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Research article

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Retrospective assessment of the association between inhalation anesthesia and post-operative complications in morbidly obese patients undergoing bariatric surgery

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Abstract

Background/Aim: Today, obesity is a rapidly growing health problem. Healthcare professionals have been encountering both obese adult and adolescent patients in the operating room more and more frequently. Morbid obesity affects all body systems, thus necessitating greater care in anesthesia management. Studies conducted in recent years have failed to find clear evidence for the most appropriate anesthesia technique with minimal effect on post-operative complications. Therefore, this study was designed to compare the effects of inhalation anesthesia and total intravenous anesthesia (TIVA) on post-operative complications in morbidly obese patients who underwent bariatric surgery.

Methods: After receiving approval from the University Ethics Committee, the files of 304 patients who underwent laparoscopic gastric bypass and sleeve gastrectomy between January 2018 and December 2021 were screened. Patients with unexpectedly difficult airways, who underwent open surgery, in whom the anesthesia technique had to be changed intra-operatively for any reason, those scheduled for intensive care as decided during surgical planning, and those with liver or kidney failure were excluded from the study. A total of 278 patients were included in the study. Patients were divided into two groups according to the method of anesthesia used: (1) TIVA (Group T) and (2) inhalation anesthesia (Group I).

Results: The study was performed with 278 patients of whom 213 were women, and 65 were men. Patient demographics were similar between the two groups. Comparison of the clinical characteristics of the study groups showed that the rate of admission to the intensive care unit (P=0.032), average duration of surgery (P<0.001), and complication rate (P<0.001) were significantly higher in the TIVA group than in the inhalation anesthesia group.

Conclusion: Morbidly obese patients exhibit higher rates of anesthesia- and surgery-related complications because of their comorbidities. Anesthesia management and selection of anesthetics are important in these patients. Based on the literature and results of our study, inhalation agents may be preferred for morbidly obese patients because they are associated with fewer complications in this patient population. Although our study indicates that inhalation anesthesia is a safe and appropriate choice, extensive studies with a larger number of patients are needed.

Keywords: Bariatric surgery, Inhalation anesthesia, Total intravenous anesthesia (TIVA), Morbid obesity, Post-operative complications

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Ethics Committee Approval
The study protocol was approved by the Ethics Committee for Clinical Studies of Marmara University Medical Faculty Istanbul Turkey (09.2022.099).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Introduction

Obesity is a growing health problem worldwide. Studies have demonstrated that morbid obesity can cause complications, such as diabetes, sleep apnea, depression, and/or heart disease. Moreover, the prevalence of morbid obesity has been steadily increasing over the last two decades. The three main treatment options for morbid obesity are lifestyle change, pharmacotherapy, and surgery. Surgical treatment has been found to be superior to the other two options because it offers a long-term and quick solution [1].

Morbidly obese patients are also at a greater risk for pre- and post-operative complications because they have more comorbidities than the normal population. General anesthesia is specific in this patient population and requires an experienced surgical team [2]. Some studies in the literature classify post-operative complications according to the Clavien–Dindo system, a grading system introduced in 2004 that provides an objective classification of post-operative complications [3, 4].

The rapid developments in laparoscopic bariatric surgery and recent increase in their use can be attributed to the reduction of post-operative complications [5]. Selection of an appropriate anesthetic agent for induction and maintenance is important for achieving favorable outcomes with laparoscopic surgery in obese patients [2, 6]. The primary aim of this retrospective study was to compare the effects of inhalation anesthesia and total intravenous anesthesia (TIVA) on post-operative complications in morbidly obese patients undergoing bariatric surgery. The secondary aim was to evaluate the relationship between laboratory data and development of complications.

Materials and methods

After obtaining approval from the Marmara University's Clinical Research Ethics Committee (approval no. 09.2022.099), the hospital database was screened, and data from 304 patients who underwent bariatric surgery between January 2018 and December 2021 were accessed. Patients with unexpectedly difficult airways, patients who underwent open surgery, patients in whom the anesthesia technique had to be changed intra-operatively for any reason, patients scheduled for intensive care as decided during surgical planning, and patients with liver or kidney failure were excluded from the study. Screening of the medical records showed that the data were only partially accessible for 10 patients; eight patients had previously undergone bariatric surgery, two patients had the method of anesthesia method changed during the operation, three patients had been switched to open surgery during the operation, two patients had initial liver enzyme levels twice the normal levels, and one patient had chronic renal failure; thus, these patients were excluded from the study. The remaining 278 patients were divided into two groups according to the method of anesthesia used: (1) TIVA (Group T) and (2) inhalation anesthesia (Group I). For bariatric surgery, our clinic uses propofol and remifentanil infusion for TIVA and desflurane or sevoflurane in combination with remifentanil infusion for inhalation anesthesia. All patients underwent electrocardiography, pulse oximetry, invasive arterial pressure monitoring, bispectral index monitoring, and capnography. Patients' demographics, admission to and length of stay in the intensive care unit (ICU), if any, duration of surgery, presence of complications, need for transfusion, choice of anesthetic agent, post-operative nausea and vomiting, pre- and postoperative lactate, blood urea nitrogen, creatinine, aspartate transaminase, and alanine transaminase levels were obtained from the screened records. Patients with a waist/hip ratio of >0.85 were evaluated as abdominally obese. Post-operative complications were classified according to the Clavien–Dindo system. The present study was designed as a retrospective cohort study.

Statistical analysis

SPSS 22.0 software was used for data analysis. Descriptive statistics were expressed as averages, standard deviations, medians, lowest and highest values, frequencies, and ratios. Variable distribution was measured using the Kolmogorov–Smirnov test. Quantitative independent variables were analyzed with the independent t- and the Mann–Whitney U tests, and quantitative dependent variables were analyzed using the Wilcoxon test. A chi-square test was used to analyze the qualitative independent data, and the Fischer's test was used when the chi-square test criteria were not fulfilled. The level of significance was set at $P < 0.05$.

Results

The study was conducted with 278 patients, of whom 213 were females, and 65 were males. Patient demographics were distributed similarly between the study groups (Table 1).

Table 1: Comparison of demographics of the study groups (Measurable values are given in median minimum–maximum values instead of numbers and percentages)

		Group I N (%)	Group T N (%)	*P*-value
Gender	Female	131 (75.3)	82 (78.8)	0.498 [a]
	Male	43 (24.7)	22 (21.2)	
Age *		43 (22-64)	41 (21-64)	0.196 [b]
BMI*		45.8 (36.5-66.2)	46 (35.6-66.4)	0.723 [b]
Waist/ hip ratio*		0.89 (0.77-1.2)	0.93 (0.76-1.1)	0.113 [b]

[a] Chi-square test, [b] Mann Whitney U test, * In the measurement data, the median minimum-maximum values are presented instead of the number percent.

Comparison of the clinical characteristics of the study groups showed that the rate of admission to the ICU (P=0.032), the average duration of surgery (P<0.001), and complication rates (P<0.001) were significantly higher in Group T than in Group I.

The rate of obtaining low grades based on the Clavien–Dindo complication grading system was significantly higher in Group I than in Group T (P=0.003). No statistically significant difference between the study groups in terms of obesity type and post-operative nausea and vomiting (PONV) were found (Table 2).

In the 44 patients who presented complications three main complications were found: (1) atelectasis (n: 18; 40.9%), (2) hypoxia (n: 8; 18.1%), and (3) anastomotic leaks (n: 7; 15.9%). The distribution of complications by groups is presented in Table 3.

Table 2: Comparison of clinical characteristics of the study groups

		Group I N (%)	Group T N (%)	*P*-value
Obesity type	Non abdominal	36 (20.7)	22 (21.2)	0.927 [a]
	Abdominal	138 (79.3)	82 (78.8)	
Intensıve Care Unit (ICU) hospitalization	No	170 (97.7)	96 (92.3)	0.032 [b]
	Yes	4 (2.3)	8 (7.7)	
Operation duration (minute)*		100 (59-210)	110 (65-287)	<0.001 [c]
ICU duration (day)*		1 (1-4)	2 (1-8)	0.272 [c]
Complication	No	157 (90.2)	77 (74.0)	<0.001 [a]
	Yes	17 (9.8)	27 (26.0)	
Operation type	Bypass	144 (82.8)	75 (72.1)	0.036 [a]
	Sleeve	30 (17.2)	29 (27.9)	
Anesthesia agent	Desflurane	118 (67.8)	0 (0.0)	<0.001 [a]
	TIVA	0 (0.0)	104 (100.0)	
	Sevoflurane	56 (32.2)	0 (0.0)	
PONV (post-operative nausea & vomiting)	No	143 (82.2)	93 (89.4)	0.103 [a]
	Yes	31 (17.8)	11 (10.6)	
Clavien-Dindo complication scores	0	157 (90.2)	77 (74.0)	0.003 [b]
	I	1 (0.6)	6 (5.8)	
	II	7 (4.0)	8 (7.7)	
	IIIA	0 (0.0)	3 (2.9)	
	IIIB	6 (3.4)	6 (5.8)	
	IV	3 (1.7)	4 (3.8)	

[a] Chi-square test [b] Fisher test, [c] Mann Whitney U test, * In the measurement data, the median minimum-maximum values are presented instead of the number percent.

Table 3: Distribution of complications in patients who developed complications by study groups

Complication	Inhalation N (%)	TIVA N (%)	Total N (%)
Anastomosis leak	4 (23.5)	3 (11.1)	7 (15.9)
Atelectasis	6 (35.3)	12 (44.4)	18 (40.9)
Infection	0 (0.0)	4 (14.8)	4 (9.09)
Hematuria	0 (0.0)	1 (3.7)	1 (2.2)
Hypoxia	3 (17.6)	5 (18.5)	8 (18.1)
Incarcerated hernia	1 (5.9)	1 (3.7)	2 (4.5)
Bleeding	0 (0.0)	1 (3.7)	1 (2.2)
Perforation	1 (5.9)	0 (0.0)	1 (2.2)
Arrhythmia	1 (5.9)	0 (0.0)	1 (2.2)
Transfusion requirement	1 (5.9)	0 (0.0)	1 (2.2)
Total	17 (100.0)	27 (100.0)	44 (100.0)

The analysis of the relationship between clinical characteristics and complications revealed that the rate of complications was significantly higher in Group T than in Group I (*P*<0.001) as shown in Figure 1. Complication rates were significantly higher in patients admitted to the ICU than in patients who were not (*P*<0.001). The mean duration of the surgery was significantly higher in patients with complications than in those without (*P*<0.001). Group T had a higher rate of complications, and in Group I, patients who received sevoflurane had a lower rate of complications than those who received desflurane (*P*=0.001). No statistically significant difference between the two groups in terms of the type of obesity, type of operation, length of stay in the ICU, PONV, and the development of complications (Table 4).

Table 4: Relationship between clinical features and complications

		Complication No N (%)	Complication Yes N (%)	*P*-value
Obesity type	Non abdominal	51 (87.9)	7 (12.1)	0.378 [a]
	Abdominal	183 (83.2)	37 (16.8)	
Anesthesia	Inhalation	157 (90.2)	17 (9.8)	<0.001 [a]
	TIVA	77 (74.0)	27 (26.0)	
ICU hospitalization	No	234 (88.0)	32 (12.0)	<0.001 [b]
	Yes	0 (0.0)	12 (100.0)	
Duration of operation (minute)		100 (59-210)	120 (65-287)	<0.001 [c]
ICU hospitalization (day)		1 (1-4)	2 (1-8)	0.272 [c]
Operation type	Bypass	182 (83.1)	37 (16.9)	0.347 [a]
	Sleeve	52 (88.1)	7 (11.9)	
Anesthesia agent	Desflurane	103 (87.3)	15 (12.7)	0.001 [a]
	TIVA	77 (74.0)	27 (26.0)	
	Sevoflurane	54 (96.4)	2 (3.6)	
PONV (postoperative nausea & vomiting)	No	196 (83.1)	40 (16.9)	0.224 [a]
	Yes	38 (90.5)	4 (9.5)	
Clavien-Dindo classification	0	233 (99.6)	1 (0.4)	<0.001 [b]
	I	0 (0.0)	7 (100.0)	
	II	1 (6.7)	14 (93.3)	
	IIIA	0 (0.0)	3 (100.0)	
	IIIB	0 (0.0)	12 (100.0)	
	IV	0 (0.0)	7 (100.0)	

[a] Chi-square test, [b] Mann Whitney U test, * In the measurement data, the median minimum-maximum values are presented instead of the number percent.

Pre- and postoperative lactate values were significantly higher in the group with complications than in the group without complications (*P*=0.007 and <0.001, respectively). No significant differences were found between the groups with respect to other laboratory data and complication rates (Table 5).

Table 5: The relationship between laboratory data and the development of complications

	Complication No Median (Min-Max)	Complication Yes Median (Min-Max)	*P*-value [a]
Preop BUN	12 (5-30)	12 (7-23)	0.654
Postop BUN	13 (4-29)	13 (4-33)	0.935
Preop creatinine	0.66 (0.42-1.22)	0.67 (0,44-1,1)	0.424
Postop creatinine	0.69 (0.33-1.77)	0.73 (0.41-1.4)	0.178
Preop ALT	29 (12-64)	29 (17-54)	0.980
Postop ALT	54 (13-738)	51 (17-217)	0,727
Preop AST	27.5 (8-101)	29 (14-54)	0.264
Postop AST	52 (9-798)	57.5 (12-285)	0.532
Preop lactate	0.9 (0.3-2.8)	1.1 (0,5-3,9)	0.007
Postop lactate	0.9 (0,4-3.2)	1.2 (0.6-5)	<0.001

[a] Mann Whitney U test

Discussion

The findings of the present study showed that inhalation anesthetic agents are safe and effective in terms of complication rate in patients undergoing bariatric surgery.

Studies conducted to date have failed to yield clear results on anesthetic agents and post-operative complications [7, 8].

Obesity can affect most of the systems in the body, including the respiratory, cardiovascular, and immune systems. Obese patients experience restrictive lung disease, which manifests in the form of an increase in oxygen consumption, carbon dioxide production, alveolar ventilation, and elevated respiratory rates even in patients at rest and with reduced pulmonary compliance. These patients also have a decreased total lung capacity and functional residual capacity and increased airway resistance. Obese patients have higher rates of incidence of post-operative atelectasis, hypoxia, prolonged intubation, and lung infections compared with patients of normal weight [9]. Therefore, it is important to select the most suitable type of anesthesia.

An experimental study of obesity has shown that propofol infusion for 1 h may cause increased airway resistance and lead to atelectasis and pulmonary inflammation because of the depletion of enzymatic antioxidants and increased levels of tumor necrosis factor alpha and interleukin 6 (TNF-α and IL-6, respectively) in lung tissue [10]. In line with this finding, our study found a higher rate of atelectasis in the TIVA group. As mentioned in the literature, weakened respiratory muscles and increased oxygen consumption in obese patients cause an increase in the tendency to develop atelectasis, and the use of TIVA may further increase the risk of developing atelectasis.

Another study comparing inhalation anesthesia and TIVA in morbidly obese patients reported that oxygen saturation in the first 2 h was lower in patients who received TIVA and that the forced vital capacity, peak expiratory flow, mid-expiratory flow, and forced inspiratory capacity as measured by spirometry were lower than the initial values by 11% to 20% and lasted for 24 h [11]. Our study found similar rates of post-operative hypoxia in the two groups. High visceral fat mass in obese individuals pushes the diaphragm upward and makes the diaphragm movements harder, thus leading to hypoxia due to fat deposits between the ribs and reduced pulmonary compliance.

Therefore, it is important to select suitable anesthetic agents that do not deepen hypoxia.

In a study of respiratory mechanics during laparoscopic sleeve gastrectomy in morbidly obese patients, Ozturk et al. compared inhalation anesthetics and propofol and found no statistically significant difference. However, they reported increased airway resistance with propofol and desflurane with air in the peritoneal cavity, whereas no change in airway resistance occurred after sevoflurane administration [12]. The most common post-operative complications found in our study were atelectasis and post-operative hypoxia (40% and 18%, respectively). Respiratory complications were more common in the TIVA group. This observation could be attributed to the fact that sevoflurane, which is an inhalation anesthetic, acts on smooth muscle, suppresses smooth muscle contractility, leads to indirect inhibition of vagal reflexes, and acts as a good bronchodilator. Several studies have shown that desflurane produces bronchodilatory effects that mimic sevoflurane although desflurane also depends minimum alveolar concentration [13].

Obesity also affects the cardiovascular system and causes increased cardiac output and workload. Fat stored throughout the body can be deposited in the heart's conduction system, thereby causing conductive dysfunction in the sinoatrial node. Thus, obese patients are at a greater risk for arrhythmia and have a 1.5-fold increase in the incidence of atrial fibrillation. Studies conducted in recent years have shown that sevoflurane, an inhalation anesthetic with low solubility, has a cardioprotective effect that prevents myocardial ischemia and arrhythmia [14, 15]. In the present study, out of 278 patients, post-operative atrial fibrillation was observed in only one patient in the inhalation anesthesia group.

In recent years, clinical and experimental studies have shown that anesthetic drugs affect the immune system and the glycocalyx layer and may also affect the development of complications. It is thought that obese patients have chronic inflammation owing to the higher level of proinflammatory cytokines (TNF-α, and IL-6 and -12) compared with the normal weight population. It is also known that obese individuals have impaired macrophage and neutrophil function. A study comparing sevoflurane and propofol with TIVA found higher levels of IL6, TNF α, and other proinflammatory cytokines in the TIVA group [16]. This study was not conducted with a group of obese patients, but similar results were noted in an experimental model of obesity. The present study found no surgical site infection in the volatile anesthesia group, but four patients (14.8%) in the TIVA group developed a surgical site infection that required medical or surgical intervention.

A study investigating the effect of propofol and sevoflurane on the microcirculation reported that the capillary filtration coefficient that decreases in response to sevoflurane may result in reduced extravasation of liquids into the interstitial space and thereby reduce the need for intra-operative fluids. This finding suggests that sevoflurane may be the anesthetic agent of choice in patients susceptible to large intra-operative fluid shifts during abdominal surgery and operations involving anastomosis [17]. In the present study, the anastomotic leak rate was 23.5% in the volatile anesthesia group and 11.1% in the TIVA group.

Regarding the effects of anesthetic drugs on post-operative kidney and liver functions, the present study could not obtain a statistically and clinically significant result in the TIVA and inhalation anesthesia groups. There are reported cases of acute hepatotoxicity in non-obese patients with sevoflurane, and there is also a reported case of a patient undergoing bariatric surgery with desflurane [18]. Acute kidney damage after bariatric surgery has been reported at 6% [19]. Acute kidney damage has been defined as a ≥1.5-fold increase in creatinine levels at postoperative day 7, an increase in creatinine by 0.3 mg at 48 hours, and urine output <0.5 ml/kg/hour in 6 hours of follow-up. Our study found no significant difference between the two groups in post-operative creatinine levels. In a study with 64 patients who underwent bariatric surgery, Fernandes et al. [20] determined acute kidney damage with neutrophil gelatinase-associated lipocalin and found no significant difference between the TIVA and volatile anesthesia groups.

PONV is common, especially during sleeve gastrectomy, in morbidly obese patients [21, 22]. Although several studies have reported better results with TIVA in terms of PONV in the short term, none could find any significant results when TIVA was compared with inhalation anesthetics in the long term [21]. The present study found PONV to be more common in the inhalation anesthesia group, but the results were not statistically significant.

Our study has some limitations. First, post-operative pain levels were not recorded; indeed, pain can trigger post-operative respiratory and cardiac complications. Another limitation is the retrospective design of our study, which meant that only records of symptomatic atelectasis and complications experienced only during hospitalization could be accessed. Different results could be achieved with prospective, randomized, multicenter, and longer-term studies. The last limitation is the likelihood that metabolic conditions of the obese patients might have affected the variable and independent outcomes.

Conclusion

Patients undergoing bariatric surgery are at a risk for several complications due to obesity and the surgical method. Most studies concerning post-operative complications could not achieve clear results. Great care is needed in the selection of anesthetic agents to prevent complications in this group of patients. In view of the present study and the studies in the literature, it can be said that volatile anesthetic agents are safe and effective in terms of complications in patients undergoing bariatric surgery.

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