due to the retrospective design. Validation of these findings in a large-scale prospective cohort studies is warranted.

Disclosure of conflict of interest

None.

Address correspondence to: Yan Li, Department of Gastrointestinal Surgery, The Fourth People's Hospital of Changzhou, No. 68 Honghe Road, Xinbei District, Changzhou 213000, Jiangsu, China. Tel: +86-0519-69806980; E-mail: liyan0983@163.com

References

[1] Matsuda T, Fujimoto A and Igarashi Y. Colorectal cancer: epidemiology, risk factors, and public health strategies. Digestion 2025; 106: 91-99.

[2] Wu S, Zhang Y, Lin Z and Wei M. Global burden of colorectal cancer in 2022 and projections to 2050: incidence and mortality estimates from GLOBOCAN. BMC Cancer 2025; 25: 1770.

[3] Tu J, Zheng L, Yan L, Shi L and Kuang Z. The global landscape of colorectal cancer incidence and mortality in 2022 and projections to 2045: new estimates from GLOBOCAN 2022. J Gastrointest Cancer 2026; 57: 88.

[4] Liem B and Gupta N. Adenoma detection rate: the perfect colonoscopy quality measure or is there more? Transl Gastroenterol Hepatol 2018; 3: 19.

[5] Chi Z, Lin Y, Huang J, Lv MY, Chen J, Chen X, Zhang B, Chen Y, Hu J, He X and Lan P. Risk factors for recurrence of colorectal conventional adenoma and serrated polyp. Gastroenterol Rep (Oxf) 2021; 10: goab038.

[6] Kim DH. Epidemiology of colonic adenoma and cancer. Clin Endosc 2026; 59: 333-344.

[7] Afify SM, Hassan G, Seno A and Seno M. Cancer-inducing niche: the force of chronic inflammation. Br J Cancer 2022; 127: 193-201.

[8] Sahoo DK, Heilmann RM, Paital B, Patel A, Yadav VK, Wong D and Jergens AE. Oxidative stress, hormones, and effects of natural antioxidants on intestinal inflammation in inflammatory bowel disease. Front Endocrinol (Lausanne) 2023; 14: 1217165.

[9] Di Vincenzo F, Del Gaudio A, Petito V, Lopetuso LR and Scaldaferri F. Gut microbiota, intestinal permeability, and systemic inflammation: a narrative review. Intern Emerg Med 2024; 19: 275-293.

[10] Papier K, Bradbury KE, Balkwill A, Barnes I, Smith-Byrne K, Gunter MJ, Berndt SI, Le Marchand L, Wu AH, Peters U, Beral V, Key TJ and Reeves GK. Diet-wide analyses for risk of colorectal cancer: prospective study of 12,251 incident cases among 542,778 women in the UK. Nat Commun 2025; 16: 375.

[11] Gao F, Jiao Y and Wang HL. Metabolic syndrome and colorectal cancer: mechanisms, epidemiological evidence, and clinical implications. World J Clin Oncol 2025; 16: 112639.

[12] Nguyen L and Shanmugan S. A review article: the relationship between obesity and colorectal cancer. Curr Diab Rep 2024; 25: 8.

[13] Li J, Chen J, Liu H, Yan S, Wang Y, Xing M and Ding S. Association of the triglyceride-glucose index with the occurrence and recurrence of colorectal adenomas: a retrospective study from China. BMC Public Health 2024; 24: 579.

[14] Mutoh M, Akasu T, Takahashi M, Niho N, Yoshida T, Sugimura T and Wakabayashi K. Possible involvement of hyperlipidemia in increasing risk of colorectal tumor development in human familial adenomatous polyposis. Jpn J Clin Oncol 2006; 36: 166-171.

[15] Meghnem D, Leong E, Pinelli M, Marshall JS and Di Cara F. Peroxisomes regulate cellular free fatty acids to modulate mast cell TLR2, TLR4, and IgE-mediated activation. Front Cell Dev Biol 2022; 10: 856243.

[16] Hu X, Fatima S, Chen M, Xu K, Huang C, Gong RH, Su T, Wong HLX, Bian Z and Kwan HY. Toll-like receptor 4 is a master regulator for colorectal cancer growth under high-fat diet by programming cancer metabolism. Cell Death Dis 2021; 12: 791.

[17] van Duijnhoven FJ, Bueno-De-Mesquita HB, Calligaro M, Jenab M, Pischon T, Jansen EH, Frohlich J, Ayyobi A, Overvad K, Toft-Petersen AP, Tjønneland A, Hansen L, Boutron-Ruault MC, Clavel-Chapelon F, Cottet V, Palli D, Tagliabue G, Panico S, Tumino R, Vineis P, Kaaks R, Teucher B, Boeing H, Drogan D, Trichopoulou A, Lagiou P, Dilis V, Peeters PH, Siersema PD, Rodríguez L, González CA, Molina-Montes E, Dorronsoro M, Tormo MJ, Barricarte A, Palmqvist R, Hallmans G, Khaw KT, Tsilidis KK, Crowe FL, Chajes V, Fedirko V, Rinaldi S, Norat T and Riboli E. Blood lipid and lipoprotein concentrations and colorectal cancer risk in the European prospective investigation into cancer and nutrition. Gut 2011; 60: 1094-1102.

[18] Wang JX, Yu SJ, Huang G, Yu YB and Li YQ. Apolipoprotein A-I: potential protection against intestinal injury induced by dietary lipid. J Inflamm Res 2024; 17: 5711-5721.

[19] Zhang S, Shen Y, Liu H, Zhu D, Fang J, Pan H and Liu W. Inflammatory microenvironment in gastric premalignant lesions: implication

and application. Front Immunol 2023; 14: 1297101.
[20] Sadati S, Khalaji A, Bonyad A, Khoshdooz S, Hosseini Kolbadi KS, Bahrami A, Moeinfar MS, Morshedi M, Ghamsaraian A, Eterafi M, Eshraghi R, Khaksary Mahabady M and Mirzaei H. NF-κB and apoptosis: colorectal cancer progression and novel strategies for treatment. Eur J Med Res 2025; 30: 616.
[21] Liao L, Wang YX, Fan SS, Hu YY, Wang XC and Zhang X. The role and clinical significance of tumor-associated macrophages in the epithelial-mesenchymal transition of lung cancer. Front Oncol 2025; 15: 1571583.
[22] Wu B, Su S, Li Y and Guo L. Dysregulated programmed cell death of intestinal epithelial cells in ulcerative colitis: molecular mechanisms and novel therapeutic interventions (Review). Int J Mol Med 2025; 56: 230.
[23] Sproston NR and Ashworth JJ. Role of C-reactive protein at sites of inflammation and infection. Front Immunol 2018; 9: 754.
[24] Guerreiro VA, Carvalho D and Freitas P. Obesity, adipose tissue, and inflammation answered in questions. J Obes 2022; 2022: 2252516.
[25] Moon JH, Kim K and Choi SH. Lipoprotein lipase: is it a magic target for the treatment of hypertriglyceridemia. Endocrinol Metab (Seoul) 2022; 37: 575-586.
[26] Ungvari Z, Fekete M, Varga P, Lehoczki A, Fekete JT, Ungvari A and Győrffy B. Overweight and obesity significantly increase colorectal cancer risk: a meta-analysis of 66 studies revealing a 25-57% elevation in risk. Geroscience 2025; 47: 3343-3364.
[27] Dong Y, Zhou J, Zhu Y, Luo L, He T, Hu H, Liu H, Zhang Y, Luo D, Xu S, Xu L, Liu J, Zhang J and Teng Z. Abdominal obesity and colorectal cancer risk: systematic review and meta-analysis of prospective studies. Biosci Rep 2017; 37: BSR20170945.
[28] Elisia I, Lam V, Cho B, Hay M, Li MY, Yeung M, Bu L, Jia W, Norton N, Lam S and Krystal G. The effect of smoking on chronic inflammation, immune function and blood cell composition. Sci Rep 2020; 10: 19480.
[29] Francis HO, Agbonifo WO, Chimezie J, Awoleye M and Adedeji T. Deciphering the impact of high-fat diet and tobacco exposure on urothelial integrity and bladder inflammation: a mechanistic systematic review. Cureus 2026; 18: e105057.