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Research Article

Anastomotic Leakage in Colorectal Surgery: The Differential Impact of Smoking and Vaping.

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Abstract

Background: *Anastomotic dehiscence is a serious complication in colorectal surgery. While traditional smoking is a known independent risk factor, the impact of the growing habit of vaping on postoperative outcomes, particularly on wound healing and anastomotic integrity, is not well understood.*

Objective: *To evaluate the association between traditional smoking, vaping, and the incidence of anastomotic dehiscence in a cohort of patients undergoing colorectal surgery.*

Methods: *We conducted a retrospective cohort study of 748 patients who underwent elective colorectal surgery. Data on smoking and vaping habits, BMI, surgical type, and patient demographics were analyzed. We used logistic regression to identify independent risk factors for anastomotic dehiscence and other postoperative complications.*

Results: *The overall rate of anastomotic dehiscence was 5.2%. We found that traditional smoking was an independent risk factor for anastomotic dehiscence (OR: 1.8, 95% CI: 1.2-2.7, $p<0.01$) as well as for wound complications, pulmonary complications, and sepsis. Interestingly, no significant association was found between vaping and anastomotic dehiscence (OR: 1.1, 95% CI: 0.8-1.5, $p=0.52$).*

Conclusion: *Traditional smoking is a significant and independent risk factor for anastomotic dehiscence and other major postoperative complications in patients undergoing colorectal surgery. These findings underscore the critical importance of implementing preoperative smoking cessation programs. In contrast, no significant association was found for vaping, suggesting different effects on surgical outcomes, which warrants further investigation.*

Introduction

Anastomotic leakage is a serious and feared complication in colorectal surgery, associated with a significant increase in postoperative morbidity and mortality. Several factors have been identified as potential contributors to this complication, among which smoking stands out as an independent risk factor. Beyond its known associations with respiratory and cardiovascular diseases, smoking has also been linked to poor wound healing and a higher risk of postoperative complications. Studies such as that by Dureuil et al. [1] have highlighted the negative influence of smoking on surgical outcomes.

Badiani et al. [2] have shown in their study that preoperative smoking is associated with a higher risk of postoperative complications in patients undergoing right hemicolectomy for colon cancer. These findings corroborate the existing evidence on the detrimental effects of smoking on wound healing. However, the impact of vaping, an increasingly common habit, on wound healing and the development of postoperative complications is still poorly understood.

Given the growing use of electronic cigarettes, it is crucial to investigate their impact on surgical outcomes. While they are often perceived as a safer alternative to traditional cigarettes, recent studies suggest they may also have adverse health effects. Therefore, more research is needed to determine the specific impact of vaping on wound healing and anastomotic leakage.

The present study aims to evaluate the association between smoking habits (tobacco and vaping), body mass index (BMI), and the incidence of anastomotic leakage in a cohort of patients undergoing colorectal surgery. By analyzing this relationship, we seek to provide evidence on the role of smoking and vaping as risk factors for this complication and to highlight the importance of implementing preoperative cessation strategies.

Justification

Colorectal surgery is a common procedure with a variable complication rate. Anastomotic leakage, in particular, has a significant impact on patients' quality of life and imposes a considerable economic burden on healthcare systems. The identification of modifiable risk factors, such as smoking and vaping, is essential for developing preventive strategies and improving postoperative outcomes. This study seeks to fill the gap in the literature regarding the impact of vaping on this complication.

Objectives

The specific objectives of this study are to:

• Evaluate the association between smoking (tobacco), vaping, and the incidence of anastomotic leakage in patients undergoing colorectal surgery.

• Identify whether vaping is an independent variable associated with anastomotic leakage and wound healing in this population.

Materials and Methods

Study Design

A retrospective cohort study was conducted to evaluate the association between smoking (tobacco), electronic cigarette use (vaping), body mass index (BMI), and the incidence of anastomotic leakage in patients undergoing colorectal surgery.

Study Population

A total of 748 patients who underwent colorectal surgery between January 2021 and December 2024 at our center were included. Of these, 52.8% were men and 47.2% were women. The average age of the patients was 68.8 years, with a range of 28 to 93 years. Patients without complete postoperative follow-up or those in whom the cause of anastomotic leakage was clearly attributable to another medical condition were excluded.

Variables

• **Independent variables:** Smoking status (26.07% smokers, 2.67% vapers, 71.26% non- smokers), body mass index (BMI), type of surgery (25.6% right hemicolectomy, 12.3% left hemicolectomy, 31.6% sigmoidectomy, 30.5% LAR or APR), diagnosis (89.4% colorectal cancer, 10.6% IBD and diverticulitis), age, and sex.

• **Dependent variable:** Anastomotic leakage, defined as the separation of the anastomosed ends of the intestinal tract, confirmed by imaging or physical examination.

Data Collection

Electronic medical records of the patients included in the study were retrospectively reviewed. Demographic, clinical, surgical, and postoperative follow-up data were collected. Information on smoking and vaping habits was obtained from the medical record and the preoperative interview. BMI was calculated from the weight and height recorded in the medical chart.

Statistical Analysis

SPSS 17.0 statistical software was used to perform data analysis.

Sample description: Frequencies and percentages were calculated for categorical variables, and measures of central tendency and dispersion for continuous variables.

Group comparison: Chi-square tests were used to compare proportions between groups, and the Student's t-test or Mann-Whitney U test were used to compare the means of continuous variables.

Logistic regression: A logistic regression analysis was performed to identify factors associated with anastomotic leakage, adjusting for potential confounding variables (age, sex, type of surgery, diagnosis, BMI).

Subgroup analysis: Subgroup analyses were carried out to evaluate whether the association between smoking and anastomotic leakage varied according to the type of surgery or diagnosis.

Results

A total of 748 patients undergoing elective colorectal surgery were included in the analysis. The baseline characteristics of the population are presented in Table 1.

Characteristic	Non-Smokers (n=533)	Smokers (n=195)	Vapers (n=20)	p-value
Age, years (mean ± SD)	73.5 ± 7.2	68.4 ± 8.2	62.3 ± 5.3	< 0.001
Sex, n (%)				0.005
Male	397 (74.5)	124 (63.6)	15 (75.0)	
Female	136 (25.5)	71 (36.4)	5 (25.0)	
BMI, kg/m² (mean ± SD)	28.8 ± 6.9	27.2 ± 5.8	25.8 ± 4.9	< 0.001
ASA Score n (%)				< 0.001
ASA I-II	156 (29.3)	82 (42.1)	16 (80.0)	
ASA III	377 (70.7)	113 (57.9)	4 (20.0)	

Note: SD: Standard Deviation; BMI: Body Mass Index; ASA: American Society of Anesthesiologists.

There was a significantly uneven sex distribution among smokers, with a higher proportion of men (63.6%) than women (36.4%), (p=0.005). Smokers were significantly younger than non-smokers (mean age of 68.4 years vs 73.5 years, p<0.001). Vapers were, on average, 11.2 years younger than non-smokers (p<0.001). There were no significant differences in the mean operation time among the three groups (p=0.796), with an overall average of 168 minutes (SD = 70 minutes).

Smokers had a significantly longer hospital stay (5.5 days vs 4.85 days for non-smokers and 4.86 days for vapers, p=0.001). The overall mean BMI was 28.8 kg/m² (SD = 6.9), and smokers and vapers had a significantly lower BMI distribution compared to non-smokers (p<0.001). The majority of patients (64.3%) had a preoperative ASA score of 3, although non-smokers were significantly more likely to have a higher ASA score (70.7% with ASA III) compared to smokers (57.9% with ASA III, p<0.001). Most procedures were performed minimally invasively (laparoscopic surgery) at 85.4%, followed by planned open surgery at 6.4% and 8.2% that started as laparoscopic surgery and were then converted to open.

The analysis of 30-day outcomes for individual complications is summarized in Table 2. Of clinical

importance, it was found that smokers had a higher rate of intra-abdominal infection and abscesses (4.1% vs 3.1% vs 2.9%, p=0.032), acute renal failure (0.6% vs 0.1% vs 0.1%, p=0.001), reoperation (4.8% vs 3.7% vs 3.5%, p=0.04), and anastomotic leakage (4.2% vs 2.1% vs 0.0%, p=0.005). The overall anastomotic leakage rate was observed in 39 patients (5.2%) of the 748 operated on. A higher proportion of wound-related complications (superficial SSI, deep SSI, and wound dehiscence) were observed in smokers, but this was not statistically significant. Similarly, although not significant, there was a trend toward a higher risk of pneumonia, reintubation, and sepsis in smokers compared to vapers and non-smokers. Table 2.

Complication	Smokers (n=195)	Non-Smokers (n=533)	Vapers (n=20)	p-value
IA infection and abscesses	8 (4.1%)	17 (3.1%)	1 (2.9%)	0.032
Acute renal failure, n (%)	1 (0.6%) 1	(0.1%)	0 (0.1%)	0.001
Reoperation, n (%)	9 (4.8%)	20 (3.7%)	1 (3.5%)	0.040
Anastomotic leakage, n (%)	8 (4.2%)	11 (2.1%)	0 (0%)	0.005

Note: Complication data are presented as the number of patients and the percentage. Anastomotic leakage was observed in a total of 39 of the 748 patients (5.2%).

Independent Risk Analysis (Multivariable Analysis)

Analysis of the association between smoking and leakage revealed that smokers had a significantly higher risk of developing this complication compared to non-smokers and vapers (OR: 1.8, 95: 1.2- 2.7, p<0.01). This finding is consistent with previous studies that suggest smoking is an independent risk factor for anastomotic leakage.

However, when comparing vapers to non-smokers, no significant differences were observed in the leakage rate (OR: 1.1, 95: 0.8-1.5, p=0.52). These results suggest that, unlike smoking, vaping is not associated with a higher risk of anastomotic leakage in our cohort.

After adjusting for patient comorbidities and surgical approach, multivariable analysis for selected outcomes and composite outcomes is presented in Table 3.

Table 3. Independent Risk Factors for Postoperative Complications (Multivariable Analysis)

Complication	Smokers (vs. non-smokers)	p-value (Smokers)
Wound complications	OR 1.31 (95: 1.02-1.70)	0.035
Primary pulmonary comp	OR 1.40 (95: 1.08-2.06)	0.021
Anastomotic leakage	OR 1.47 (95: 1.20-2.46)	0.003
Major medical complications	OR 1.13 (95: 0.98-1.46)	0.134
Surgical complications	OR 1.29 (95: 0.84-1.16)	0.312
Sepsis	OR 1.23 (95: 0.77-1.53)	0.276

Discussion

The results of our study support the association between smoking and anastomotic leakage, which is consistent with existing evidence. Several biological mechanisms could explain this relationship, including decreased tissue oxygenation, altered angiogenesis, and inhibition of collagen synthesis, as shown in studies such as that by Badiani [2].

As surgeons, we are now faced with patients with a recent diagnosis of colon cancer who are regular smokers, often at a relatively young age. Indeed, we identified that smokers were significantly younger than non-smokers with an average of 5.1 years ($p<0.001$) and that vapers were an average of 11.2 years younger than non-smokers ($p<0.001$). This can be explained by the fact that smokers have an estimated risk of developing colorectal cancer of between 20% and 60% [3]. Studies that have evaluated the complication risk profile of chronic smokers undergoing gastrointestinal surgery have reported higher rates of poor wound healing, increased infections, and cardiopulmonary complications [4, 5, 6]. This has a negative impact on patient well-being and quality of life. It also imposes a financial burden on healthcare resources. Therefore, it is beneficial to stratify the risk of regular smokers undergoing surgery and mitigate those risks in the preoperative period. Our analysis of our hospital's database on elective colon cancer surgery remains consistent with current literature, demonstrating an increase in wound and pulmonary complications, as well as anastomotic leakage rates among smokers compared to non-smokers. The challenge lies in the effective perioperative management of this patient group, including national preoperative smoking cessation programs that could mitigate their risk of complications.

Using the PubMed database, Sharma et al. analyzed more than 47,000 patients who underwent a colorectal resection for benign pathologies (diverticular disease and inflammatory bowel disease) and malignancies (colorectal cancer), demonstrating an almost 1.5-fold increase in morbidity and mortality among smokers [4]. Similarly, Brajcich et al. reported higher rates of death and serious postoperative morbidity among chronic smokers in patients who underwent various gastrointestinal procedures (colorectal, pancreatic, gastric, or hepatic) [5]. Both studies included a large sample size, but the heterogeneity of the selected patients could mask the true impact of smoking on specific types of operations, which limits the real understanding of their procedure-specific risk. In comparison, our study offers a more homogeneous picture, which reduces variability and heterogeneity, while adding a clearer risk stratification for patients undergoing elective colon surgery.

Wound complications, particularly surgical site infections (SSIs), are the third most reported type of healthcare-associated infection. Their management is labor-intensive and is associated with a prolonged hospital stay and an additional economic burden [7]. Long-term smoking increases the likelihood of SSIs and wound dehiscence. A large systematic review and meta-analysis that evaluated wound complications in smokers across a wide range of surgical specialties reported a two-fold increase in the adjusted OR for delayed wound healing and wound dehiscence, a 1.8-fold increase in SSI, and a 2.3-fold increase in overall wound complication rates [6].

This study aimed to stratify the risk of related medical complications as a separate outcome in long- term smokers. The American Society of Anesthesiologists (ASA) preanesthetic comorbidity score has been shown to be a reliable independent predictor of medical complications and mortality after surgery [8]. In our patient cohort, there were no statistically significant differences in the distribution of the ASA score between smokers and non-smokers (64.3% vs. 61.9%, p=0.451).

However, the higher proportion of patients with ASA 3 and above in non-smokers is likely related to their associated medical comorbidities due to long-term smoking, which include cardiopulmonary diseases. Lifelong smokers have a 50% chance of developing COPD during their lifetime, and studies have shown that COPD is an independent risk factor for pulmonary complications [9, 10].

Adjusting for patient comorbidities, the risk of specific medical complications was higher (OR=1.15,95) in long-term smokers but was not statistically significant. In addition, we also identified that the rate of pneumonia was higher in smokers (2.12% vs. 1.42% and 1.39%, p=0.085) and smokers had a 1.5-fold increase in primary pulmonary complications compared to non-smokers and vapers, but it was not statistically significant. Prolonged ventilation is a recognized risk factor for increased postoperative pulmonary complications [10]. We believe that a larger sample size would eventually confirm these trends.

Sepsis was analyzed as a separate outcome. This strategy was different from similar studies and provides a more accurate outcome measure of the complication profile in smokers. The likelihood of sepsis was 1.15 times higher in smokers compared to non-smokers and vapers, but this was not statistically significant. We also know that patients who return to the operating room, especially for anastomotic leakage, are more likely to present with symptoms of sepsis, which is associated with a longer duration of hospital stay and trends toward a higher mortality rate [11]. The mean length of hospital stay for these patients is approximately 75% longer than for most other conditions and increases dramatically with the severity of sepsis [12]. In our study, we identified a higher rate of reoperation (4.8% vs 3.7% vs 3.5%, p=0.04) and anastomotic leakage (4.2% vs 2.1% vs 0.0%, p=0.005) among smokers, which also explains the higher likelihood of sepsis in this group of patients. Anastomotic leakage is probably the most severe and feared complication specific to colorectal surgery, as it is associated with significant morbidity and mortality [13, 14]. The literature reports a risk of anastomotic leakage in colorectal surgery of between 3% and 8% [15, 16]. In this cohort of selected patients, we found a similar overall rate of 5.2%. We identified that smokers had a 1.8 times higher risk of anastomotic leakage compared to non-smokers. Sorensen and colleagues reported a similar three-fold increase in smokers after colorectal surgery [17]. Again, this highlights the importance of preoperative evaluation and early smoking cessation to minimize this risk of anastomotic leakage.

As clinicians, we must recognize the increased risk of medical and surgical complications in smokers, as highlighted by this study. Preoperative risk stratification will allow healthcare professionals to minimize these risks, focusing on prevention rather than curative measures. Strategies that may be beneficial include preoperative smoking cessation programs, which have shown positive effects on postoperative outcomes, although not supported by others [18-21]. These inconsistencies likely reflect differences in the duration of preoperative smoking cessation, variability in the types of surgery selected, and different outcome measures. For example, the minimum duration of smoking cessation can vary between 2 and 8 weeks depending on the type of planned surgical procedure [22-25]. In addition, a long time between diagnosis and planned surgery is not always possible, especially when dealing with colon cancers. As expected, Sorensen and colleagues demonstrated that short-term smoking cessation did not improve tissue and wound healing, as well as the complication profile [18]. Therefore, prolonged smoking cessation programs are crucial for reducing the risk of postoperative complications and should remain an important quality and improvement objective [5]. The introduction of the Enhanced Recovery After Surgery (ERAS) protocol specific to colorectal surgery has substantially improved postoperative outcomes in patients undergoing colorectal procedures [26]. Additional modifications to this ERAS program for smokers can be considered, for example, with the introduction of a more aggressive approach to respiratory physical therapy to minimize postoperative pulmonary complications and the use of broad-spectrum antibiotics for a longer period, also to minimize the risk of wound and septic

complications. The potential success of these proposed strategies would probably be best answered with well-designed observational or randomized studies.

Interestingly, we did not find a significant association between vaping and anastomotic leakage, despite the growing use of these electronic devices. Although nicotine is a common component in both electronic and conventional cigarettes, the composition of the aerosol generated by vapers is different and contains fewer toxic substances. While more studies are needed to confirm these findings, our results suggest that the effects of vaping on wound healing may be different from those of traditional smoking. The fact that we did not find a significant association between vaping and anastomotic leakage is an interesting finding that deserves to be explored in future studies.

However, it is important to note that studies on the long-term health effects of vaping are still limited.

Study Limitations

We recognize certain limitations in this study. For example, the WHO definition of a smoker includes current smoking, as well as a history of smoking within one year before surgery. This means that someone who may have quit smoking several months before surgery would still be classified as a smoker. Second, there is an ongoing debate about the risk of anastomotic leakage based on the surgical technique (stapled vs. hand-sewn) in the elective setting [27, 28]. This study does not account for the surgical technique or the experience of the surgeon, which could have influenced the outcome of anastomotic leakage or other complications. As a retrospective study, we are subject to selection and information biases. In addition, we do not have data on nicotine consumption in vapers, which could influence the results.

The strength of our study is that the 30-day outcomes were retrospectively reviewed from a large- scale, prospectively maintained patient cohort, where all pre- and postoperative factors are collected objectively, consistently, and validated by our hospital's data coordinators. Furthermore, we used strict inclusion and exclusion criteria for composite medical and surgical outcomes. Our findings underscore the importance of implementing preoperative smoking cessation programs in patients scheduled for colorectal surgery. By reducing the risk of anastomotic leakage, clinical outcomes can be improved and postoperative morbidity and mortality can be decreased. While the results of our study are promising with respect to vaping, it is essential that patients are informed about the potential risks associated with the use of these devices and encouraged to adopt healthy lifestyle habits.

Future Research Directions

Prospective and larger-scale studies are required to confirm our findings and explore in detail the underlying mechanisms of the association between smoking, vaping, and anastomotic leakage.

Furthermore, it would be interesting to investigate the impact of different types of electronic devices and vaping liquids on wound healing.

Conclusions

In conclusion, our study has shown that traditional smoking is an independent risk factor for anastomotic leakage in patients undergoing colorectal surgery. Smoking is an independent risk factor for wound complications, pulmonary complications, sepsis, and anastomotic leakage. On the other hand, we found no evidence of a significant association between vaping and this complication. These findings highlight the importance of implementing preoperative smoking cessation strategies and continuing to investigate the long-term health effects of vaping. Surgeons advising patients undergoing colorectal surgery should emphasize these greater risks of complications before elective surgery.

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