MedPharmRes (MPR) TITLE PAGE

ARTICLE INFORMATION	Fill in information in each box below
Article Type	Research article
Article Title (within 20 words without abbreviations)	Prevalence, Colonoscopic Features, and Risk Factors of Colonic Diverticulosis in Vietnamese Adults Undergoing Colonoscopy: A Cross-Sectional Study
Running Title (within 10 words)	Prevalence, Colonoscopic Features, and Risk Factors of Colonic Diverticulosis
Author	Uyen Pham-Phuong Vo[1,2], Nhu Thi-Hanh Vu[1,2*], Quang Dinh Le[1,2], Doan Thi-Nha Nguyen[1,2], Mai Ngoc Luu[1,2], Nhung Thi-Hong Ngo[2], Duc Trong Quach[1,2]
Affiliation	1 Department of Internal Medicine, School of Medicine, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam 2 GI Endoscopy Department, University Medical Center, Vietnam
ORCID (for more information, please visit https://orcid.org)	Uyen Pham Phuong Vo (https://orcid.org/0000-0001-5173-0976) Nhu Thi Hanh Vu (https://orcid.org/0000-0003-4208-7813) Quang Dinh Le (https://orcid.org/0000-0001-7133-7258) Doan Thi Nha Nguyen (https://orcid.org/0000-0002-4842-9565) Mai Ngoc Luu (https://orcid.org/0000-0002-8129-1764) Nhung Thi Hong Ngo (https://orcid.org/0009-0003-0258-6439)

	Duc Trong Quach (https://orcid.org/0000-0003-0141-921X)
Competing interests	No potential conflict of interest relevant to this article was reported.
Funding sources State funding sources (grants, funding sources, equipment, and supplies). Include name and number of grant if available.	Not applicable.
Acknowledgements	Not applicable.
Availability of data and material	Upon reasonable request, the datasets of this study can be available from the corresponding author.
Authors' contributions Please specify the authors' role using this form. Authors can't change and add items, but you can delete items that are not applicable.	Conceptualization: DT Quach Data curation: UPP Vo, NTH Vu, QD Le DTN Nguyen, MN Luu, NTH Ngo Formal analysis: UPP Vo Methodology: UPP Vo, DT Quach Software: UPP Vo, NTH Vu, QD Le DTN Nguyen, MN Luu Validation: UPP Vo, NTH Vu, DT Quach Investigation: UPP Vo, DT Quach Writing - original draft: UPP Vo, DT Quach Writing - review & editing: UPP Vo, NTH Vu, QD Le DTN Nguyen, MN Luu, NTH Ngo, DT Quach
Ethics approval and consent to participate	All procedures in this study were approved by the Institutional Review Board (IRB) of University of Medicine and Pharmacy at Ho Chi Minh City,

	Vietnam (IRB-VN01002/IORG0008603/FWA00023448).

CORRESPONDING AUTHOR CONTACT INFORMATION

For the corresponding author (responsible for correspondence, proofreading, and reprints)	**Fill in information in each box below**
First name, middle initial, last name	Nhu Thi Hanh Vu
Email address – this is where your proofs will be sent	vuhanhnhu@ump.edu.vn
Secondary Email address	vuhnahnhu2000@yahoo.com
Address	217 Hong Bang Street, Ward 12, District 5, Ho Chi Minh City
Cell phone number	+84-907513827
Office phone number	
Fax number	

Abstract

Background: Colonic diverticulosis is common in gastrointestinal disease with a rising prevalence in Asia. Regional differences exist in prevalence, distribution, and risk factors of diverticulosis; however, data from Vietnam are still lacking. The purpose of our study was to ascertain the prevalence, colonoscopic features, and risk factors of colonic diverticulosis among Vietnamese adults undergoing colonoscopy.

Methods: A descriptive cross-sectional study was performed prospectively on patients undergoing colonoscopy at the Gastrointestinal Endoscopy Department of the University Medical Center-Ho Chi Minh City. Metabolic syndrome was established on the Adult Treatment Panel III guidelines. Univariate and multivariate analyses were conducted to identify risk factors.

Results: There were 480 participants, with a mean age of 53.2 ± 12.7 years. The male-to-female ratio was 0.8. The prevalence of diverticulosis was 29.6%. Right-sided diverticulosis was observed in 69% of cases. Multiple diverticula were present in 68.4% of cases. Multivariate analysis identified advanced age (OR = 2.38, 95% confidence interval (CI): 1.41 – 4.05, p = 0.001), male sex (OR = 1.78, 95% CI: 1.05 – 3.02, p = 0.033), central obesity (OR = 1.61, 95% CI: 1.03 – 2.50, p = 0.037), metabolic syndrome (OR = 1.91, 95% CI: 1.12 – 3.27, p = 0.021), and heavy alcohol consumption (OR = 2.23, 95% CI: 1.03 – 4.84, p = 0.042) as independent risk factors of diverticulosis.

Conclusions: Diverticulosis was prevalent in Vietnamese, with a right-sided predominance of the colon and multiple diverticula. Advanced age, male sex, central obesity, metabolic syndrome, and heavy alcohol consumption were risk factors.

Keywords: diverticulosis, risk factor, endoscopic characteristics, Vietnam

1. Introduction

Colonic diverticulosis, a common gastrointestinal condition, is typified by sac-like protrusions in the colon. However, estimating its true prevalence is challenging, as most cases are asymptomatic and often detected incidentally during colonoscopy or abdominal computed tomography [1]. Although the majority remain asymptomatic, approximately 10-30% of cases may develop complications such as diverticulitis, perforation, fistula formation, bleeding, and an increased risk of thromboembolic events [2]. These complications not only lead to a significant number of hospital admissions and outpatient visits but also contribute to substantial morbidity and mortality. This imposes a significant economic burden, resulting in increased healthcare costs, hospitalizations, and higher resource utilization worldwide. In Western countries, diverticular complications account for an estimated 23,600 deaths annually [3].

There are notable differences in the prevalence, endoscopic characteristics, and risk factors of colonic diverticulosis between Western and Asian populations. The prevalence of diverticulosis is influenced by geographic region, ethnicity, and age, likely due to the combined effects of genetic and environmental factors. Diverticulosis is predominant in Western populations and among the older adults, with prevalence rates of approximately 50% in individuals aged over 60 years and up to 65% in those over 85 years. In contrast, it has been relatively uncommon in Asian populations and younger age groups, with a prevalence of approximately 5% among individuals under 40 years [1, 3, 4]. However, recent studies have shown a rising trend in the prevalence of diverticulosis in Asia, particularly among younger age groups. In Japan, epidemiological data show an increase in prevalence from 13% in the 1990s to 23.9% in the 2000s [5, 6].

Additionally, the anatomy of diverticula varies significantly across regions. In Western populations, diverticula are predominantly located in the left colon, whereas in Asian populations, they tend to occur more frequently in the right colon [6]. Several risk factors have been reported in Western studies, including older age, obesity, low-fiber diet, alcohol consumption, and smoking [7]. In Asia, although fewer studies exist, some have also identified risk factors such as advanced age, alcohol use, constipation, diabetes mellitus, and hypertriglyceridemia [5, 8]. However, most existing studies are retrospective, and findings on risk factors (such as gender, obesity, alcohol consumption, and smoking) remain inconsistent.

Moreover, comprehensive assessments of all potential risk factors for diverticulosis are still lacking.

In Vietnam, there is a limited literature body on the epidemiological properties of colonic diverticulosis. Therefore, the study was conducted to assess the prevalence, endoscopic features, and risk factors of colonic diverticulosis in Vietnamese adults undergoing colonoscopy. These findings are crucial for understanding the disease burden, facilitating the identification of high-risk individuals, and contributing to the development of appropriate diagnostic and therapeutic interventions to minimize complications.

2. Materials and Methods

2.1. Study settings and participants

Between April 2023 and June 2024, a cross-sectional study was conducted prospectively at the Gastrointestinal Endoscopy Department of the University Medical Center-Ho Chi Minh City. Patients aged 18 years and older who were indicated for colonoscopy and had undergone complete blood biochemistry tests, including fasting glycemia, high-density lipoprotein level, and triglyceridemia, were eligible for the study. Exclusion criteria included patients with symptoms related to complicated diverticular disease, such as rebound tenderness, fever, hematochezia, incomplete colonoscopy, inadequate bowel preparation, colonoscopic withdrawal time less than 6 minutes, history of colorectal surgery, and those who declined to either participate in the study or undergo colonoscopy (Fig. 1) [Place Figure 1 near this point]. Inadequate bowel preparation was diagnosed when the Boston Bowel Preparation Score was under 6.

We calculated the required sample size based on the formula for detecting a specific odds ratio with predetermined level of confidence and statistical power.

$$N = \frac{(1+r)^2 * (Z_{\alpha/2} + Z_{1-\beta})^2}{r * [ln(OR)^2] * [\mathrm{p}(1-\mathrm{p})]}$$

The odds ratio (OR) and value for p in the sample size calculation were based on a previous study conducted in Japan, where the prevalence of the absence of diverticulosis among the elderly was approximately 76% and the OR was 1.96 [5]. Given that the overall prevalence of diverticulosis in Asian populations ranges from 20% to 30%, we selected a value of r at 2.3 for the calculation [8-10]. These studies were chosen because the demographic characteristics of their populations are comparable to the Vietnamese population.

The demographic information and anthropometric data were recorded. Information on previous diverticulosis-related complications (diverticulitis, perforation, and bleeding), comorbidities (such as diabetes, hypertension, and dyslipidemia), use of laxatives in the past month, and weight gain since the age of 20 were collected. Furthermore, clinical symptoms such as abdominal pain, characteristics of feces, changes in bowel habits, and weight loss were recorded. Dietary intake and lifestyle habits - such as smoking status and alcohol consumption - as well as the results of blood tests, including glucose, triglyceride indicators, and high-density lipoprotein cholesterol, which were performed within the last six months, were also noted.

We categorized individuals into younger and older adults, with cut-off points at 45 and 65 years of age, respectively. A body mass index (BMI) of at least 25 kg/m² was classified as obesity, based on World Health Organization (WHO) criteria for Asian populations [11]. A waist circumference of over 85 cm for women and over 90 cm for men was considered central obesity. Significant weight gain was defined as an increase of more than 10 kg since the age of 20 [12]. The Rome IV criteria were used to diagnose irritable bowel syndrome (IBS) [13]. The Adult Treatment Panel III criteria for metabolic syndrome requires the presence of three or more of the following five elements: exhibiting central obesity (as defined above), systolic blood pressure of at least 130 mmHg and/or diastolic blood pressure of at least 85 mmHg or previously diagnosed hypertension under treatment, triglyceride level of at least 150 mg/dL, HDL cholesterol of 40 mg/dL or lower in men and 50 mg/dL or lower in women, and fasting plasma glucose of at least 100 mg/dL or previously detected type 2 diabetes under treatment [14].

Dietary consumption was divided into two categories for dietary assessment: a meat-based dietary pattern, which includes red or processed meat, fried noodles, chicken, and cephalopods; and a vegetable-based dietary pattern, which includes vegetables, fruits, and beans. Usage of laxatives was divided into four groups: no use, occasional use, weekly use, and daily use. Smoking and alcohol consumption status were categorized into three groups: never-users, former users, and current users. According to the National Health Interview Survey, an average weekly consumption of ≤3 drinks was considered light drinking; >3 to ≤7 drinks for women and >3 to ≤14 drinks for men were considered moderate drinking; and >7 drinks for women and >14 drinks for men were considered heavy drinking. To assess smoking status, we used pack-years, defined as smoking one pack per day for one year. Those with 1–20 pack-years were classified

as light smokers, those with 20.1–40 pack-years as moderate smokers, and those with over 40 pack-years as heavy smokers.

Colonoscopy was indicated for all patients with lower gastrointestinal symptoms. Five experienced endoscopists performed the procedures. All were trained by a senior expert (DTQ) at the GI Endoscopy Department, University Medical Center-Ho Chi Minh City. They work as a unified team, participate in regular quarterly meetings to collectively discuss and evaluate endoscopic findings. Each endoscopist has over 10 years of experience and performs more than 300 colonoscopies annually. Therefore, the inter-observer variability in lesion detection was minimal. The Olympus CLV-CV 180 endoscope (Olympus, Tokyo, Japan) was utilized. Bowel preparation followed the hospital's standard diagnostic colonoscopy protocol. The endoscopists carefully examined the entire colonic mucosa to detect abnormalities. Both endoscopic and full medical records were retrieved from electronic archive system. Detected lesions were documented during colonoscopy. Polyps were removed entirely and histologically examined by pathologists. When diverticula were identified, the endoscopist recorded their location, the largest and smallest sizes using biopsy forceps as a reference, the number of diverticula, and the characteristics of diverticular lesions in each colonic segment. The right-sided colon comprises the cecum, the ascending colon, the hepatic flexure, and the transverse colon; the left-sided colon includes the splenic flexure, the descending colon, the sigmoid colon, and the rectum; and the pan-colon includes both the right- and left-sided colon. Diverticular lesions were defined as erythematous, erosive, suppurative, or hemorrhagic changes. Based on colonoscopy findings, two groups of patients were recognized: those with diverticulosis and those without.

2.3. Statistical method

The Statistical Package for the Social Sciences (SPSS) version 26 was used for data analysis. For continuous variables, descriptive statistics summarized data in means ± standard deviations and medians (interquartile ranges) for normal and non-normal distributions, respectively. For categorical variables, descriptive statistics were presented as frequencies (%). Chi-square analysis and Fisher's exact test for categorical variables were used. The t-test and Wilcoxon test were employed for continuous variables with normal and non-normal distributions, respectively. Due to our small sample size, multivariate analysis was used to identify significant variables ($p < 0.1$) found by univariate analysis, in order to estimate the risk factors associated with diverticulosis. For every variable, the OR with 95% CI were computed. In multivariate analysis,

we employed forward stepwise logistic regression. A p-value threshold of < 0.1 was used as the entry criterion for variable inclusion. The procedure was concluded when no additional variables met this entry criterion. To assess multicollinearity, we examined the Pearson correlation coefficients pair-wise between independent variables. No correlation coefficient exceeded 0.75, indicating that multicollinearity was not detected. A statistically significant p-value was defined as less than 0.05. The Hosmer-Lemeshow test was used to evaluate how well the statistical model fits. The observed data aligned with the expected value if the Chi-square value was low and the p-value was greater than 0.05. White's test was implemented to detect heteroscedasticity. The presence of heteroscedasticity was noted if the p-value was less than 0.05.

2.4. Ethical considerations

All procedures were conducted in accordance with the principles outlined in the Declaration of Helsinki. The Ethics Committee in Biomedical Research, University of Medicine and Pharmacy at Ho Chi Minh City approved this study, with decision number IRBVN01002/IORG0008603/FWA00023448. Each subject acquired written informed consent.

3. Results

3.1. Characteristics of the study population

A total of 600 patients underwent colonoscopy. After excluding 120 cases based on eligibility criteria, 480 participants were recruited for data collection. The mean age of participants was 53.2 ± 12.7 years. Most patients were middle-aged, and approximately 20.2% were over 65 years old. The male-to-female ratio was 0.8. 34% of patients had metabolic syndrome. Among the 137 patients diagnosed with irritable bowel syndrome (IBS), diarrhea-predominant IBS was the most common subtype (20.8%), followed by mixed-type IBS (5.6%) and constipation-predominant IBS (3.1%). Approximately 92.9% of patients did not use laxatives in the past month. The baseline characteristics, as well as lifestyle and dietary habits are summarized in Table 1 [Insert Table 1 here].

3.2. Prevalence of diverticulosis

A total of 142 patients (29.6%) were found to have diverticulosis on colonoscopy (Fig.2) [Place Figure 2 near this point]. Meanwhile, only three patients (0.6%) had a documented history of diverticular complications, including 2 cases of diverticulitis and 1 case of diverticular perforation (Table 1).

3.3. Characteristics of colonic diverticula on colonoscopy findings

Although females accounted for a larger proportion in the sample, the prevalence of colorectal diverticulosis was significantly higher in males (56.3%) than in females (43.7%) (OR = 2.04, 95% CI 1.37 – 3.03, p < 0.0001). Among the older adults, the prevalence of diverticulosis among females was nearly 2.5 times higher than among males (70% vs. 30%, p = 0.086). Additionally, the detection rate of diverticulosis in older patients (≥ 65 years) was twice in younger patients (≤ 45 years) (28.2% vs. 14.1%, 95% CI: 1.87 – 6.57, p < 0.0001).

The distribution of diverticulosis is shown in Table 2 [Insert Table 2 here]. Of 480 patients, 111 (23.1%) had diverticula in the ascending colon, the most frequent location of diverticulosis in our study. Among 142 patients with diverticulosis, right-sided diverticulosis, left-sided diverticulosis, and bilateral diverticulosis were observed in 69%, 13.4%, and 17.6% of cases, respectively. Despite an insignificant association between the age of patients and the location of diverticulosis, the mean age of patients (54.6 ± 11.7) with right-sided diverticulosis appeared lower than the mean age of those (60.4 ± 13.7) with left-sided diverticulosis (95% CI 0.916 – 1.002, p = 0.059).

Among patients with diverticulosis, single diverticulum and multiple diverticula were present in 31.6% and 68.4% of cases, respectively. The greatest number of diverticula was 45. A significant difference in the mean age was noted between patients with a single diverticulum and those with multiple diverticula (55.7 ± 13.6 vs. 56.5 ± 11.4 years, respectively; 95% CI 1.008 – 1.046, p = 0.004).

The percentage of patients with diverticula larger than 1.0 cm and those with more than 10 diverticula was roughly 8.4% and 28.1%, respectively. The smallest diverticulum measured 0.3 cm, while the largest measured 2.0 cm. No signs of diverticular complications such as inflammation, abscess, bleeding, or perforation were noted. Other endoscopic findings accompanying diverticulosis included hemorrhoids (89.4%), neoplastic polyps (15.5%), adenomas (10.6%), and colorectal cancer (0%). No endoscopic complications were reported during the procedures.

3.4. Risk factors of colonic diverticula

Table 3 presents the risk factors associated with diverticulosis in univariate analysis [Insert Table 3 here]. Advanced age, sex, central obesity, hypertension, diabetes, metabolic syndrome, alcohol intake, the amount of alcohol consumption, HDL-C, triglyceridemia, and glycemia were significantly associated with diverticular disease. In multivariate analysis, advanced age (OR =

2.38, 95% CI 1.41 – 4.05, p = 0.001), male sex (OR = 1.78, 95% CI 1.05 – 3.02, p = 0.033), central obesity (OR = 1.61, 95% CI 1.03 – 2.50, p = 0.037), metabolic syndrome (OR = 1.91, 95% CI 1.12 – 3.27, p = 0.021), and heavy alcohol consumption (OR = 2.23, 95% CI 1.03 – 4.84, p = 0.042) were found to be the risk factors of diverticulosis (Table 4) [Insert Table 4 here]. Our model yielded a Chi-square value of 34.31 with a p-value of 0.27, indicating a good model fit. In addition, the p-value was 0.318 in White's test, indicating no presence of heteroscedasticity.

4. Discussion

This is the first study to investigate the prevalence, endoscopic characteristics, and risk factors of diverticulosis in a Vietnamese population. The prevalence of diverticulosis was 29.6%. Most diverticula were distributed in the right-sided colon and presented as multiple diverticula. In addition, our findings demonstrated a significant association between diverticulosis and advanced age, sex, metabolic syndrome, central obesity, and alcohol consumption.

4.1 Prevalence of diverticulosis

Diverticulosis is a common disease in European countries, with a prevalence ranging from 5% to 45% [15]. In our study, the prevalence of diverticulosis was 29.6%, which remained lower than that in most European populations [1, 9]. In comparison with Asian studies, our result aligned with data from Japan (26%) and Lebanon (33%), but was notably higher than the rate reported in Korea (12%) [16, 17]. When compared with other Southeast Asian countries, our findings were consistent with those reported in Thailand (28.5%), Hong Kong, and the Philippines (25–35%), but were higher than those reported by Tam Anh Hospital in Vietnam (20.8%) [8-10]. Differences in inclusion criteria may partly explain these variations. In our study, only patients with available lipid and glucose profiles within the past six months were included. In Vietnam, the number of individuals undergoing routine annual health check-ups remains limited. Therefore, most patients who underwent these tests may suffer from diseases related to diabetes and dyslipidemia. Both dyslipidemia and diabetes are components of metabolic syndrome, a known risk factor for colonic diverticulosis. In contrast, the studies conducted at Tam Anh Hospital and South Korea did not require blood test results for the inclusion criteria, which may account for the lower reported prevalence.

Overall, there has been a remarkable increase in the prevalence of diverticular disease globally since the mid-1990s, particularly in Asian countries [1]. This trend is attributed to changes in dietary patterns and lifestyle, and improved public awareness in health screening programs [1]. Interestingly, among the 142 patients with diverticulosis in our cohort, only 3 (0.6%) were previously aware of their condition due to a history of diverticular complications. This observation aligns with previous literature, which suggests that most diverticula are asymptomatic and are typically detected incidentally during colonoscopy or contrast-enhanced abdominal CT scans. Such asymptomatic presentation contributes to wide variability in prevalence rates across studies, depending on geographic and ethnic factors, demographic characteristics, study designs, as well as the diagnostic expertise of endoscopists.

4.2. Characteristics of colonic diverticula on colonoscopy findings

A well-documented difference exists in the anatomical distribution of colonic diverticula between Western and Asian populations. Right-sided colonic diverticulosis is significantly more prevalent in Asian populations (70%) compared to European populations (15%) [18]. In accordance with this pattern, our study found a predominance of diverticula in the right colon (69%), with the ascending colon being the most commonly affected segment (23.1%). Left-sided diverticula accounted for only 13.4% of cases. Compared to previous hospital-based studies, our findings were similar to those reported in Japan (69.3%) but showed a higher prevalence of right-sided colonic diverticulosis than that reported in Thailand (46.7%) [8, 19]. This variation may stem from differences in diagnostic modalities. While our study utilized colonoscopy for diagnosis, the Thai study relied on double-contrast barium enema, which may be less sensitive in detecting right-sided lesions. Various theories have been proposed to elucidate why Asian populations are more likely to suffer from right-sided diverticulosis. The reasons may be congenital or genetic predisposition, dietary influences, and structural changes in the colonic wall's response to environmental factors. Among these, genetic predisposition is believed to play a particularly pivotal role [20].

Given the high prevalence of right-sided diverticulosis in Asian populations, including Vietnamese, we emphasize the importance of thorough inspection of the right colonic mucosa during colonoscopy, particularly during the withdrawal phase, to minimize missed diagnoses.

In our study, the majority of patients (68.4%) were found to have multiple diverticula, with 28.1% of them having more than 10 diverticula. This finding aligns with reports from both

European and Asian populations [17]. This high prevalence of multiple diverticula may explain why complications of diverticular disease, such as gastrointestinal bleeding and diverticulitis, frequently recur despite prior successful interventions.

An interesting observation from our study was that while age did not show a significant correlation with the location of diverticula, it had a strong correlation with the number of diverticula. In contrast, the study conducted in Korea did not observe such a relationship [17]. The weakening of the intestinal muscular layer at multiple sites with increasing age may contribute to the development of numerous diverticula. This highlights the importance of identifying risk factors early and implementing preventive strategies in younger individuals to mitigate the progression of diverticulosis.

Most patients in our study had small- to medium-sized diverticula. Only 8.4% of patients had diverticula larger than 1 cm in diameter. In clinical practice, it is crucial to find these lesions because they can be misdiagnosed, particularly in blind areas such as colonic folds, near tumors or polyps, or among cases with inadequate bowel preparation.

4.3. Risk factors of colonic diverticula

Our results revealed that individuals aged 65 years and older had a higher prevalence (28.2%) compared to younger adults (14.1%). As people age, their risk of developing diverticulosis increases, and our data confirm that individuals older than 65 years are at significantly higher risk. These results align with findings from previous studies conducted in Japan, Taiwan, and Israel [5, 21, 22]. There is currently no universally accepted explanation for the age-related distribution of diverticular disease. However, several hypotheses suggested that age-related connective tissue degeneration, lifestyle habits, and low dietary fiber intake may contribute [6, 23]. Age-related changes, such as continuous deposition of collagen and elastin in the intestinal wall, abnormal colonic motility due to fiber deficiency, reduced elasticity of the intestinal wall, and impaired pressure regulation, increase susceptibility to diverticulosis in older adults [6]. Our analysis revealed a significant difference in the prevalence of diverticular disease between males (56.3%) and females (43.7%) (95% CI 1.05 – 3.02, $p = 0.033$). Similar to several prior reports, we observed that females were at lower risk of developing diverticulosis than males in the same age group [24]. One hypothesis regarding endogenous ovarian steroid hormones, which may exert a protective effect against the development of diverticula, was mentioned. Interestingly, although men had a higher overall prevalence of diverticulosis, women

in the elderly subgroup exhibited a greater burden of disease. These results were consistent with studies conducted in Poland and China [6, 25]. Among older women, additional risk factors of diverticulosis include obesity, use of hormone replacement therapy during menopause, and reduced physical activity. In our analysis, alcohol consumption was significantly associated with diverticulosis ($p < 0.0001$). However, only heavy drinking was identified as a risk factor for diverticulosis in multivariate analysis. Song *et al*. reported that alcohol consumption doubles the risk of diverticulosis compared to abstinence [17]. Sharara *et al*. found that the risk increased from 1.91 to 2.7 with higher levels of alcohol intake ($p = 0.001$) [26]. In a prospective study in Japan, Nagata *et al*. showed that heavy alcohol use not only raised the risk of diverticulosis (OR = 5.6, $p < 0.001$) but also increased the likelihood of diverticular bleeding [27]. Meanwhile, a meta-analysis found no association between alcohol use and diverticulosis. Variations in findings across studies may be due to differences in the type of alcohol consumed, the definition of "heavy drinking," and the characteristics of the populations studied. Although the mechanism is not fully understood, alcohol may influence colonic motility and exert direct toxic effects on colonic mucosa through oxidative stress mechanisms [27].

Although a high BMI is often associated with low dietary fiber intake and presumed to increase the risk of diverticulosis, no significant association between BMI and diverticulosis was noted in our multivariate analysis, consistent with findings from other studies [17]. Interestingly, abdominal obesity was found to have a substantial correlation with diverticulosis (OR = 1.61, 95% CI 1.03 – 2.50, $p = 0.037$). This result aligns with multiple studies from both Europe and Asia. Research in Portugal and Turkey has demonstrated that increased subcutaneous fat thickness, as measured by abdominal ultrasound or CT scan, is associated with diverticulosis [28]. Similarly, two studies in Japan reported that visceral fat area, rather than BMI, was an independent predictor of diverticulosis and diverticulitis [29]. Although the precise mechanism is unclear, one hypothesis suggests that visceral adiposity leads to elevated serum levels of cytokines, such as nitric oxide synthase, which may alter colonic segmentation. Additionally, changes in gut microbiota and colonic motility may contribute to developing diverticulosis.

In our multivariate analysis, central obesity was an independent risk factor. Our findings are consistent with those reported by Kopylov et al [22]. Despite limited data on this association, Teixeira et al. also reported a significant relationship between metabolic syndrome and

diverticulosis (OR = 3.6, 95% CI: 1.587–8.546). While another study did not directly assess the risk of diverticulosis associated with metabolic syndrome, it did demonstrate that patients with metabolic syndrome experienced more adverse events after diverticulitis surgery than those with isolated obesity, hypertension, or diabetes [30]. These results further support the hypothesis that the pathogenesis of diverticular disease may involve metabolic syndrome. In addition, the presence of central obesity, hypertension, diabetes, low HDL-C, and hypertriglyceridemia defines metabolic syndrome. All of them were significantly associated with diverticulosis in univariate analysis. However, in multivariate analysis, only central obesity remained an independent risk factor. Therefore, it should be noted that the prevention and treatment of disorders related to metabolic syndrome, especially central obesity, should be emphasized as a key strategy to reduce the risk of the development of diverticulosis in Vietnam.

Our study had several strengths. First, the study was conducted prospectively, allowing for the full collection of data, including blood pressure and anthropometric measurements such as waist circumference, height, and weight. Additionally, lifestyle factors such as bowel habits, smoking, alcohol use, and dietary intake were collected through direct patient interviews and controlled for in the analysis. Second, we assessed the correlation between diverticulosis and the degree of alcohol and tobacco use, rather than merely their presence, thereby offering practical insights for risk stratification and prevention strategies in clinical practice, especially in heavy drinkers.

Nonetheless, several limitations should be acknowledged. The research was conducted in only one center. In addition, we only chose patients who were indicated for colonoscopy. Therefore, the results may not represent the characteristics of diverticulosis for the general population.

5. Conclusion

In conclusion, 29.6% of the participants in our research have colonic diverticulosis. The majority of diverticula (69%) are found in the right colon, and multiple diverticula present in 68.4% of the sample. Advanced age, male sex, central obesity, metabolic syndrome, and heavy alcohol consumption are risk factors for diverticulosis.

References

1. Martel J, Raskin JB, NDSG. History, incidence, and epidemiology of diverticulosis. Clin Gastroenterol. 2008;42(10):1125-7.
2. Lanas A, Abad-Baroja D, Lanas-Gimeno A. Progress and challenges in the management of diverticular disease: which treatment? Therap Adv Gastroenterol. 2018;11(1):1756284818789055.
3. Kang JY, Dhar A, Pollok R, Leicester RL, Benson MJ, Kumar D, et al. Diverticular disease of the colon: ethnic differences in frequency. Aliment Pharmacol Ther. 2004;19(1):765-9.
4. Hawkins AT, Wise PE, Chan T, Lee JT, Mullaney TG, Wood V, et al. Diverticulitis – An Update from the Age Old Paradigm. Curr Probl Surg. 2020;57(10):100862.
5. Yamamichi N, Shimamoto T, Takahashi U, Sakaguchi Y, Kakimoto H, Matsuda R, et al. Trend and Risk Factors of Diverticulosis in Japan: Age, Gender, and Lifestyle/Metabolic-Related Factors May Cooperatively Affect on the Colorectal Diverticula Formation. PLoS One. 2015;10(4):e0123688.
6. Wang SF, Li CY, Dai ZM, Wang ZK, Peng LHZ, Chang XL, et al. Gender, Age, and Concomitant Diseases of Colorectal Diverticulum in China: A Study of 7,964 Cases. Dig Dis. 2019;37(2):116-22.
7. Alessandra V, Ginevra C, Chiara M, Alberto M, Antonio N, Mario C, et al. Epidemiology and risk factors for diverticular disease. Acta Biomed. 2018;89(9):107-12.
8. Lohsiriwat V, Suthikeeree W. Pattern and distribution of colonic diverticulosis: analysis of 2877 barium enemas in Thailand. World J Gastroenterol. 2013;19(46):8709–13.
9. Pham HT, Do MH, Tran TB, Nguyen PL, Ho TBT, Hoang LL, et al. Distribution and characteristics of colonic diverticula in patients undergoing colonoscopy at Tam Anh Hospital in Ho Chi Minh city. Vietnam Medical Journal. 2024;542(1):214-7.
10. Chen Z, Yu J, Song Y, Chui D. Aging Beijing: challenges and strategies of health care for the elderly. Ageing Res Rev. 2010;9(1):S2-5.
11. Haam JH, Kim BT, Kim EM, Kwon H, Kang JH, Park JH, et al. Diagnosis of Obesity: 2022 Update of Clinical Practice Guidelines for Obesity by the Korean Society for the Study of Obesity. J Obes Metab Syndr. 2023;32(2):121-9.

12. Mam W, Jovani M, Liu PH, Nguyen LH, Cao Y, Tam Y, et al. Association Between Obesity and Weight Change and Risk of Diverticulitis in Women. Gastroenterology. 2018;155(1):58-66.
13. Lacy BE, Mearin F, Chang L, Chey W.D, Lembo A.J, Simren M, et al. Bowel Disorders. Gastroenterology. 2016;150(1):1393–407.
14. Evaluation Expert Panel on Detection, and Treatment of High Blood Cholesterol in Adults: Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP). Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA. 2001;285(1):2486–97.
15. Hughes LE. Postmortem survey of diverticular disease of the colon. I. Diverticulosis and diverticulitis. Gut. 1969;10(1):336–44.
16. Kazuo T, Yusuke S, Takashi N, Hiroshi I, Masahiko I, Atsushi N, et al. Recent Trends in Colonic Diverticulosis in Yokohama City: A Possibility of Changing to a More Western Profile. Intern Med. 2015;54(1):2545-50.
17. Song JH, Kim YS, Lee JH, Ok KS, Ryu SH, Lee JH, et al. Clinical Characteristics of Colonic Diverticulosis in Korea: A Prospective Study. Korean J Intern Med. 2010;25(2):140–46.
18. Lee YS. Diverticular disease of the large bowel in Singapore. An autopsy survey. Dis Colon Rectum 1986;29(1):330-5.
19. Inoue M. Epidemiological evaluation and clinical aspect of colon diverticulosis. J Jap Society of Colon & Anus. 1992;45(1):904-13.
20. Turner GA, O'Grady MJ, Purcell RV, Frizelle FA. The Epidemiology and Etiology of Right-Sided Colonic Diverticulosis: A Review. Ann Coloproctol 2021;37(4):196-203.
21. Wang FW, Chuang HY, Tu MS, King TM, Wang JH, Hsu CW, et al. Prevalence and risk factors of asymptomatic colorectal diverticulosis in Taiwan. BMC Gastroenterol. 2015;15(1):40.
22. Kopylov U, Ben-Horin S, Lahat A, Segev S, Avidan B, Carter D. Obesity, metabolic syndrome and the risk of development of colonic diverticulosis. Digestion. 2012;86(1):201–05.
23. Miron A, Ardelean M, Bogdan M, Giulea C. Surgical management of colonic diverticular disease. Chirurgia. 2007;102(1):37.

24. Peery AF, Keku TO, Galanko JA, Sandler RS. Sex and Race Disparities in Diverticulosis Prevalence. Clin Gastroenterol Hepatol. 2020;18(9):1980-6.
25. Isohata N, Nagata K, Utano K, Nozaki R, Nozu S, Kato T, et al. Prevalence and distribution of the colonic diverticulosis. Review of 417 cases from Lower Silesia in Poland. Rom J Gastroenterol 2004;13(1):281.
26. Sharara A, El-Halabi MM, Mansour NM, Malli A, Ghaith OA, Hashash JG, et al. Alcohol consumption is a risk factor for colonic diverticulosis. J Clin Gastroenterol. 2013;47(5):420-5.
27. Nagata N, Niikura R, Shimbo T, Kishida Y, Sekine K, Tanaka S, et al. Alcohol and Smoking Affect Risk of Uncomplicated Colonic Diverticulosis in Japan. PLoS One. 2013;8(12):e81137.
28. Lee SP, Ahn YW, Lee OY, Lee KN. The relationship between colonic diverticulosis and abdominal visceral and subcutaneous fat accumulation measured by abdominal CT scan. Turk J Gastroenterol 2014;25(1):192-7.
29. Nagata N, Sakamoto K, Arai T, Niikura R, Shimbo T, Shinozaki M, et al. Visceral Abdominal Obesity Measured by Computed Tomography is Associated With Increased Risk of Colonic Diverticulosis. J Clin Gastroenterol. 2015;49(10):816-22.
30. Jehan F, Zeeshan M, Con J, Hanna K, Tang A, Hamidi M, et al. Metabolic Syndrome Exponentially Increases the Risk of Adverse Outcomes in Operative Diverticulitis. J Surg Res. 2020;245(1):544-51.

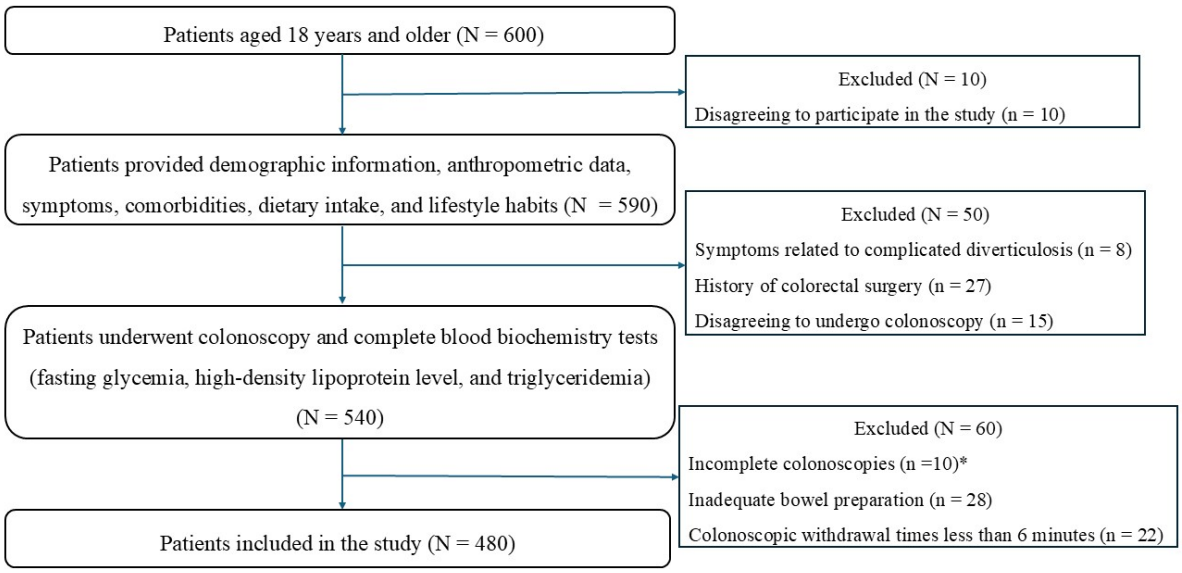

Fig. 1: Flow chart of the study

* Due to narrow lumen related to advanced colon cancer (n = 3) and technical difficulty (n = 7)

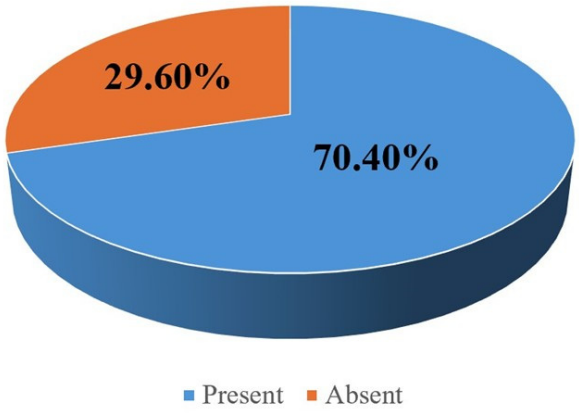

Fig. 2: The prevalence of diverticulosis