Impact of Body Mass Index on Surgical Outcome of Colorectal Carcinoma

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Introduction: The prevalence of obesity has a substantial impact on colorectal surgeons, as it is associated with an increased incidence of conditions that commonly require colorectal resection, such as cancer, diverticulitis, and inflammatory bowel disease. This study aims to evaluate the impact of body mass index (BMI) on the surgical outcome of colorectal cancer (CRC).

Patients and methods: This retrospective study included 100 patients aged ≥ 18 years, both sexes undergoing colorectal carcinoma surgery. Patients were divided into two groups: Group I: Obese patients (BMI ≥ 29 kg/m2) and Group II: Non-obese patients (BMI<29kg/M2). The preoperative, intraoperative, and postoperative data were retrieved from the hospital database.

Results: The interval between the operation and ileostomy closure was significantly higher in group I than in group II (P<0.05). Total postoperative complications were significantly higher in group I than in group II [21 (39.62%) vs 3 (11.11%), P=0.009]. Hospital stay was significantly higher in group I than in group II (8.19 ± 3.2 vs 6.11 ± 2.52; P=0.004).

Conclusions: BMI significantly impacts surgical outcomes in patients with CRC. Awareness of the BMI's influence on surgical complications, and the development of personalized clinical strategies are important to optimize treatment and improve patient outcomes.

Key words: Body mass index, surgical outcome, colorectal carcinoma, obesity.

Introduction

Globally, colorectal cancer (CRC) stands as one of the most commonly diagnosed malignancies, with approximately 1.8 million new cases annually - around 1.1 million of these affect the colon and roughly 700,000 involve the rectum. Fatalities related to these types of cancer are significant as well, with an estimated 550,000 deaths from colon cancer and around 310,000 from rectal cancer each year.[1]

The Body Mass Index (BMI) serves as a general indicator of total body fat, providing a simple and widely recognized proxy for assessing obesity.[2] According to the World Health Organization (WHO), BMI is less than 18.5, it falls within the underweight range. BMI 18.5 to <25, falls within the healthy weight range. BMI 25.0 to <30, falls within the overweight range. BMI 30.0 or higher, falls within the obesity range.[3]

Patients with obesity face have a heightened risk of several health complications, such as diabetes mellitus, high blood pressure, and elevated cholesterol levels, which have a negative impact on surgical results. This includes prolonged durations of surgery,[4] higher incidences of infections at the surgical site,[5] an increased likelihood of wound leak,[6] and greater post-surgery mortality rates compared to individuals without obesity. Consequently, obesity is acknowledged as a contributing factor to unfavourable surgical outcomes across different medical specialties, including gynaecology, orthopedics, and heart-related surgeries.[7]

The prevalence of obesity has a pronounced impact on the practice of colorectal surgery. Obese patients more frequently present with conditions that necessitate colorectal resections, such as diverticulitis, cancer, and inflammatory bowel disease (IBD).[8] These conditions are not only more common in the obese population but are also linked to higher healthcare expenditures and a greater likelihood of needing to switch from laparoscopic procedures to open surgery.[9]

In the field of colorectal surgery, determinants of postoperative complications have been identified and include a history of tobacco and alcohol use, obesity, being older than 65 years, and having preexisting medical conditions that result in an American Society of Anaesthesiologists (ASA) score greater than III.[10] These factors are correlated with elevated healthcare costs attributable to extended durations of hospitalization, suboptimal functional and cancer-related results, and heightened risk of mortality.[11]

The growing rate of obesity is a significant issue for rectal surgeons, as it not only plays a role in the development of CRC but can also affect post-surgical outcomes. Nevertheless, due to conflicting results from various studies, there is currently no agreement on this matter. Therefore, this study aims to evaluate the impact of BMI on the surgical outcome of colorectal carcinoma.

DOI: 10.21608/ASJS.2024.368167

Patients and methods

This retrospective study included 100 patients aged ≥ 18 years of both sexes who underwent colorectal carcinoma surgery at Mansoura University Hospitals for a period of from February 2018 to February 2023. The research was conducted with approval from the Ethical Committee of Mansoura University Hospitals (Approval code: R.24.03.2528)

Exclusion criteria were IBD, a synchronous malignant colorectal neoplasm, synchronous resection of another organ at the time of rectal cancer surgery, end-stage renal disease, and disseminated cancer.

Patients were divided into two groups: Group I: Obese patients (BMI ≥ 29 kg/m2) and group II: Non-obese patients (BMI < 29 kg/m2).

Data was retrieved from hospital records. The collection of demographic information included variables such as age, gender, BMI, smoking habits, and alcohol consumption. Comorbid health conditions were classified based on their origin – cardiac, respiratory, or metabolic. Within each category, specific diseases were documented when applicable. Laboratory investigations include [Complete blood count, S. albumin, carcinoembryonic antigen (CEA), and CA 19-9]. Radiological investigation including [CT with oral and IV contrast]. Colonoscopy was done and biopsy from the mass was taken for preoperative histopathology.

The surgical features and outcomes were also retrieved including Cancer location, operative urgency, method of anastomosis, type of diversion if done, length of hospital stays, management of leak, ileostomy closure, and the interval between operation and closure.

The primary outcome was postoperative complications. The secondary outcomes were the length of hospital stay and the interval between operation and closure.

Sample size calculation

The determination of the necessary number of participants for the study was carried out with the aid of the G. power 3.1.9.2 software from Universitat Kiel, Germany. The estimated sample size was informed by historical data indicating that postoperative complications occurred in 7.4% of individuals in Group I and 40% in Group II, as reported by a prior study.[12] The calculations were made to maintain a 5% alpha error and ensure a 95% statistical power, with an equal distribution of subjects between groups. To account for any potential dropouts, an additional four participants were included, leading to a total of 110 patients being enrolled in the study.

Statistical analysis

The data were analyzed using the statistical software SPSS version 27, provided by IBM in Armonk, NY, USA. To assess the normality of data distribution, both the Shapiro-Wilks test and the visual inspection of histograms were utilized. The analysis of parametric data that conformed to a normal distribution was conducted through the means of computing means and standard deviations (SD), with the unpaired Student's t-test being applied for comparative analysis. Qualitative data were expressed in terms of frequencies and percentages and were subject to evaluation by either the Chi-square test or Fisher's exact test. In addition, multivariate regression analysis was employed to explore the association between one dependent variable and several independent variables. Significance for all tests was set at a P value of less than 0.05, using a two-tailed test.

Results

Age, sex, height, smoking, alcohol status, N stage, cancer location, obstruction, perforation, neoadjuvant therapy, CEA level, CA 19-9, haemoglobin, and albumin were insignificantly different between both groups. Weight, BMI, and obstructive sleep apnea (OSA) were significantly higher in group I than in group II (P<0.05). Diabetes mellitus (DM), chronic obstructive pulmonary disease, hyperthyroidism and hypothyroidism were insignificantly different between both groups. T stage was significantly different between both groups (P=0.027) and N stage and cancer location were insignificantly different between both groups, **(Table 1).**

Operation time, method of anastomosis, and operative urgency were insignificantly different between both groups, **(Table 2).**

Ileostomy closure, interval between operation and closure, anastomotic leakage and wound infection were significantly higher in group I than in group II (P<0.05). Management of leak, Ileus, acute urinary retention and adhesion, and small bowel obstruction were insignificantly different between both groups.

Total postoperative complications were significantly higher in group I than in group II [21 (39.62%) vs 3 (11.11%), P=0.009]. Hospital stay was significantly higher in group I than in group II (P=0.004), **(Table 3).**

In multivariate regression, BMI was an independent predictor of postoperative complications (P <0.001) while age, sex, smoking, chronic obstructive pulmonary disease, chronic renal failure, hyperthyroidism, hypothyroidism, OSA, CA 19-9, CEA level, haemoglobin, and albumin were not, **(Table 4).**

Table 1: Preoperative data of the studied groups

		Group I (n=53)	Group II (n=27)	P value
Age (years)		48.72 ± 10.58	52.81 ± 15.2	0.163
Sex	Male	37 (69.81%)	17 (62.96%)	0.536
	Female	16 (30.19%)	10 (37.04%)	
Weight (kg)		107.49 ± 13.18	73.78 ± 7.62	<0.001*
Height (cm)		168.13 ± 6.93	171.04 ± 5.71	0.064
BMI (kg/m²)		37.75 ± 5.09	25.07 ± 2.58	<0.001*
Comorbidities	Smoking	19 (35.85%)	6 (22.22%)	0.214
	Alcohol status	1 (1.89%)	0 (0%)	0.473
	DM	15 (28.3%)	4 (14.81%)	0.180
	Chronic obstructive pulmonary disease	7 (13.21%)	3 (11.11%)	0.789
	OSA	11 (20.75%)	1 (3.7%)	0.043*
	Hyperthyroidism	2 (3.77%)	3 (11.11%)	0.20
	Hypothyroidism	3 (5.66%)	1 (3.7%)	1
T stage	T1	3 (5.66%)	2 (7.41%)	0.027*
	T2	9 (16.98%)	4 (14.81%)	
	T3	33 (62.26%)	9 (33.33%)	
	T4	8 (15.09%)	12 (44.44%)	
N stage	N0	23 (43.4%)	11 (40.74%)	0.974
	N1	17 (32.08%)	9 (33.33%)	
	N2	13 (24.53%)	7 (25.93%)	
Cancer location	Cecum	4 (7.55%)	3 (11.11%)	0.959
	Ascending	8 (15.09%)	5 (18.52%)	
	Transverse	7 (13.21%)	2 (7.41%)	
	Descending	3 (5.66%)	2 (7.41%)	
	Sigmoid	12 (22.64%)	6 (22.22%)	
	Rectum	19 (35.85%)	9 (33.33%)	
Obstruction		3 (5.66%)	1 (3.7%)	0.704
Perforation		2 (3.77%)	1 (3.7%)	0.988
Neoadjuvant therapy		9 (16.98%)	5 (18.52%)	0.864
Laboratory investigations	Haemoglobin (g/dl)	12.03 ± 1.35	11.74 ± 1.31	0.366
	Albumin (g/dl)	3.33 ± 0.63	3.14 ± 0.74	0.229
	CEA level (ng/ml)	16.28 ± 29.41	14.3 ± 31.53	0.781
	CA 19-9 (U/ml)	21.85 ± 17.14	19.67 ± 14.99	0.576

Data are presented as mean ± SD or frequency (%). BMI: body mass index. DM: Diabetes mellitus, OSA: obstructive sleep apnea.

Table 2: Intraoperative data of the studied groups

		Group I (n=53)	Group II (n=27)	P value
Operation time (min)		231.89 ± 73.62	207.41 ± 73.54	0.163
Method of anastomosis	Manual	42 (79.25%)	21 (77.78%)	0.879
	Stapler	11 (20.75%)	6 (22.22%)	
Operative urgency	Elective	43 (81.13%)	24 (88.89%)	0.374
	Emergency	10 (18.87%)	3 (11.11%)	

Data presented as frequency (%).

Table 3: Postoperative data of the studied groups

		Group I (n=53)	Group II (n=27)	P value
Ileostomy closure		37 (69.81%)	25 (92.59%)	0.021*
The interval between operation and closure (Months)		11.62 ± 3.75	4.56 ± 2.08	<0.001*
Management of leak	Exploration	1 (1.89%)	0 (0%)	0.576
	Conservative	3 (5.66%)	1 (1.89%)	
Complications	Anastomotic leakage	14 (26.42%)	1 (3.7%)	0.015*
	Ileus	4 (7.55%)	2 (7.41%)	0.982
	Wound infection	13 (24.53%)	1 (3.7%)	0.027*
	Acute urinary retention	2 (3.77%)	1 (3.7%)	0.988
	Adhesion and small bowel obstruction	7 (13.21%)	1 (3.7%)	0.180
	Total postoperative complications	21 (39.62%)	3 (11.11%)	0.009*
Hospital stay (days)		8.19 ± 3.2	6.11 ± 2.52	0.004*

Data presented as mean ± SD or frequency (%).

Table 4: Multivariate regression of risk factors versus total post-operative complications

	Odds ratio	95% CI	P value
Age (years)	1.048	0.972 – 1.130	0.215
Sex	0.927	0.281-3.054	0.901
BMI (kg/m^2)	1.387	1.211 – 1.588	<0.001*
Smoking	1.001	0.338 – 2.96	0.998
Chronic obstructive pulmonary disease	0.988	0.222 – 4.38	0.987
Hyperthyroidism	4.94	0.273-13.32	0.998
Hypothyroidism	2.57	0.324-20.42	0.370
OSA	1.480	0.314-6.96	0.619
CA 19-9 (U/ml)	0.989	0.959-1.021	0.522
CEA level (ng/ml)	1.011	0.995-1.027	0.167
Haemoglobin (g/dl)	1	0.691-1.446	0.999
Albumin (g/dl)	1.418	0.667-3.011	0.363

*Significant as P value≤0.05, CI: Confidence interval, OSA: obstructive sleep apnea.

Discussion

CRC is a prevalent cancer worldwide, and surgical resection remains a cornerstone of treatment. BMI, a quantitative measure of weight, has been shown to dynamically influence CRC outcomes, including ileostomy closure, complication, and hospital stay.

Obesity is frequently associated with a range of comorbid conditions, which can complicate the clinical management of affected individuals. Some of the key comorbid conditions associated with obesity include smoking, alcohol use, diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), and hypothyroidism. These conditions were prevalent in obese patients in our study but without significant difference when compared to non-obese patients in our study.

Smoking has been linked to increased abdominal fat accumulation, contributing to obesity-related complications. Additionally, smoking can exacerbate metabolic syndrome, a cluster of conditions that includes obesity, increasing the risk of cardiovascular diseases.[13] Smoking cessation is crucial for obese individuals to reduce the risk of cardiovascular and metabolic complications.

Alcoholic beverages are high in calories and can lead to an increase in overall caloric intake. Furthermore, alcohol can influence metabolic processes, potentially leading to the accumulation of visceral fat.[14] Chronic heavy drinking is associated with a higher risk of developing obesity-related conditions, including liver disease and cardiovascular problems. Obesity is a major risk factor for the development of type 2 diabetes mellitus (T2DM). The excess adipose tissue, particularly visceral fat, contributes to insulin resistance, a hallmark of T2DM. The relationship between obesity and T2DM is well-documented, with obesity significantly increasing the risk of developing this metabolic disorder.[15] The interplay between obesity and COPD is complex; obesity can worsen respiratory symptoms and decrease lung function due to the increased mechanical load on the respiratory system. Additionally, obesity can exacerbate systemic inflammation, further complicating COPD management.[16] Hypothyroidism is a condition characterized by an underactive thyroid gland, leading to a decrease in metabolic rate. This can contribute to weight gain and obesity. The relationship between hypothyroidism and obesity is bidirectional; while hypothyroidism can lead to weight gain, obesity can also alter thyroid hormone metabolism.[17] Managing thyroid function is crucial in the treatment of obesity-related thyroid dysfunction.

Our results revealed that OSA was the most common comorbid condition associated with obesity. OSA is a prevalent sleep disorder characterized by intermittent and repetitive episodes of partial or complete obstruction of the upper airway during sleep, leading to disrupted respiratory patterns and decreased oxygen saturation.[18,19] One of the proposed mechanisms for the association between obesity and OSA is the deposition of adipose tissue in the upper airway, which can lead to a narrowed airway lumen and increased collapsibility during sleep.[20] Additionally, obesity is associated with an increased risk of developing visceral fat, which has been shown to contribute to the pathophysiology of OSA through increased neck circumference and alterations in lung volumes and chest wall mechanics.[20] A study conducted by Young et al.[21] found that nearly 40% of obese participants had OSA, with the risk of OSA increasing with higher BMI levels. Furthermore, OSA has been identified as the most common comorbid condition associated with obesity, with a prevalence rate exceeding that of other obesity-related comorbidities such as diabetes, hypertension, and cardiovascular diseases.[22,23] The clinical implications of the strong relationship between obesity and OSA are significant.[23] Therefore, it is crucial for healthcare providers to screen for OSA in obese individuals and to implement appropriate interventions, such as weight loss and continuous positive airway pressure (CPAP) therapy.

According to our results, ileostomy closure and the interval between operation and closure were significantly higher in group I than in group II ($P<0.05$).

An emerging consideration in determining the optimal timing for ileostomy closure is the patient's nutritional and metabolic status, particularly obesity, which has been associated with both surgical complications and altered wound healing.[24] The interval between the initial operation and the closure of the ileostomy can impact the risk of complications, with evidence suggesting that shorter intervals may be associated with lower complication rates.[25] However, in the context of obesity, the situation might be more complex. Obesity is a well-recognized risk factor for surgical site infections (SSIs), postoperative complications, and increased healthcare costs.[26] Given this, it has been suggested that an extended interval between ileostomy creation and closure might be warranted in obese patients to allow for weight reduction measures that may decrease the potential for complications and enhance recovery.[26]

Research has explored the association between obesity, the timing of ileostomy closure, and outcomes. For instance, some studies indicate that higher BMI may be a predictor of increased complications following ileostomy closure, including anastomotic leakages and SSIs.[26] However, other studies show that while obesity does indeed correlate with a higher likelihood of complications, these risks do not necessarily diminish by delaying ileostomy closure.[27] This raises the question of whether delayed closure truly benefits obese patients or, conversely, if it leads to a prolonged period of inconvenience and potential morbidity associated with living with an ileostomy.

Our results revealed that anastomotic leakage, wound infection and total postoperative complications were significantly associated with obesity. Also, hospital stay was significantly higher in group I than in group II (8.19 ± 3.2 vs 6.11 ± 2.52; $P=0.004$).

The increased adipose tissue in obese patients can lead to poor wound healing, greater tissue trauma during surgery, and a higher risk of infection. It has shown that obese patients undergoing ileostomy closure are at a higher risk for wound infections compared to their non-obese counterparts.[28] The delayed interval before closure can further exacerbate this risk by prolonging the exposure to potential infection sources.

Anastomotic leakage is another serious complication associated with ileostomy closure. Obesity increases the technical difficulty of surgery, which can compromise the integrity of anastomosis. The increased intra-abdominal pressure and altered wound healing processes in obese patients can also contribute to a higher risk of leakage. Prolonging the interval before ileostomy closure in obese patients might mitigate some risks, but it does not eliminate the increased susceptibility to leakage.[29]

Patients undergoing surgery for CRC are at an increased risk of postoperative morbidity and mortality, with obese individuals facing a particularly elevated risk profile. The adipose tissue in obese patients is known to secrete inflammatory cytokines, which may contribute to an augmented inflammatory response and impaired wound healing.[30] Additionally, technical difficulty during surgery is increased in obese patients due to the excess visceral fat, which can obscure surgical planes and make the identification of key anatomical structures more challenging, thereby prolonging operative time and heightening the prospect of surgical complications.[31]

A systematic review by Healy et al.[32] examining the outcomes of CRC surgery in obese individuals concluded that obese patients had a higher incidence of postoperative infections, anastomotic leaks, and venous thromboembolism. These complications can significantly impact the overall recovery of the patient, often necessitating additional interventions and extending the length of hospital stay.

A meta-analysis by Qiao et al.[33] examined the impact of body mass index (BMI) on surgical site wound infection, mortality, and postoperative hospital stay in subjects undergoing possibly curative surgery for CRC. The systematic literature search included 2247 patients, with 2889 classified as obese and 9358 as non-obese. The key findings are: Obese subjects exhibited a significantly higher risk of surgical site wound infection (OR: 1.87; 95% CI: 1.62–2.15; $P < 0.001$) and higher mortality (OR: 1.58; 95% CI: 1.07–2.32; $P = 0.02$) compared to non-obese. There was no significant difference in postoperative hospital stay between obese and non-obese subjects (MD: 0.81; 95% CI: -0.030 to 1.92; $P = 0.15$). Exercise care when interpreting the analysis owing to the limited number of studies in specific comparisons.

Furthermore, the length of hospital stay is critical for healthcare providers, patients, and health systems due to its implications on resource allocations and costs.

A study by Makino et al.[34] elucidated that obesity was independently associated with longer postoperative hospital stays after CRC surgery. The mechanisms suggested include complex wound management issues, increased rate of complications necessitating intensive monitoring, and delayed mobilization due to obesity-related comorbidities, which may predispose to deconditioning and reduced respiratory function postoperatively.[35]

Notably, the literature demonstrates not only immediate postoperative concerns for obese individuals with colorectal carcinoma but also an association with long-term outcomes. Obese patients had an increased likelihood of reoperation and readmission within 30 days of surgery, indicating a sustained period of vulnerability beyond the initial hospitalization.[36]

Preventive strategies, including preoperative weight reduction, optimization of comorbid conditions, and careful postoperative management, have been proposed to reduce the risks and improve outcomes for obese patients with CRC undergoing surgery.[37]

Limitations of the study included that the sample size was relatively small. The study was in a single center. Further research is needed to refine our understanding of the relationship between BMI and surgical outcomes, as well as to develop targeted interventions for patients with varying BMI levels. Patients with overweight are advised to lose weight through diet, medication, and physical activity, while those suffering from underweight require more focus on nutrition to prepare for surgery and optimize outcomes.

Conclusions

BMI significantly impacts surgical outcomes in patients with CRC. Awareness of the BMI's influence on surgical complications, and the development of personalized clinical strategies are important to optimize treatment and improve patient outcomes.

Financial support and sponsorship: Nil

Conflict of Interest: Nil

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