e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.7.69

International Journal of Pharmaceutical Quality Assurance 2025; 16(7); 432-438

Original Research Article

Comparative Assessment of Anesthetic Drug Requirements and Recovery Profile Across Different BMI Categories

Vikash Gaurav

Specialist Medical Officer, Department of Anesthesia, Sadar Hospital, Koderma, Jharkhand, India

Received: 10-05-2025 / Revised: 11-06-2025 / Accepted: 22-07-2025
Corresponding Author: Dr. Vikash Gaurav
Conflict of interest: Nil

Abstract:

Background: ¨Body mass index (BMI) significantly influences anesthetic pharmacokinetics, pharmacodynamics, and postoperative recovery. Obesity and overweight alter drug distribution, metabolism, and elimination, affecting anesthetic requirements and recovery times.

Aim: To evaluate the impact of BMI on anesthetic drug requirements and recovery profile in patients undergoing elective surgeries under general anesthesia.

Methodology: This prospective, observational study included 80 adult patients (ASA I–II) undergoing elective surgeries at the Department of Anesthesia, Sadar Hospital, Koderma, Jharkhand, India, over 6 months. Patients were categorized into normal (n=26), overweight (n=27), and obese (n=27) BMI groups. Induction doses of propofol and fentanyl, intraoperative anesthetic consumption, and recovery parameters (time to eye opening, verbal response, Aldrete ≥9) were recorded. Data were analyzed using ANOVA, Chi-square test, and Pearson's correlation.

Results: Weight-adjusted propofol and fentanyl doses decreased with increasing BMI ($p < 0.05$), while total propofol and inhalational agent consumption increased ($p < 0.001$). Recovery times were prolonged in higher BMI groups (T1: 6.2 → 10.4 min; T2: 7.1 → 12.2 min; T3: 11.4 → 18.6 min; $p < 0.001$). BMI correlated negatively with propofol mg/kg ($r = –0.62$) and positively with total propofol ($r = 0.71$), inhalational consumption ($r = 0.65$), and recovery times ($r = 0.74–0.79$).

Conclusion: Elevated BMI is associated with higher absolute anesthetic requirements and delayed recovery despite reduced per-kilogram dosing. Individualized dosing strategies and careful perioperative monitoring are recommended for optimal outcomes.

Keywords: BMI, Anesthesia, Propofol, Recovery, Perioperative Care, Overweight, Obesity.

Introduction

The body ¨mass index (BMI) has become one of the most important anthropometric parameters that affect the perioperative anesthetic care and postoperative results [1]. BMI is defined as kilograms weight divided by the square of height in meters and is a highly generic surrogate endpoint of fat distribution in the body and nutritional health. Following the classification that has been suggested by the World Health Organization, people are defined underweight, normal weight, overweight, and obese in accordance with certain BMI levels. Anesthetic implication of altered BMI has become more pertinent in the ordinary clinical practice given the fact that prevalence of overweight and obesity has gained significance all over the world in the past decades. Each end of the BMI (underweight and obesity) has distinct physiological problems both of which have an enormous impact on the pharmacokinetics and pharmacodynamics of anesthetic drugs, their dosage regimen and recovery processes after surgery [2].

The demand of anesthetic drugs is extremely dependent on the body composition change linked to the fluctuation of the BMI [3]. Obese patients have a change of the volume distribution of lipophilic anesthetic drugs like propofol, benzodiazepines and volatile anesthetics due to the increase in mass of adipose tissue. Enhanced fat stores can also increase the rate of drug retention and subsequent release into systemic circulation and this may slow down the process of anesthesia recovery. In contrast, hydrophilic drugs can find their way into the lean body mass and the extracellular fluid and their dose should be adjusted according to the ideal or adjusted body weight as opposed to the total body weight. In the underweight patients, muscle mass, plasma protein concentration, and organ mechanisms are also decreased and this may convert into a sensitive area of the drug and decreased clearance, subsequently decreasing the anesthetic requirement [4]. Therefore, differences in BMI have a direct effect on the

dosage of induction and maintenance level of anesthetic drugs.

The change (pharmacokinetic) of patients with high BMI is further exacerbated by changes in cardiac output, hepatic blood flow, and renal clearance [5]. Obesity is said to be connected with the elevation of the cardiac output and the greatly enlarged blood volume that can both raise the initial distribution of the drug and alter the peak plasma concentrations. Further, hepatic steatosis and enzymatic activity will also change the drug metabolism, whereas the renal changes may alter the elimination half-life. These body adjustments make it difficult to predict the level of anesthesia and the recovery period. A constant dose of a drug that does not take into account the BMI can cause underdosing (resulting in intraoperative awareness -or overdosing) that results in slower emergence and respiratory depression [6].

BMI also has a strong impact on airway care and respiratory physiology which, in turn, affects anesthetic needs and recovery patterns [7]. The obese patients are characterized by low functional residual capacity; high oxygen use and high probability of developing hypoventilation or obstructive sleep apnea. These qualify them to be desaturated quickly at induction and long postoperative hypoxemia [8] predisposed. Consequently, anesthesiologists tend to change the dosage of" sedatives and opioids to achieve the minimum respiratory depression and sufficient analgesia and hypnosis. On "the other hand, underweight patients can have less strength in respiratory muscles and also feel changed ventilatory responses which can also change the anesthetic sensitivity and recovery properties.

Anesthetic recovery is a complex process that depends on the various factors based on the drug excretion, drugs redistribution, metabolic rate and individual physiological reserves of a patient [9]. Stronger BMI is linked to the extended recovery, delays of the process of extubation, and longer post-anesthesia care unit hours related to residual sedative effects and poor respiratory performance. The deposition of lipophilic agents in adipose tissue can cause the slowness of the clearance processes and re-sedation. Furthermore, comorbidities like diabetes mellitus, hypertension, and heart disease associated with obesity can further complicate the process of recovery because they negatively affect the functionality of organs and predispose patients to perioperative risk [10]. Conversely, underweight patients can have an accelerated redistribution of some lipophilic drugs but still have risks of hypotension, hypothermia and delayed wound healing, which could affect the quality of recovery.

The development of anesthetic drugs and monitoring has underlined the focus on the personalized dosage procedure based on BMI and body structure. Target-controlled infusion systems, depth-of-anesthesia systems, and multimodal analgesic approaches should be employed to increase the efficiency of drugs administration and reduce negative consequences. Modern anesthetic practice is suggesting the use of lean body weight or adjusted body weight or pharmacokinetic modeling instead of total body weight alone in patients. These interventions aim at promoting intraoperative hemodynamic stability, minimising postoperative complications, and rapid recovery.

Altogether, BMI has a significant influence on anesthetic drug needs and post-surgical recovery due to complicated changes in pharmacokinetics, pharmacodynamics, and physiology. The increasing weight of abnormal BMI in the world creates the need to know these relations so that anesthetic support can be provided safely and effectively. Having a good understanding of BMI-related differences can allow anesthesiologists to develop a more precise dose of medications, predict complications, and enhance recovery in a wide range of patients.

Methodology

Study Design: The present study was designed as a hospital-based prospective, observational analytical study to evaluate the impact of Body Mass Index (BMI) on anesthetic drug requirements and recovery profile among patients undergoing elective surgeries under general anesthesia.

Study Area: The study was conducted in the Department of Anesthesia, Sadar Hospital, Koderma, Jharkhand, India.

Study Duration: The duration of the study was 6 months from June 2024 to November 2024.

Study Participants: A total of 80 adult patients scheduled for elective surgical procedures under general anesthesia were enrolled in the study.

Inclusion Criteria

- Patients aged between 18–65 years.
- Patients of either gender.
- Patients belonging to American Society of Anesthesiologists (ASA) physical status I and II.
- Patients undergoing elective surgeries under general anesthesia with supraglottic airway device or endotracheal intubation.
- Patients categorized into BMI groups according to WHO classification" (Normal weight: 18.5–24.9 kg/m²; Overweight: 25–29.9 kg/m²; Obese: ≥30 kg/m²).
- Patients "who provided written informed consent.

Exclusion Criteria

- Patients with BMI <18.5 kg/m².
- Patients with ASA physical status III or above.

- Patients with significant cardiovascular, respiratory, hepatic, renal, or neurological disorders.
- Patients with known neuromuscular diseases.
- Patients on chronic sedative or opioid therapy.
- Pregnant or lactating women.
- Patients with anticipated difficult airway.
- Patients unwilling to participate in the study.

Sample Size: The sample size of the study was 80 patients. The participants were distributed proportionately across different BMI categories to assess variations in anesthetic drug requirements and recovery characteristics.

Procedure: The process of recruiting eligible patients started after we obtained and written informed consent during their pre-anesthetic evaluation. The researchers used the formula weight (kg) divided by height squared (m^2) to calculate BMI, which they used to classify the patients into different categories.

Standard guidelines required all patients to remain nil per oral during their treatment. The operating room established standard monitoring which included electrocardiography (ECG) non-invasive blood pressure (NIBP) pulse oximetry (SpO_2) and end-tidal carbon dioxide ($EtCO_2$) monitoring as soon as the patient arrived. The medical team documented the initial vital signs of the patient.

The premedication procedure used intravenous midazolam at a dosage range of 0.02 to 0.03 mg per kilogram together with fentanyl at a dosage range of 1 to 2 micrograms per kilogram. The anesthesia induction process used propofol which doctors administered through intravenous injection until patients lost their ability to speak. The total induction dose required (mg/kg) was recorded. Clinicians used either a supraglottic airway device or endotracheal tube for airway management depending on clinical requirements. The medical staff gave patients neuromuscular blocking agents according to their needs and recorded the total dosage.

Anesthesia was maintained using inhalational agents (sevoflurane or isoflurane) in oxygen and air mixture, with concentration adjusted to maintain adequate depth of anesthesia. Additional doses of opioids or anesthetic agents were administered based on hemodynamic responses. Total intraoperative anesthetic consumption was recorded.

At the end of surgery, inhalational agents were discontinued, and reversal of neuromuscular blockade was administered where applicable. Recovery parameters recorded included:

1. Time from discontinuation of anesthetic agent to eye opening on verbal command (T1).
2. Time to response to verbal commands (T2).
3. Time to achieve Aldrete recovery score ≥9 (T3).

Hemodynamic parameters and any perioperative adverse events were documented. The relationship between BMI and total anesthetic drug requirement (mg/kg), as well as recovery" times, was assessed.

Statistical Analysis: Data were "entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were expressed as frequency and percentage. Comparison between BMI groups was performed using independent sample t-test or one-way ANOVA for continuous variables and Chi-square test for categorical variables. Correlation between BMI and anesthetic drug requirement as well as recovery times was assessed using Pearson's correlation coefficient and linear regression analysis. A p-value of <0.05 was considered statistically significant.

Result

Table 1 presents the demographic characteristics of the study participants according to BMI group, including normal (n = 26), overweight (n = 27), and obese (n = 27) categories. The mean age showed a gradual increase from the normal group (39.4 ± 8.2 years) to the overweight (41.1 ± 9.0 years) and obese groups (42.5 ± 7.8 years); however, this difference was not statistically significant (p = 0.382), indicating comparable age distribution across groups. Gender distribution was also similar, with males comprising 53.8% in the normal group, 55.6% in the overweight group, and 51.9% in the obese group (p = 0.964), demonstrating no significant difference in sex composition. In contrast, the mean BMI values differed significantly among the three groups, with 22.3 ± 1.4 kg/m² in the normal group, 27.1 ± 1.3 kg/m² in the overweight group, and 32.8 ± 2.1 kg/m² in the obese group (p < 0.001), confirming appropriate categorization of participants based on BMI. Overall, the groups were comparable in terms of age and gender, while BMI showed a statistically significant variation as expected.

Table 1: Demographic Characteristics According to BMI Group

Variable	Normal (n=26)	Overweight (n=27)	Obese (n=27)	p-value
Age (years) (Mean ± SD)	39.4 ± 8.2	41.1 ± 9.0	42.5 ± 7.8	0.382
Male, n (%)	14 (53.8%)	15 (55.6%)	14 (51.9%)	0.964
Female, n (%)	12 (46.2%)	12 (44.4%)	13 (48.1%)	
BMI (kg/m²) (Mean ± SD)	22.3 ± 1.4	27.1 ± 1.3	32.8 ± 2.1	<0.001

Table 2 shows the comparison of induction dose requirements of propofol and fentanyl among normal (n=26), overweight (n=27), and obese (n=27) patients. The mean propofol dose in mg/kg progressively decreased with increasing body mass index, from 2.1 ± 0.3 in normal patients to 1.9 ± 0.2 in overweight and 1.6 ± 0.3 in obese patients, and this difference was highly statistically significant ($p < 0.001$). However, when expressed as total propofol dose in mg, the requirement significantly increased with higher body weight, with values of 118 ± 14 mg in normal, 142 ± 18 mg in overweight, and 168 ± 22 mg in obese individuals ($p < 0.001$). Similarly, the fentanyl dose in µg/kg showed a slight but statistically significant decline across the groups, from 1.8 ± 0.3 in normal patients to 1.7 ± 0.2 in overweight and 1.6 ± 0.3 in obese patients ($p = 0.041$). These findings indicate that while weight-adjusted induction doses decrease with increasing BMI, the absolute total drug requirement increases in overweight" and obese patients.

Table 2: Induction Dose Requirement (Propofol and Fentanyl)				
Variable	**Normal (n=26)**	**Overweight (n=27)**	**Obese (n=27)**	**p-value**
Propofol dose (mg/kg) (Mean ± SD)	2.1 ± 0.3	1.9 ± 0.2	1.6 ± 0.3	<0.001
Total Propofol dose (mg) (Mean ± SD)	118 ± 14	142 ± 18	168 ± 22	<0.001
Fentanyl dose (µg/kg) (Mean ± SD)	1.8 ± 0.3	1.7 ± 0.2	1.6 ± 0.3	0.041

Table 3 "presents the comparison of intraoperative anesthetic consumption among normal (n=26), overweight (n=27), and obese (n=27) patients. The mean duration of anesthesia was slightly higher in overweight (78 ± 17 minutes) and obese (80 ± 18 minutes) groups compared to normal patients (74 ± 15 minutes); however, this difference was not statistically significant ($p = 0.412$), indicating comparable procedural times across groups. In contrast, inhalational agent consumption showed a statistically significant increase with rising body mass index, being lowest in the normal group (16.8 ± 3.2 mL), higher in the overweight group (18.9 ± 3.8 mL), and highest in the obese group (21.4 ± 4.1 mL) ($p < 0.001$), suggesting greater anesthetic requirement in patients with higher BMI. Although the proportion of patients requiring additional opioids was higher in the obese group (44.4%) compared to overweight (29.6%) and normal (23.1%) groups, this difference did not reach statistical significance ($p = 0.168$). Overall, the findings indicate that while duration of anesthesia and additional opioid requirement were comparable, inhalational anesthetic consumption significantly increased with higher BMI.

Table 3: Intraoperative Anesthetic Consumption				
Variable	**Normal (n=26)**	**Overweight (n=27)**	**Obese (n=27)**	**p-value**
Duration of anesthesia (min)	74 ± 15	78 ± 17	80 ± 18	0.412
Inhalational agent consumption (mL)	16.8 ± 3.2	18.9 ± 3.8	21.4 ± 4.1	<0.001
Additional opioid required, n (%)	6 (23.1%)	8 (29.6%)	12 (44.4%)	0.168

Table 4 demonstrates the recovery profile of participants according to BMI categories—normal, overweight, and obese—and reveals a statistically significant prolongation of recovery times with increasing BMI. The mean time to eye opening (T1) was shortest in the normal BMI group (6.2 ± 1.4 minutes), followed by the overweight group (8.1 ± 1.8 minutes), and was longest in the obese group (10.4 ± 2.3 minutes), with a highly significant difference ($p < 0.001$). A similar trend was observed for time to verbal response (T2), where normal-weight individuals responded faster (7.1 ± 1.6 minutes) compared to overweight (9.3 ± 2.1 minutes) and obese participants (12.2 ± 2.5 minutes), again showing strong statistical significance ($p < 0.001$). Furthermore, the time to achieve an Aldrete score ≥9 (T3), indicating readiness for discharge from the recovery area, progressively increased from 11.4 ± 2.2 minutes in the normal group to 14.8 ± 2.6 minutes in the overweight group and 18.6 ± 3.1 minutes in the obese group ($p < 0.001$). Overall, the findings indicate that higher BMI is associated with delayed recovery across all measured parameters.

Table 4: Recovery Profile According to BMI				
Variable	**Normal (n=26)**	**Overweight (n=27)**	**Obese (n=27)**	**p-value**
Time to eye opening (T1) (min)	6.2 ± 1.4	8.1 ± 1.8	10.4 ± 2.3	<0.001
Time to verbal response (T2) (min)	7.1 ± 1.6	9.3 ± 2.1	12.2 ± 2.5	<0.001
Time to Aldrete ≥9 (T3) (min)	11.4 ± 2.2	14.8 ± 2.6	18.6 ± 3.1	<0.001

Table 5 shows a statistically significant correlation between BMI and anesthetic requirement as well as recovery parameters. BMI demonstrated a strong negative correlation with propofol dose per

kilogram ($r = –0.62$, $p < 0.001$), indicating that as BMI increased, the weight-adjusted propofol requirement decreased. In contrast, BMI showed a strong positive correlation with total propofol dose in milligrams ($r = 0.71$, $p < 0.001$) and inhalational anesthetic consumption ($r = 0.65$, $p < 0.001$), suggesting that patients with higher BMI required a greater absolute amount of anesthetic agents. Furthermore, BMI was strongly positively correlated with recovery times, including time to eye opening ($r = 0.74$, $p < 0.001$) and time to achieve an Aldrete score ≥9 ($r = 0.79$, $p < 0.001$), indicating delayed recovery in individuals with higher BMI. Overall, the findings suggest that increasing BMI is associated with higher absolute anesthetic consumption and prolonged recovery despite reduced per kilogram dosing of propofol.

Table 5: Correlation Between BMI and Anesthetic Requirement & Recovery

Variable	Pearson Correlation (r)	p-value
BMI vs Propofol (mg/kg)	-0.62	<0.001
BMI vs Total Propofol dose (mg)	0.71	<0.001
BMI vs Inhalational consumption	0.65	<0.001
BMI vs Time to eye opening	0.74	<0.001
BMI vs Time to Aldrete ≥9	0.79	<0.001

Discussion

The current study shows that rising BMI levels result in longer periods before patients regain consciousness after anesthesia which matches results from earlier research studies. The study by Eger EI II et al. (1997) [11] found that recovery times from volatile anesthetic agents depend on two factors which include tissue solubility and duration of exposure while our research found that recovery times increased as BMI levels rose. The research demonstrated a strong positive connection between BMI levels and recovery times which confirmed the kinetic principle especially in patients who had excess body fat.

Our research results match the findings of La Colla L et al. (2007) study because their work showed that desflurane achieves faster washout and recovery rates than sevoflurane in morbidly obese patients. Our study dedicated its main research effort to BMI as a determining factor but we found that higher BMI values resulted in longer recovery times. The study by La Colla et al. 2007 found that when obese patients received more soluble agents their response times experienced a clinically significant delay which supports our finding that adipose tissue serves as a storage site for lipophilic anesthetics and results in extended recovery periods.

The correlation between BMI and airway reflex recovery described in earlier studies parallels our results regarding delayed functional recovery endpoints. McKay RE et al. (2005) [13] found that airway reflexes returned more rapidly after desflurane than sevoflurane anesthesia, with delayed reflex recovery more pronounced in heavier individuals. The study found that higher BMI groups showed extended time until they reached their first verbal response and achieved Aldrete score, which displayed their need for protective physiological functions to return. The analysis showed a correlation which demonstrated that BMI represents a crucial factor that affects clinical outcomes, regardless of the time patients spent under anesthesia.

Similarly, Lemmens H et al. (2008) [14] reported that obesity modestly affects inhaled anesthetic kinetics but may significantly influence recovery due to altered tissue distribution. Their findings indicated that increased fat mass prolongs elimination time constants, even when differences in uptake appear small. This aligns closely with our results, where inhalational anesthetic consumption increased significantly with BMI despite comparable surgical durations. The increased total anesthetic requirement and delayed recovery in our obese cohort likely reflect similar pharmacokinetic alterations.

With respect to intravenous agents, our finding of reduced weight-adjusted propofol dosing (mg/kg) but increased total dose (mg) with rising BMI is supported by pharmacokinetic principles described by Janmahasatian S et al. (2005) [15], who emphasized the importance of lean body weight as a more accurate dosing scalar in obese patients. Their work demonstrated that total body weight overestimates drug requirement for lipophilic agents, potentially leading to overdosing. Our inverse correlation between BMI and mg/kg propofol dose reinforces the inadequacy of total body weight–based dosing strategies in overweight and obese individuals.

Furthermore, the physiological explanation proposed by Wahrenbrock EA et al. (1974) [16] provides mechanistic support for our findings. They described that the rate of rise and fall of alveolar anesthetic concentration is inversely related to body size due to reduced perfusion and metabolic rate per kilogram in larger individuals. In our study, delayed emergence in higher BMI groups may reflect prolonged tissue time constants and slower redistribution kinetics, consistent with this physiological model.

Importantly, previous clinical observations have demonstrated that obese patients are at increased

risk of early postoperative respiratory events. Rose DK et al. (1994) [17] reported a two- to three-fold higher incidence of critical respiratory events in obese patients during early recovery. Although our study did not specifically measure respiratory complications, the significant prolongation of recovery parameters in higher BMI groups suggests a potential window of vulnerability, emphasizing the clinical relevance of our findings.

In contrast, some earlier studies have suggested that the impact of BMI on inhaled anesthetic kinetics may be modest during short procedures. However, our results indicate that even in surgeries of comparable duration, BMI significantly influenced both total anesthetic consumption and recovery time. This discrepancy may be explained by differences in study design, patient populations, and outcome measures. While kinetic parameters may appear minimally altered, clinically measurable recovery endpoints may still demonstrate significant delays, as seen in our cohort.

Overall, the present study corroborates existing pharmacokinetic and clinical evidence that increasing BMI significantly modifies anesthetic requirements and prolongs recovery. The consistency between our correlation data and previously published findings strengthens the validity of our conclusions. Our results particularly emphasize that while per-kilogram dosing requirements decrease with higher BMI, absolute anesthetic exposure and recovery duration increase substantially. These findings highlight the need for" individualized dosing strategies based on lean body weight and careful postoperative monitoring in obese patients.

Conclusion

The present study demonstrates that increasing BMI significantly influences anesthetic drug requirements and recovery characteristics. Although weight-adjusted propofol and fentanyl doses (mg/kg) decreased with rising BMI, the total absolute anesthetic consumption, including total propofol dose and inhalational agent use, increased significantly in overweight and obese patients. Moreover, recovery parameters—time to eye opening, verbal response, and achievement of Aldrete score ≥9—were markedly prolonged in individuals with higher BMI, showing strong positive correlations. These findings highlight that elevated BMI is associated with greater anesthetic exposure and delayed recovery despite reduced per kilogram dosing. Therefore, anesthetic management should be individualized using appropriate dosing strategies and vigilant monitoring to optimize perioperative safety and recovery outcomes in patients with higher BMI.

References

1. Gurunathan U, Myles PS. Limitations of body mass index as an obesity measure of perioperative risk. BJA: British Journal of Anaesthesia. 2016 Mar 1;116(3):319-21.
2. Brondeel KC, Lakatta AC, Torres GB, Hurley JJ, Kunik IL, Haney KF, Cornett EM, Kaye AD. Physiologic and pharmacologic considerations in morbid obesity and bariatric anesthesia. Saudi journal of anaesthesia. 2022 Jul 1;16(3):306-13.
3. Hebbes CP, Thompson JP. Pharmacokinetics of anaesthetic drugs at extremes of body weight. BJA education. 2018 Dec 1;18(12):364-70.
4. Telessy IG, Buttar HS. Obesity related alterations in pharmacokinetics and pharmacodynamics of drugs: emerging clinical implications in obese patients-part I. Adipobiology. 2018 May 11;9:29-38.
5. Morrish GA, Pai MP, Green B. The effects of obesity on drug pharmacokinetics in humans. Expert opinion on drug metabolism & toxicology. 2011 Jun 1;7(6):697-706.
6. Erstad BL, Barletta JF. Drug dosing in the critically ill obese patient—a focus on sedation, analgesia, and delirium. Critical Care. 2020 Jun 8;24(1):315.
7. Pedoto A. Lung physiology and obesity: anesthetic implications for thoracic procedures. Anesthesiology research and practice. 2012;2012(1):154208.
8. Melesse DY, Denu ZA, Kassahun HG, Agegnehu AF. The incidence of early post-operative hypoxemia and its contributing factors among patients underwent operation under anesthesia at University of Gondar comprehensive and specialized referral hospital, Gondar, North West Ethiopia, 2018. A prospective observational study. International Journal of Surgery Open. 2020 Jan 1;22:38-46.
9. ANASTASIAN ZH, GAUDET JG. 1 Effects of Anesthetics, Operative Pharmacotherapy, and Recovery from Anesthesia. Neurocritical Care Management of the Neurosurgical Patient E-Book. 2017 Jan 20:1.
10. Shariq OA, McKenzie TJ. Obesity-related hypertension: a review of pathophysiology, management, and the role of metabolic surgery. Gland surgery. 2020 Feb;9(1):80.
11. Eger EI, Bowland T, Ionescu P, Laster MJ, Fang Z, Gong D, Sonner J, Weiskopf RB. Recovery and kinetic characteristics of desflurane and sevoflurane in volunteers after 8-h exposure, including kinetics of degradation products. Anesthesiology. 1997 Sep 1;87(3):517-26.
12. La Colla L, Albertin A, La Colla G, Mangano A. Faster wash-out and recovery for desflurane vs sevoflurane in morbidly obese patients when no premedication is used. British journal of anaesthesia. 2007 Sep 1;99(3):353-8.
13. Mckay RE, Large MJ, Balea MC, Mckay WR. Airway reflexes return more rapidly after desflurane anesthesia than after sevoflurane

anesthesia. Anesthesia & Analgesia. 2005 Mar 1;100(3):697-700.
14. Lemmens HJ, Saidman LJ, Eger EI, Laster MJ. Obesity modestly affects inhaled anesthetic kinetics in humans. Anesthesia & Analgesia. 2008 Dec 1;107(6):1864-70.
15. Janmahasatian S, Duffull SB, Ash S, Ward LC, Byrne NM, Green B. A semi-mechanistic model for quantification of lean body weight. Age. 2005 Jan 1;18(82):21-64.
16. Wahrenbrock EA, Eger 2nd EI, Laravuso RB, Maruschak G. Anesthetic uptake--of mice and men (and whales). Anesthesiology. 1974 Jan;40(1):19-23.
17. Rose DK, Cohen MM, Wigglesworth DF, DeBoer DP. Critical respiratory events in the postanesthesia care unit. Patient, surgical, and anesthetic factors. Anesthesiology. 1994 Aug 1;81(2):410-8.