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Body mass index and the incidence of surgical site infection following elective colorectal cancer surgery: A single-centre study

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Abstract
Introduction: Colorectal cancer is a condition where uncontrolled cell growth occurs in the colon or rectum due to genetic changes that transform proto-oncogenes into oncogenes and inactivate tumor suppressor genes. As surgery is the main treatment method for colorectal cancer, complications such as surgical site infection are commonly found. In line with the rising global prevalence of obesity, an elevated body mass index has emerged as a factor closely associated with these complications. This study aimed to determine the association between body mass index and the incidence of surgical site infection among patients undergoing elective colorectal cancer surgery.
Method: This study used an analytical observational research design with a retrospective cohort approach. Data were obtained from the medical records of research subjects, consisting of colorectal cancer patients who underwent elective surgery at Dr. Moewardi General Hospital Surakarta. Sampling was performed using simple random sampling with a sample size of 60 patients.
Results: Multivariate analysis using binary logistic regression on association between body mass index and the incidence of surgical site infection resulted in a p-value of 0.019 (p<0.05) with an OR of 4.169 (95% CI: 1.27-13.72).
Conclusion: There is a significant association between body mass index and the incidence of surgical site infection among patients undergoing elective colorectal cancer surgery.

Keywords: Colorectal cancer, surgery, surgical site infection, body mass index

Introduction

Cancer is a disease that occurs due to the abnormal growth of various types of cells in the body. Damaged or abnormal cells appear when there are mistakes in the cell's growth cycle [1]. Cancer found in the large intestine particularly in the colon and rectum is called colorectal cancer. Based on data estimates from GLOBOCAN in 2022, there were more than 1.9 million new cases of colorectal cancer with 900,000 deaths from a total of 118 countries studied. In Indonesia, colorectal cancer ranks fourth with 35,676 new cases and 19,255 deaths in the same year [2].

The management of colorectal cancer is based on a comprehensive approach, prioritizing surgery while utilizing chemotherapy and radiotherapy as adjuvant treatments [3, 4]. The American Society of Colon and Rectal Surgeons (ASCRS) clinical practice guidelines specifically recommended colectomy as the main treatment for locally resectable colorectal cancer [5]. While surgery remains the primary treatment option, it is not without the risk of complications. Among these, surgical site infection (SSI) is the most frequently encountered in digestive procedures. Surgical site infection is a condition in which signs and symptoms of local infection are found around the site of the incision after invasive surgery [6, 7].

One factor strongly associated with the incidence of surgical site infection in digestive surgery is an elevated body mass index (BMI) [8]. An elevated BMI is defined as a measurement of ≥23 kg/m², which classified as overweight according to the World Health Organization (WHO) guidelines adjusted for Asia-Pacific population [9]. In patients with a high BMI, surgical procedures can be complicated by excessive adipose tissue and constricted abdominal cavity which frequently leads to vascular trauma. Furthermore, increased BMI also impairs oxygen circulation to the wound and reduce collagen production, leading to immune system dysfunction that leaves patients susceptible to infection [10].

To date, a significant number of colorectal cancer cases have been recorded at Dr. Moewardi General Hospital Surakarta. Approximately 50 elective colorectal cancer surgeries are performed each month. In some cases, surgical complications such as surgical site infection occur. However, there is currently a lack of data specifically characterizing the association between the incidence of surgical site infection and BMI. Therefore, the author is interested in conducting this study to identify the association between BMI and the incidence of surgical site infection among patients undergoing elective colorectal cancer surgery.

Materials and Methods

This study was conducted using an analytical observational design with a retrospective cohort approach. It evaluates the outcomes of exposure across groups of individuals who meet the specific inclusion and exclusion criteria by reviewing existing data from medical records. This study took place in the Digestive Surgery Department of Dr. Moewardi General Hospital in Surakarta, Central Java.

The population of this study consisted of colorectal cancer patients who underwent elective surgery at Dr. Moewardi General Hospital Surakarta in 2024-2025. Inclusion criteria included patients diagnosed with colorectal cancer, aged ≥20 years, underwent elective surgery, and had available preoperative BMI data. Exclusion criteria included patients with a history of active preoperative infection, had receive neoadjuvant therapy, had a history of other surgical procedures within 30 days before or after colorectal cancer surgery, or had a low BMI (<18.5 kg/m²).

A simple random sampling technique was used to obtain a sample size of 60 patients. The independent variable was BMI, categorized into normal (18.5-22.9 kg/m²) and high (≥23.0 kg/m²) groups. The dependent variable was the incidence of surgical site infection, categorized into SSI and non-SSI. Additionally, several confounding variables that could influence the outcomes such as age, albumin, diabetes mellitus, and smoking status were also included in the analysis.

Data analysis was done using IBM SPSS Statistics for Windows. For categorical variables, bivariate analysis of the primary and confounding variables was conducted using Chi-square test or Fisher's Exact test if any cell found to have less than 5 expected cell frequency. Numerical confounding variables were analyzed using Mann-Whitney U test. Lastly, multivariate analysis was conducted using binary logistic regression.

Results

Patient Characteristics

The study was conducted by retrieving data from the medical records department at Dr. Moewardi General Hospital Surakarta between October and November 2025. Data were collected from 60 patients diagnosed with colorectal cancer who underwent elective surgery. Subjects were selected based on predefined inclusion and exclusion criteria using a random number generator, in accordance with the simple random sampling method used in this study.

Table 1: Subject Characteristics based on Demographics and Clinical Profiles

Variable	Frequency (n)	Percentage (%)
Gender		
Male	31	51.7%
Female	29	48.3%
Age		
Adult (19-59)	34	56.7%
Elderly (>60)	26	43.3%
Body Mass Index (kg/m²)		
Normal (18.5-22.9)	30	50%
High (≥23.0)	30	50%
Overweight (23.0-24.9)	17	28%
Obese I (25.0-29.9)	10	16%
Obese II (≥30)	3	5%
Diabetes Mellitus		
Yes	5	8.3%
No	55	91.7%
Smoking Status		
Yes	11	18.3%
No	49	81.7%
Albumin (g/dL)		
Hypoalbuminemia (<3.5)	37	61.7%
Normal (≥3.5)	23	38.3%
Surgical Site Infection		
Yes	22	36.7%
No	38	63.3%

As shown in Table 1, the total study population consisted of 60 patients, with a male majority of 31 subjects (51.7%). A total of 34 patients (56.7%) were within the adult age range of 19-59. Consistent with the sampling method, the subjects were evenly split between normal and high BMI with 30 patients in each category (50%). Within the high BMI category, 17 patients (28%) were overweight, 10 (16%) were classified as obesity I, and 3 (5%) as obesity II.

Regarding clinical comorbidities, 55 patients (91.7%) were non-diabetic and 49 (81.7%) were non-smokers. Low albumin levels (<3.5 g/dL) were found in 37 patients (61.7%). The incidence of surgical site infection was recorded in 22 patients (36.7%).

Table 2: Subject Characteristics based on Tumor Location and Staging

Variable	Frequency (n)	Percentage (%)
Tumor Location		
Ascending colon	4	6.7%
Descending colon	2	3.3%
Colon, unspecified	8	13.3%
Sigmoid colon	5	8.3%
Transverse colon	3	5.0%
Caecum	2	3.3%
Rectosigmoid junction	10	16.7%
Rectum	26	43.3%
Tumor Staging		
II	1	1.7%
III	34	56.7%
IV	25	41.7%

As shown in Table 2, the most frequent tumor location was rectum, accounting for 26 patients (43.3%), followed by the rectosigmoid junction in 10 patients (16.7%). The least common sites were the descending colon and caecum, with 2 patients (3.3%) each. Regarding tumor staging, Stage III was the most prevalent, identified in 34 patients (56.7%).

Bivariate Analysis

Table 3: Association between Body Mass Index (BMI) and Surgical Site Infection

Variable		Surgical Site Infection		RR (95% CI)	p-value
		Yes	No		
Body Mass Index (kg/m²)	Normal	7 (23.3%)	23 (76.7%)	2.14 (1.02-4.50)	0.032
	High	15 (50%)	15 (50%)		
Total		22	38		

As shown in Table 3, bivariate analysis using the Chi-square test resulted in a p-value of 0.032 (p<0.05). The risk assessment showed a Relative Risk (RR) of 2.14 (95% CI: 1.02-4.50). These findings indicate that BMI were significantly associated with the incidence of surgical site infection.

Table 4: Association between Potential Confounders and Surgical Site Infection

Variable		Surgical Site Infection		RR (95% CI)	p-value
		Yes	No		
Age (Years)*		59.00 (25-74)	55.50 (22-80)	-	0.607
Albumin (g/dL)*		2.95 (1.9-9.6)	3.25 (2,3-8,5)	-	0.168
Diabetes Mellitus	Ya	2 (40.0%)	3 (60.0%)	1.100 (0.356-3.402)	1.000
	Tidak	20 (36.4%)	35 (63.6%)		
Smoking Status	Ya	5 (45.5%)	6 (54,5%)	1.310 (0.617-2.781)	0.511
	Tidak	17 (34.7%)	32 (65.3%)		
Total		22	38		

* Mann-Whitney U test

As shown in Table 4, the Shapiro-Wilk normality test for age and albumin resulted in p-values of 0.024 and <0.001 (p<0,05), showing a non-normal distribution. Subsequent analysis using the Mann-Whitney U test resulted in p-values of 0.607 and 0.168 (p>0,05). These findings indicate that neither age nor albumin were significantly associated with the incidence of surgical site infection. However, since the p-value for albumin was below the 0.25 threshold, it met the criteria for inclusion in the subsequent multivariate analysis.

Furthermore, Fisher's Exact tests performed on diabetes mellitus and smoking status resulted in p-values of 1.000 and 0.511 (p>0.05). These findings indicate that neither diabetes mellitus nor smoking status were significantly associated with the incidence of surgical site infection.

Multivariate Analysis

Table 5: Multivariate Logistic Regression Analysis of Risk Factors for Surgical Site Infection

Variable	OR (95% CI)	p-value
Body Mass Index (kg/m²)	4.169 (1.27-13.72)	0.019
Albumin (g/dL)	0.425 (0.13-1.41)	0.171

As shown in Table 5, multivariate analysis using binary logistic regression method was conducted on BMI and albumin levels, both of which met the p<0.25 threshold in the bivariate analysis. For BMI, the analysis resulted in a p-value of 0.019 (p<0.05) with an Odds Ratio (OR) of 4.169 (95% CI: 1.27-13.72). Analysis for albumin on the other hand resulted in a p-value of 0.171 with an OR of 0.425 (95% CI: 0.13-1.41). These findings confirm a significant association between BMI and the incidence of surgical site infection, identifying high BMI as an independent risk factor for this complication.

Discussion

Summary of Key Findings

Based on the analysis of 60 patients consisting of 30 with normal BMI (18.5-22.9 kg/m²) and 30 others with high BMI (≥23.0 kg/m²), surgical site infection was observed in 22 patients (36.7%) while 38 patients (63.3%) remained infection-free. Bivariate analysis revealed a statistically significant association between BMI and surgical site infection incidence with a p-value of 0.032 and a RR of 2.14 (95% CI: 1.02-4.50). These findings were further validated by multivariate analysis, which controlled albumin as a confounding variable, resulted in a p-value of 0.019 and an OR of 4.169 (95% CI: 1.27-13.72).

Comparison with Previous Studies

These findings are consistent with previous research by Yamashita *et al*. (2021), which investigated the impact of obesity on colorectal cancer surgical outcomes. Their study observed a significant increase in postoperative complications, particularly infectious complications such as surgical site infection in patients with class II obesity compared to non-obese and class I obese patients (p = 0.002). This result is further supported by larger-scale studies, such as the one conducted by Juvik, Fransgaard, and Roikjaer (2023) in Denmark. That study reported a heightened risk of surgical complications, including surgical site infection, correlated with increasing BMI classes, with an OR of 1.40.

Mechanisms of Increased Surgical Site Infection Risk in Patients with High BMI

Several biological and technical factors explain the link between high BMI and surgical site infection risk. High BMI reflects increased subcutaneous and visceral adiposity. This expanded adipose tissue layer typically suffers from poor blood supply, leading to localized hypoperfusion and hypoxia at the surgical incision [11]. Hypoxia, a state of oxygen deficiency within the wound tissue, impairs the phagocytic function of immune cells such as neutrophils which rely on oxygen-dependent mechanisms. Furthermore, it inhibits collagen synthesis, which is essential for proper tissue repair [12].

Systemically, increased adiposity induces a state of chronic low-grade inflammation due to the continuous release of pro-inflammatory cytokines, such as TNF-α. This can lead to immune cell dysfunction and further impair the wound-healing process [13, 14]. Regarding technical surgical factors, study conducted by Yamashita *et al*. (2021) highlighted the challenges associated with operating on obese patients. Obesity often requires more complex intraoperative maneuvers which may result in tissue trauma around the incision site, making it more susceptible to infection. Additionally, excessive adipose layers complicate dissection and significantly prolong the operative duration. Such an increase in surgical time leads to extended tissue exposure to the operating room environment, hence further elevating the risk of surgical site infection [15].

Analysis of Confounding Variables

In this study, several potential confounding variables including age, albumin, diabetes mellitus, and smoking status were analyzed. The objective was to determine whether these four variables acted as true confounders in the association between BMI (independent variable) and the incidence of surgical site infection (dependent variable). The analysis revealed that none of these variables were significantly associated with surgical site infection incidence, as all p-values exceeded the 0.05 significance threshold. Specifically, the p-values were 0.607 for age, 0.171 for albumin, 1.000 for diabetes mellitus, and 0.511 for smoking status

Age, albumin, diabetes mellitus, and smoking status have been identified in several previous studies as independent risk factors for infectious complications. For instance, Normann *et al*. (2024) found a correlation between high comorbidity levels, decreased functional status, and surgical site infection incidence in elderly patients. Similarly, Truong *et al*. (2016) reported that surgical site infection occur more frequently in patients with hypoalbuminemia. Furthermore, Siddique *et al*. (2016) observed an increased incidence of surgical site infection in diabetic patients, particularly those with uncontrolled perioperative glucose levels. Regarding tobacco use, Fan Chiang *et al*. (2023) identified an elevated risk of wound dehiscence and surgical site infection among smokers. Despite these associations, it was confirmed through multivariate analysis that BMI remains an independent risk factor for surgical site infection in this study. This confirms that BMI is an independent risk factor, effectively ruling out bias from other variables.

Conclusion

In conclusion, this study found a statistically significant association between body mass index and the incidence of surgical site infection among patients undergoing elective colorectal cancer surgery.

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