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Original Article

Surgery Section

Association between BMI and Intraoperative Time and Length of Hospital Stay among Patients undergoing Laparoscopic Colorectal Surgery: A Retrospective Study

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ABSTRACT

Introduction: Now-a-days, most surgeons are aware that obese patients face more difficulties during laparoscopic colorectal surgery compared to non obese patients, especially with the prevalence of advanced laparoscopic procedures.

Aim: To investigate the association between Body Mass Index (BMI) and operative time, as well as the length of hospital stay after laparoscopic colorectal surgery.

Materials and Methods: A retrospective observational study was conducted at Sri Guru Ram Das (SGRD) Charitable Hospital in Amritsar, Punjab, India, from January 2016 to January 2019. The study included 139 patients who underwent laparoscopic colorectal surgery. The dataset consisted of four variables: BMI (continuous), intraoperative time (continuous), diagnosis (nominal, including various diseases such as Crohn's disease, colon cancer, ulcerative colitis, and diverticulitis), and length of stay (dichotomous, categorised as "yes" if the total length of stay in the hospital was greater than three days, and "no" if it was three days or under). Mean and standard deviations were calculated for both BMI and intraoperative time. The Pearson's r correlation test was used to assess the association between BMI and intraoperative time.

Results: A total of 139 patients were included in the study, with 72 (51.80%) having a length of stay less than three days and 67 (48.20%) having a length of stay greater than three days. Higher BMI was found to be associated with a prolonged length of stay (>three days) in the hospital following colorectal surgery, with a p-value of 0.007. However, the study did not find a statistically significant association between BMI and intraoperative time, with a p-value of 0.1795.

Conclusion: Obese patients tend to spend a longer time in the hospital compared to non obese patients. Therefore, caution should be exercised when performing elective laparoscopic procedures on obese patients.

Keywords: Elective surgery, Laparotomy, Morbidity injury, Obesity

INTRODUCTION

Obesity is defined as the excessive accumulation of fat in the body, posing a health risk to individuals [1]. According to the World Health Organisation (WHO), a crude measure of obesity is the Body Mass Index (BMI) [1]. An individual is considered obese when their BMI reaches 30 or higher. Obesity is a significant public health problem in both industrialised and developing countries. The global prevalence of obesity has risen significantly over the past few decades [2]. It is estimated that worldwide, obesity causes 2.8 million deaths annually and contributes to approximately 35.8 million (2.3%) of global disability-adjusted life years [3]. In the United States, obesity is responsible for approximately 300,000 premature deaths annually, surpassing the combined number of deaths caused by breast, colon, lung, and prostate cancers [4]. Obesity is a major risk factor for various health conditions, including cerebrovascular accidents, myocardial infarction, congestive heart failure, dyslipidemia, diabetes, gallstones, gout, hypertension, insulin resistance, osteoarthritis, sleep apnea, and cancer [5].

In addition to these health problems, obesity is associated with increased technical difficulties and higher surgical risks, particularly in colorectal surgery [6,7]. Individuals with high BMI often have pre-existing conditions and are categorised as a high-risk mortality group. High BMI is linked to a greater risk of converting laparoscopic procedures to open procedures, intraoperative nerve injuries, tearing of the mesentery and mesocolon during bowel extraction, surgical site infections, septic wound complications, and postoperative anastomotic leaks [5].

Apart from the elevated risks involved in surgical management of obese patients, higher BMI also prolongs operative time and length of hospital stay, directly impacting short- and long-term health outcomes while increasing the cost burden on the healthcare system [5]. Research literature presents multiple studies with mixed results regarding the relationship between BMI and operative time, as well as length of hospital stay after laparoscopic colorectal surgery [5,8].

Therefore, the primary aim of this study was to investigate the association between BMI and operative time, as well as the length of hospital stay following laparoscopic colorectal surgery. Additionally, the study explored whether the diagnosis of different diseases had any association with the patient's length of stay in the hospital after the procedure.

MATERIALS AND METHODS

A retrospective observational study was conducted at SGRD Charitable Hospital in Amritsar, Punjab, India from January 2016 to January 2019. As anonymised and de-identified data were used from the hospital, no approval from a Medical Ethical Committee or Institutional Board was required. The de-identified health information of patients was obtained from an institutional review board-approved database.

Inclusion criteria: The study included data from all patients who underwent laparoscopic colorectal surgery at SGRD Charitable Hospital, Amritsar.

Exclusion criteria: Integrated data of open surgery and laparoscopic surgery, as well as data from patients who underwent emergency surgery or had insufficient data after contacting the investigators, were excluded from the study.

A total of 139 case records were analysed. The dataset included four variables: BMI (continuous), intraoperative time (continuous), diagnosis (nominal, listing various diseases-Crohn's disease, colon cancer, ulcerative colitis, diverticulitis-without any intrinsic order), and length of stay (dichotomous-answered as "yes" if the total length of stay in the hospital was greater than three days, and "no" if it was three days or less).

BMI Classification: The BMI (kg/m^2) classification according to the definition by WHO was adopted: normal (18.5≤ BMI <25), preobese (25≤ BMI <30), overweight (BMI ≥25), obese (BMI ≥30), obese class I (30≤ BMI <35), obese class II (35≤ BMI <40), and obese class III (BMI ≥40) [9].

STATISTICAL ANALYSIS

The data was analysed using Statistical Package for the Social Sciences (SPSS) version 26.0. Means and standard deviations were calculated for both BMI and intraoperative time, and histograms were used to assess the normality of their distribution. Frequencies and percentages were calculated for the numeric summary of both the diagnosis and the length of stay, and bar charts were used to visualise comparisons among categories. Scatter plots and correlation tables were created to study the association between continuous-continuous variables (BMI and intraoperative time), mosaic plots and two-way contingency tables were created to study the association between categorical-categorical variables (diagnosis and length of stay), and side-side box plots were created to study the association between continuous-categorical variables (BMI and length of stay). Three hypothesis tests were conducted to analyse the associations between these variables.

Pearson's correlation coefficient was used to measure the association between BMI and operative time. The Chi-square test was used to determine the relationship between diagnosis and the length of stay. A two-sample t-test (assuming reasonable conditions if 0.5≤S12/S22≤2) was conducted to investigate the link between BMI and the length of stay in the hospital after laparoscopic colorectal surgery. The significance level for these tests was set at alpha (α)=0.05. A p-value less than the selected alpha level was considered statistically significant for all analyses. Additionally, Chi-square distribution and z statistics were used to determine statistical significance by comparing them with the test statistics.

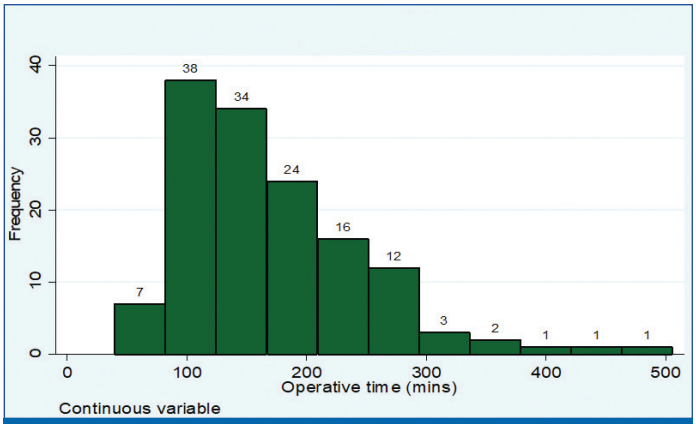
RESULTS

The mean age of the patients was 54±18 years. Out of 139 patients, 78 (56.11%) were males, while 61 (43.89%) were females. The mean values for BMI and intraoperative time are presented in [Table/Fig-1].

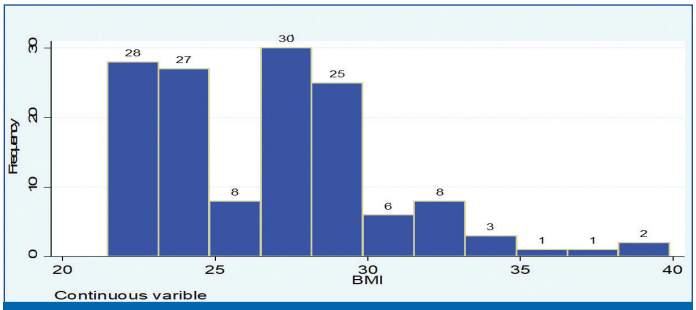
Variables	Mean±SD
Intraoperative time (minutes)	171.5±76.15
BMI (kg/m^2)	26.73±3.80
Mean age (years)	54±18

[Table/Fig-1]: Mean of BMI and intraoperative time in the study group.

The histogram for intraoperative time data showed a right-skewed distribution, with most observations lying to the left of the mean (including the median, as the mean is greater than the median), and a long tail on the right side. The right-skewing of the histogram was mainly due to larger values of intraoperative time (e.g., 400, 506) [Table/Fig-2]. Similarly, the histogram for BMI data did not follow a proper normal curve or symmetric distribution [Table/Fig-3]. The BMI histogram also displayed right-skewing due to larger values, resulting in a tailing or skewing towards the right side [10].



[Table/Fig-2]: Histogram representing intraoperative time.



[Table/Fig-3]: Histogram representing BMI.

The frequency of patients with a length of stay greater than three days was 72 (51.80%), while the frequency of patients with a length of stay less than or equal to three days was 67 (48.20%). Among the patients, 40 (28.78%) had colon cancer, and 38 (27.34%) had diverticulitis [Table/Fig-4].

Length of stay (days)	Diagnosis				
	Colon cancer	Crohn's disease	Diverticulitis	Ulcerative colitis	Total
>3	24	14	20	14	72
<3	16	17	18	16	67
Total	40	31	38	30	139

[Table/Fig-4]: Distribution of cases according to LOS and diagnosis.

The most significant association found was between BMI and the length of stay in the hospital after laparoscopic colorectal surgery. This was the only hypothesis test that led to the rejection of the null hypothesis and yielded statistically significant results. The two-sample t-test (assuming equal variances) between BMI and length of stay resulted in a test statistic of -2.7038, a p-value of 0.0077, and 137 degrees of freedom [Table/Fig-5].

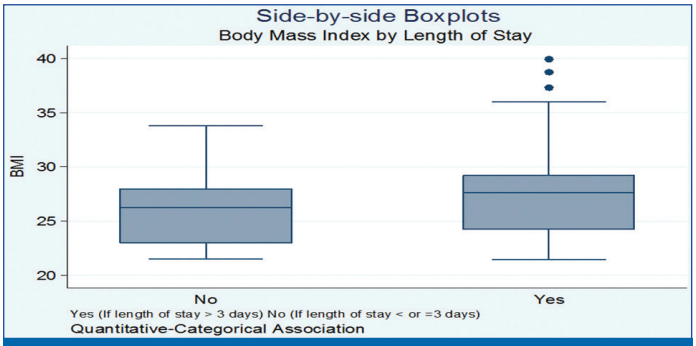
Group	Number	BMI, Mean±SD	p-value
Length of stay ≤3 days	72	25.91±3.31	0.0077
Length of stay >3 days	67	27.61±4.09	
Combined	139	26.73±3.80	

[Table/Fig-5]: Mean values of BMI of patients according to their length of stay. In patients with higher BMI the length of stay was prolonged

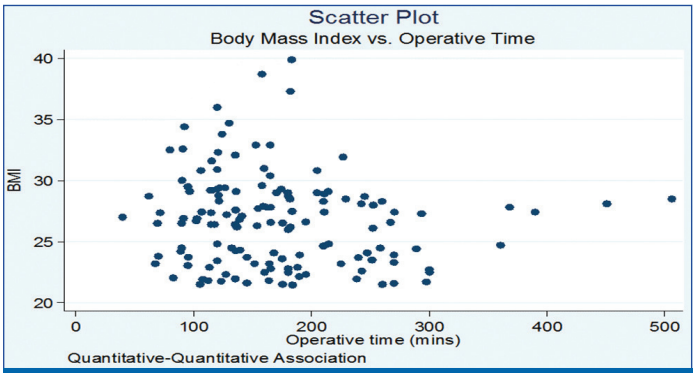
In patients with a higher BMI, the length of stay was prolonged in the hospital after colorectal surgery. The side-by-side boxplots graphically illustrate the difference in two groups of patients with different lengths of stay. It shows that the box plot of patients with a length of stay greater than three days (marked as "yes") is slightly on the higher side of the range of high BMI values. The upper whisker of patients with prolonged length of stay crosses a BMI of 35. Some outliers can also be seen in this group on the higher end [Table/Fig-6].

The Pearson's r correlation test was used to measure whether there was an association between BMI and intraoperative time. The test results were a p-value of 0.1795, r (-0.1145) with 137 degrees of

freedom. Since the p-value was greater than the selected alpha level of 0.05, the null hypothesis was not rejected. The study did not find a statistically significant correlation between BMI and intraoperative time. The scatter plot does not appear to show a linear association [Table/Fig-7].

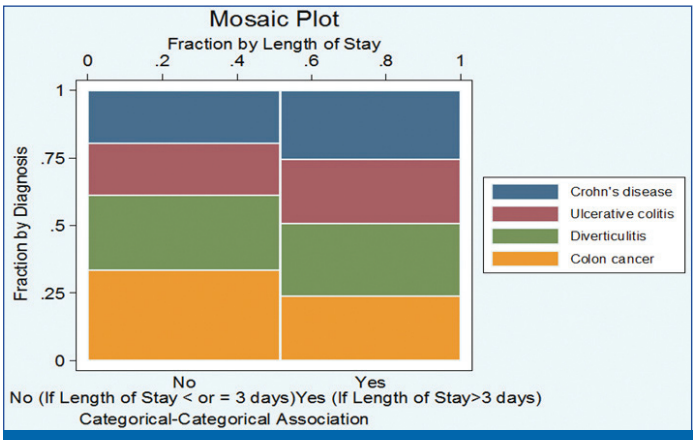


[Table/Fig-6]: Association between BMI and LOS.



[Table/Fig-7]: Correlation between BMI and intraoperative time.

The chi-square test was used to determine the relationship between diagnosis and the length of stay. The test found a p-value of 0.583, test statistics of 1.9516 with three degrees of freedom. Since the p-value was greater than the selected alpha level, the null hypothesis was not rejected. Therefore, the study did not find statistically significant evidence at α=0.05 to show that the diagnosis and the length of stay in the hospital after laparoscopic colorectal surgery are significantly associated. The mosaic plot displays various colors representing the fraction of patients with different diseases. It shows that the diseases-colon cancer, Crohn's disease, ulcerative colitis, and diverticulitis-were approximately equally distributed in the patient group whose length of stay is more than three days. Also, the graph indicates that a higher fraction of colon cancer patients have a shorter length of stay after colorectal surgery compared to other diseases. The x-axis represents patients' diseases categorised by the length of stay into two groups: yes-if the total length of stay was greater than three days and no-if the length of stay is less than or equal to three days. The mosaic plot shows that both groups with different diseases roughly have an equal number of patients [Table/Fig-8].



[Table/Fig-8]: Relationship between diagnosis and length of stay.

DISCUSSION

The global prevalence of obesity among adults continues to rise. The relationship between obesity and laparoscopic colorectal surgery has evolved over the years. Obesity is a significant and growing health problem, and an increasing number of colorectal cancer patients are obese, with a BMI above 30 kg/m^2. Historically, it was believed that individuals with a higher BMI had a higher risk of inferior surgical results, including an increased likelihood of perioperative complications and longer hospital admissions. However, more recent research has challenged this assumption [11-13].

Previous research has examined the relationship between BMI and perioperative outcomes in the population undergoing general surgery. Initial reports investigating the feasibility of laparoscopy in patients with an increased BMI resulted in worse outcomes compared to non obese individuals. This included more postoperative complications, conversions to open procedures, and an increased length of stay. In cases of cancer resections, however, it was shown to be oncologically safe. Nonetheless, as techniques have improved and there is greater familiarity and capability with laparoscopic surgery, short-term outcomes have become more comparable to open surgery [14-16].

Therefore, the present study aimed to study the relationship of the duration of intraoperative procedures and the length of stay with BMI in patients after laparoscopic colorectal surgery. The results of this study found that obesity is associated with the length of stay in the hospital after laparoscopic colorectal surgery. The BMI was higher in patients with a prolonged length of stay in the hospital after colorectal surgery (p-value=0.0077, α=0.05).

Multiple studies in the scientific literature support this association. A study conducted by Chew MH et al. stated that BMI was associated with the hospital length of stay-the higher the BMI, the longer the length of stay in the hospital after surgery [17]. Another study conducted by Kurmann A et al., demonstrates that a higher BMI considerably increases the patient's length of stay in the hospital [18]. This study stated that BMI increases the risk for surgical site infection, which, in turn, increases hospital stay. Studies that showed an increase in the number of problems in obese patients also described an increased length of stay. However, these two outcomes are naturally related. For example, ileus is the most common cause of prolonged hospital admission after colorectal surgery. This can be attributed to longer operating time and postoperative complications that need to be resolved before discharge. Therefore, it is not surprising that if the number of complications is reduced, so is the length of stay [19,20].

The present study has shown that despite an increased BMI, the intraoperative time is no different for non obese patients. Previous studies have shown increased operating time in obese patients, which is most likely a reflection of the difficulty in operating on these patients [21]. Additionally, this study did not find any statistically significant evidence to indicate that diagnosis and length of stay in the hospital are significantly associated.

Aytac E et al., in a retrospective cohort study conducted in a high-volume colorectal unit, compared surgical outcomes in obese and non obese patients undergoing surgery for mid and low-rectal cancers. Researchers found that technical difficulties can be encountered in obese patients during a rectal resection, including the anatomic confines of the pelvis and a bulky mesocolon that can limit the delivery of the colon to the anal canal. Obesity may predispose individuals with diverticular disease to an increased risk of complications, which may be more pronounced in men. Abdominal obesity may even be a stronger risk factor than BMI itself [22].

Further research is needed to study other factors (confounding variables) that can influence the association between BMI and the length of a patient's stay in the hospital. Since the length of stay is directly related to short and long-term health outcomes for patients

and healthcare costs, effective surgical techniques or enhanced recovery pathways should be developed based on these research findings. This can help decrease the length of a patient's stay in the hospital and reduce the healthcare costs associated with colorectal surgery.

Limitation(s)

The findings of this study are drawn from a single surgical centre, and they may only apply to patients who were candidates for laparoscopic colorectal surgery. Additionally, this specialty database only provides information about four specific diseases on which surgery was performed, so results may differ for other diseases. There were potential confounding variables, such as age, gender, past surgical history, pre-existing health conditions (diabetes, hypertension), smoking status, diet, and exercise, that were not taken into consideration. The use of a single centre limits the generalisability of the study. The results might also differ if the diagnostic criteria were based on international recommendations. The study design was also a notable limitation. The authors reviewed a prospectively maintained database, but it was not a randomised controlled trial, so definitive conclusions cannot be based solely on the results of this study.

CONCLUSION(S)

Obese individuals have a significantly higher risk of developing postoperative problems and require more time in the hospital compared to non obese patients. Caution should be exercised when offering elective laparoscopic colorectal segmental resection to obese patients due to the increased likelihood of conversion to laparotomy.

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