

Anesthesia for Craniotomy Tumor Removal Patient with Morbid Obesity

Dewi Yulianti Bisri¹, Mutivanya Inez Maharani², Tatang Bisri³

¹Doctoral Medical Science, Universitas Padjajaran, Department Anesthesiology and Intensive Care, Faculty of Medicine, Universitas Padjajaran/Dr. Hasan Sadikin General Hospital Bandung-Indonesia. Email: yuliantibisri@yahoo.com

²Specialist Anesthesiology, Medical Science, Universitas Padjajaran, Department Anesthesiology and Intensive Care, Faculty of Medicine, Universitas Jenderal Achmad Yani Cimahi-Bandung/Santosa Hospital Bandung Central-Indonesia. Email: mutivanya@gmail.com

³Doctoral Medical Science, Universitas Padjajaran, Department Anesthesiology and Intensive Care, Faculty of Medicine, Universitas Jenderal Achmad Yani Cimahi-Bandung/Santosa Hospital Bandung Central-Indonesia. Email: tatang.bisri@yahoo.co.id

Abstract

Purpose: Obesity is one of the greatest health challenges in the western world. Obesity is defined as a body mass index (BMI) >30 kg/m², with BMI >35 and >55 kg/m² considered 'morbidly' obese and 'super morbidly' obese, respectively. The aim of this study was to examine anesthetic management for craniotomy tumor removal in patients with morbid obesity. **Design/methodology/data analysis:** This research uses a qualitative descriptive research method with a case study approach of a 39 year old female patient with a body weight of 110 kg, height 160 cm, and body mass index (BMI) 42.9 kg/m², Mallampati score 2, thyromental distance > 3 fingers hospitalized for removal of meningioma. Data collection techniques in this research used literature study, observation and laboratory tests. The data that has been collected is then analyzed descriptively. **Findings:** The results of the study showed that in the operating room, the patient was positioned in a neutral position 300 head up and Ramp. Preoxygenation with 100% O₂ was performed via a face mask. Anesthesia was maintained with continuous intravenous propofol 25-50 µg/kg/min, intravenous rocuronium 40 mg/h, and volatile anesthesia using sevoflurane 0.5-1% vol with oxygen: air at a fraction of 50%. Monitoring during surgery includes evaluation of systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, oxygen saturation, ECG waves, EtCO₂, and urine output. The operation lasted 4 hours in the supine position. Post-surgery patients are then treated in the Intensive Care Unit (ICU) for one day before being transferred to the ward and finally to a regular room. He received treatment for 5 days before being discharged. Problems faced during anesthesia in obese patients are airway management, ventilation, position, drug dosage, presence of comorbidities and post-operative care for recovery from anesthesia and surgery. **Originality/value:** While addressing common challenges encountered during anesthesia in obese patients, this research takes a step further by proposing innovative solutions. The study acknowledges the complexities of airway management, ventilation, positioning, drug dosage, comorbidities, and post-operative care. However, it introduces novel considerations or

techniques to mitigate these challenges, possibly involving emerging technologies or interdisciplinary collaboration for enhanced patient outcomes. Practical implications: The practical implications of this research advocate for a nuanced and individualized approach to anesthetic management in morbidly obese patients undergoing craniotomy tumor removal, fostering improved patient care and safety.

Keywords: Brain tumor removal, morbid obesity, anesthesia.

Obesity is one of the greatest health challenges faced by Western countries. Recent figures suggest that up to 23% of men and 25% of women in the UK are obese. Obesity is defined as a body mass index (BMI) of >30 kg/m², whereas those with a BMI of >35 and >55 kg/m² are considered 'morbidly' obese and 'super morbidly' obese respectively.¹ Obesity is a major health problem affecting every organ system and is associated with various health consequences including an increased risks for coronary artery disease (CAD), dyslipidemia, hypertension, diabetes mellitus (DM), obstructive sleep apnoea (OSA), and socioeconomic and psychosocial impairments.^{1,2} Challenges faced during anaesthesia of patients with obesity undergoing surgeries are in addition to the presence of comorbidities, airway management, ventilation, patient positioning, drug dosing and post-dissection management.¹⁻¹²

The target of anaesthesia brain tumors removal is to prevent the occurrence of secondary brain injuries that can be caused by hypoxia, hypercapnia, anemia, and hypotension. Which is attained through maintaining autoregulation and response to CO₂ and maximizing brain looseness to reduce retraction pressures. ¹³⁻¹⁶

Obesity is associated with a 30% greater chance of difficult or failed intubation. In addition a Mallampati class of ≥ 3 and a neck circumference of ≥ 43 cm are linked to increased risk of difficult intubation. ² If an airway management occurs and the patient falls into a state of hypoxia and hypercarbia, increased in cerebral blood flow (CBF) may ensue due to

cerebral vasodilation and an increase in intracranial pressure (ICP).¹³⁻¹⁶

Induction of anaesthesia becomes important in view of difficulties of airway management with the possibility of difficult ventilation and difficult intubation. Since morbid obesity reflects a higher fat content, anaesthetics low solubility in fat should be the option. The use of intravenous anaesthesia and inhalation anaesthesia of sevoflurane and desflurane can also became an option.²

This paper presents a case study on the anaesthetic treatment of a patient with morbid obesity undergoing surgical removal of meningiomas tumors.

Literature Review

2.1 History

A 39-year-old female patient came in with a chief complaint of severe intermittent headache that started five years ago and become worse with time. There were no signs of increased intracranial pressure or other neurological deficits. The patient has undergone CT-scans and was diagnosed with a supratentorial brain tumor since 2017 but refused to receive therapy. History of previous anaesthesia and surgery was refuted. History of other diseases such as hypertension and diabetes mellitus as well as asthma and allergies to food and medications was also refuted. The patient was then admitted to Santosa Hospital Bandung Central Indonesia.

The problems investigated in this patient were patient condition, evidence of an increased in intracranial pressure (ICP), symptoms of an increase in ICP such as headache, nausea, vomiting, blurred vision, and somnolence. Symptoms of local suppression of the tumour

such as seizures and focal neurological deficits. Location of the tumor, diagnosis of the tumor, therapies given, and the presence of craniotomy history.

2.2 Physical Examination

On physical examination, the patient was found to have a body weight of 110 kg, a height of 160 cm, and a body mass index (BMI) of 42.9 kg/m². The patient was compositis with a blood pressure of 142/80 mmHg, a regular pulse rate of 75 times per minute, a breath rate of 18

times per minute and oxygen saturation of 99% with free air. Patient received a Mallampati score of 2 with normal flexion movements and extensions of the neck and temporomandibular joints, the thyromental distance was > 3 fingers with no wheezing auscultation and ronchi. No neurological deficits were found.

2.3 Laboratory test result

The preoperative laboratory test result are presented in table 1.

Table 1. Laboratory test preoperative

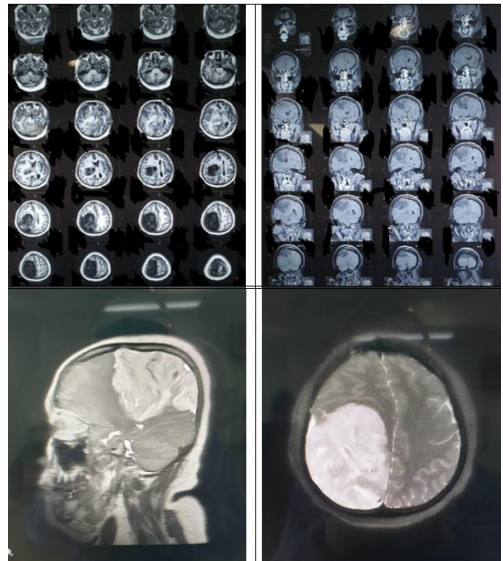
Hb	Ht	Leu	Tr	PT	APTT	INR
14,7	43	16.250	368.000	10,2	21,0	1,00
SGOT	SGPT	BG	Ur	Cr	Na	K
10	22	108	38	0,75	139	4,2

Source: research result

Note: Hb = hemoglobin; Ht = haematocrit; Leu = Leucocyte; Tr = Thrombocyte; PT = Prothrombine time; APTT = activated partial thromboplastine time; INR = international normalized ratio; SGOT = serum glutamic oxaloacetic transaminase; SGPT = serum glutamic pyruvic transaminase; BG = blood glucosa at random; Ur = ureum; Cr = creatinine; Na = natrium/sodium; K = kalium/potassium.

Laboratory examinations revealed leucocytosis with a leucocyte count of 16,250/mm³ while other parameters were within normal limits. On examination of the thoracic photos antero-posterior (AP) normal results were demonstrated and sinus rhythm was observed in the ECG (76 times per minutes). The head CT-scan examination showed a slow progressively growing extra-axial intracranial solid mass of 52 x 72 mm (in 2017), 59 x 76 mm (in 2019), and 69 x 96 mm (in 2022) that urged the cortex with no signs of suspicious invasion and suggestive frontoparietal convectivity meningioma.

The mass effect appeared to biliterate the right cerebral cortical sulci, compressing parenchyma and the left and right lateral ventricle and 3rd ventricles, and causing a midline shift of 15 mm to the left. Suppression of the Monroe foramen led to hydrocephalus with dilation of the left and right lateral ventricles, left uncused herniation, and suppression of the left mesencephalon (figure 1).



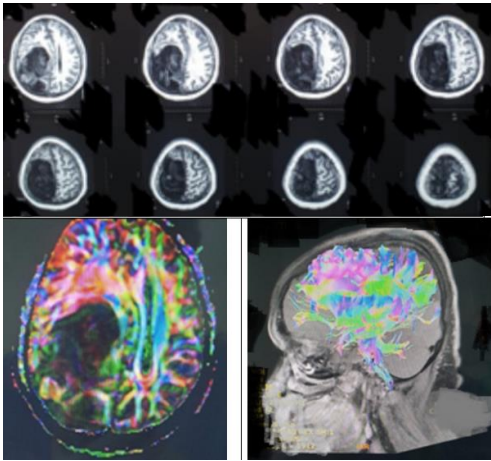


Figure 1. Brain tumor

Source: Documentation of Santosa Hospital Bandung Central Indonesia

The patient was diagnosed with a supratentorial space occupying lesion at the frontoparietal region of the right side caused by suspected meningioma convexity and morbid obesity with ASA III physical status. Patient was then planned for a craniotomy tumor removal procedure.

2.4 Anesthetic management

In the operating theater, the patient was positioned in a neutral 30° head up and Ramp position. Preoxygenation with 100% O₂ was established through a face mask and patient asked to do volunteer hyperventilation. Induction was performed with 150 µg of fentanyl, 200 mg of propofol, and 100 mg of intravenous rocuronium. Intubation was performed using a Macintosh laryngoscope using a spiral endotracheal tube (ETT) size 7.0 with a balloon. Maintenance anaesthesia was established using continuous intravenous propofol 25-50 µg/kg/min, and intravenous rocuronium 40 mg/h, with volatile anaesthesia using sevoflurane 0.5-1% vol with oxygen: air at 50% fraction. Mechanical ventilation was performed with a tidal volume of 600 mL, respiratory rate (RR) 14 times/min. Monitoring during surgery was conducted to evaluate systolic blood

pressure, diastolic, mean arterial pressure, heart rate, peripheral oxygen saturation (SpO₂), ECG, end Tidal CO₂ (EtCO₂), and urine production through a catheter. The amount of bleeding and diuresis was both 1000 cc. Patients received 1500 cc crystalloids, 500 cc colloidal, 200 cc packed red cell (PRC), 55 grams of mannitol and 10 mg of dexamethasone. When the periosteum was opened, the dura did not appear to be tense and when the dura was opened, it demonstrated a slack brain. Tumor masses were found in the right frontoparietal region, white in color and easily bled. A resection of 90% of the tumor was performed. The operation lasted 4 hours in the supination. The vital signs during operation is presented in figure.

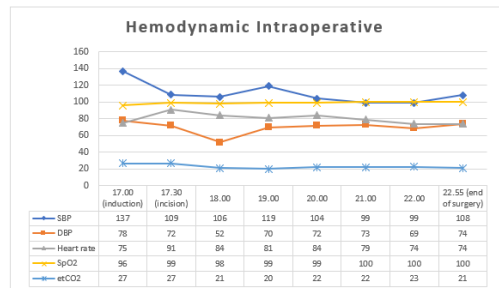


Figure 2. Hemodynamic of blood pressure, mean arterial pressure, pulses, and oxygen saturation during surgery

Source: Research result

Notes: SBP = systolic blood pressure; DBP = diastolic blood pressure. HR = heart rate. SpO₂ = saturation peripheral of oxygen; MAP = mean arterial pressure; etCO₂ = endTidal CO₂

2.5 Postoperative management at ICU

The post-dissected patients was treated in the Intensive Care Unit (ICU) for one day before being transferred to the ward. On the first day in the ICU, the patient was admitted at 23:00 and she was still under ventilator control (pressure control, FiO₂ 50%, RR 14 x/min, P-inspiration 14, PEEP 5 and achieved a tidal volume of 500-520 mL, SpO₂ 98-99%) and weaning was performed gradually until extubation at 07.00 am. While in the ICU the patient received 100

mg meperidine and 100 mg dexametopfen in 50 ml drip 0.9% NaCl with a dose of 2.1 ml/hour and 1 gram/8 hours intravenous paracetamol. Other therapies in the ICU include ceftriaxone, omeprazole, mannitol, and tranexamic acid. In the ICU, the patient was compositentis with a blood pressure of 129/79 mmHg, HR of 67 times/min with regular beating, respiration of 18 times/min, SpO2 99% with nasal cannula of 3 L/min, urine output of 30-50-90 mL/h, diuresis of 0.5 mL/h, and a cumulative balance of + 268 cc/9 hours.

Postoperative laboratory result presented Hb of 11.2, Na of 136, K of 3.9. Analgesics was provided in the form of 100 mg meperidine, 100 mg dexametopfen in 50 ml, 2.1 mL/h and 1 gram paracetamol per in 8 hours. Other therapies compromised of 2 mg/24 hours ceftriaxone iv, 1 g/24 hours citicolin, 10 mg/6 hours dexamethasone, 10 mg/8h vit K, 500 mg/8 hours tranexamic acid, and 100 mg/8 hours phenytoin. After spending one day ICU, the patient is then transferred to a regular room and treated for 5 days before being discharged.

Methods

This research uses a qualitative descriptive research method with a case study approach of a 39 year old female patient with a body weight of 110 kg, height 160 cm, and body mass index (BMI) 42.9 kg/m², Mallampati score 2, thyromental distance > 3 fingers hospitalized for removal of meningioma. The qualitative descriptive research method is a research approach that aims to describe and analyze a phenomenon or event in a detailed and holistic way. Data collection techniques in this research used literature study, observation and laboratory tests. The collected data is then analyzed descriptively to provide a comprehensive picture of the patient's clinical profile as well as factors that can influence the post-operative care and recovery process. This case study approach allows researchers to investigate in detail these specific cases, while descriptive analysis helps in

thoroughly understanding patient characteristics and relevant clinical aspects.

Discussion

On the preoperative visit, pre-dissected examinations were conducted starting from anamnesis, to physical and supporting examination. During the anamnesis, comorbidities, past and present medication, allergies, habits, past surgery and anesthesia history, and STOP-BANG questionnaire base OSA were explored. Physical examination is were conducted by assessing the airway, respiration, circulation, disabilities, environment/temperature, body weight, height, and BMI. As for the supporting examination, routine laboratory test and laboratory test upon indication were performed and indicators of systemic or pulmonary hypertension, ischemic heart disease, and heart failure were also evaluated. ECG testing was also performed to evaluate the possibility of right ventricular hypertrophy, followed by stress echocardiography and cardiopulmonary exercise testing.²

STOP-Bang Questionnaire

1. Snoring: Do you snore loudly (loud enough to be heard through closed door?)
2. Tired: Do you often feel tired, fatigued, or sleepy during day time?
3. Observed: Has anyone observed you stop breathing during your sleep?
4. Blood Pressure: Do you have or are you being treated for high BP?
5. BMI: more than 35 kg/m²?
6. Age: over 50 years old?
7. Neck circumference: > 40 cm
8. Gender: Male?

High Risk OSA: yes to ≥3 question

Low risk OSA: yes <3 question

Figure 3. STOP-Bang Questionnaire
Source: Malhotra G. Miller's Anesthesia, 9th ed;2020.2

As obesity is associated with various chronic medical conditions, preoperative history and physical examinations are crucial. Comorbidities may include respiratory, cardiovascular, endocrine, gastrointestinal, and musculoskeletal disorder, malignancy, and protein, vitamin, iron, and calcium deficiencies. Some drugs may influence anesthetic management and creating problem such as cardiopulmonary and gastrointestinal problems. Thus medication, except insulin and oral anti diabetic (OAD) to be continued until the time of the surgery. 1-5

Obesity is associated with a 30% greater chance of difficult or failed intubation. Mallampati class ≥ 3 and neck circumference ≥ 43 cm are linked to increase risk of difficult intubation. Therefore, it is necessary to assess thyromental distance and rang of movement of the neck and larynx before conducting the anesthesia procedure. The patient in this case study showed no difficulties in ventilation and intubation.3-4

Weight and height measurements are conducted to get the BMI and ideal body weight (IBW) values because controlled ventilation (V_t) is calculated based on "predicted" or IBW, while the dose of anesthetic drugs is administered base on the IBW or lean body weight (LBW), not actual total body weight (TBW). 3-4

Intake of clear fluids and light meals up to 2 and 6 hours, before induction of anesthesia is the common practice for healthy patients. Data from recent studies suggests that there is no difference in residual fluid volume, pH, or gastric emptying rates in obese patients compared to the lean patients. Moreover, in healthy patients, there are no differences in residual gastric fluid volume and pH after drinking clear fluids up to 2 hours before surgery when compared to after overnight fasting. The residual gastric fluid volume and pH also appear to be similar in obese diabetic patients. The fasting formula uses the formula applied for surgery is 2-4-6-8, meaning 2 hours of fasting from clear fluid, 4 hours of fasting from breast milk, 6 hours of fasting from formula milk, and 8 hours of fasting from solid food. 2-4

For intubation in general anesthesia, a large neck circumference and high Mallampati score are the most important parameter. Supine position is not well tolerated by a morbidly obese patients as the posterior cervical fat can exaggerate the flexed position. Therefore, the "stacked" or "ramped position", and preoxygenation at reverse Trendelenburg position is commonly used. The Society for Obesity and Bariatric Anesthesia (SOBA) recommends tracheal intubation for patients with a BMI of > 35 kg/m². 3-4

Another consideration for anesthesia in morbidly obese patient is the possibility of difficult ventilation and difficult intubation that may occurs in patient with a BMI of >35 along with other anatomical findings such as Mallampati score of >3 , neck circumference of > 43 cm, short thyromental distance of < 3 fingers or < 6 cm), a history of snoring or OSA, inability to open the mouth or small mouth opening distance between the upper and lower incisors (< 5 cm), and a short thick neck. In these patients positioning should be done in a way that protect pressure areas because pressure score and neural injury are common, leading to the importance of proper patient positioning is for a safe and efficient surgery. In these patients, a supine position will lead to difficulty in breathing markedly reduced functional residual capacity (FRC) and significant increase in O₂ consumption and cardiac output. The abdominal weight can compress inferior vena cava and aorta, impeding normal blood flow. The Trendelenburg position exacerbates this condition and overweight patient do not tolerate the prone position. 2-4

During ventilation avoid lung overdistention must be avoided and a tidal volume ventilation of 6-8 mL/kg/IBW is use or even smaller for protective lung ventilation and avoiding larger VT and/or high ventilatory pressure. Increasing ventilator rate for excessive hypercapnia and permissive hypercapnia shoulds be considered.3-4

Other common considerations include complaints and signs of the effects of period and increased ICP. Assessment should also be done on possible specific challenges/problems such as intraoperative hemorrhage, seizures, and air embolism. The pathophysiology of increased ICP, brain perfusion and cerebral blood flow, the link between anesthesia and ICP, brain perfusion pressure, CMRO₂, decreased ICP, swelling of the brain and brain pressure should also be well understood. 13-16

The target of anesthesia is to protect the brain from secondary injuries. Morbid obese patients carry additional risk factors for anesthesia including occurrence of hypoxia, hypercapnia, anemia, and hypotension. Hence the anesthetic techniques applied should maintain autoregulation and response to CO₂, maximizing brain slack to reduce retraction pressure. 13-16

It is necessary to conduct pre-dissected neurological evaluations that include from anamnesis, physical examination and radiological examination. The anamnesis assesses the presence of seizures, presence of focal neurological deficits of either motor or sensory deficits and signs of increased ICP such as headache, nausea, vomiting, and blurred vision. The hydration status is assessed by asking about fluid intake and diuretic consumption during anamnesis. Medications taken by the patient should also be listed such as steroids and antiepileptic drugs, along with their adverse effects and accompanying medical conditions. 13-16

The evaluation of presurgical neurological physical examination includes the assessment of the mental status and level of consciousness, as well as evaluation on the presence of papilla edema, Cushing's response (hypertension, bradycardia), pupil size, speech deficit, Glasgow Coma Scale (GCS) score and focal deficit. 13-16

The presurgical neurological evaluation needed by patient with a similar condition of the patient in this case study included CT or MRI-scan to evaluate the size and location of the tumor, i.e whether is it close to large blood

vessels or eloquent areas of the brain, the mass effect of the presence of midline shift, temporal or frontal herniation, basal loss of cerebrospinal fluids (CSF) cisterna, and hydrocephalus. 13-16

Patients with no sign of ICP increase may benefit more from the administration of oral small doses of benzodiazepines as premedication. In this case study patient, the premedication drugs were not given. Instead a psychological approach was conducted during the preoperative visit one day before surgery. 13-16

The recommended induction of anesthesia includes adequate preoperative anxiolysis. Before anesthesia is performed, the ECG monitor, capnograph, pulse oximeter, and non-invasive blood pressure should be installed. Venous pathways and arterial pathways must also be establish under local anesthesia. Preoxygenation is the performed, followed by the provision of fentanyl, 2 mg/kg propofol, and nondepolarizing muscle relaxant. Hyperventilation and then conducted with a target of 35 mmHg PaCO₂ and 1 mg/kg body weight lidocaine was given in 60-90 seconds and half a dose of propofol is also provided before laryngoscopy intubation. After the SBP drops by about 20% from the baseline the intubation is conducted. 13-16

The recommendations for the anesthetic include 0.5-1.5% sevoflurane or 3-6% desflurane, 50-150 mcg/kg/min propofol, and analgesia with fentanyl. When installing the pin holder local anesthesia or additional fentanyl should be given. Patient is positioned with of the head up of 10-20 degrees with a free jugular vein, then 0.5-0.75 g/kg mannitol or lumbar drainage is used to achieve slack brain. The target of fluid administration is normovolemia with isotonic crystalloids (NaCl or balance solution ringerfundin) or 6% HES to replace blood loss. 13-16

To get a slack brain in anesthesia, the chemical brain retractor concept with mild hyperosmolarity is applied. Before lifting the head bone, 0.5-0.75 mg/kg of 20% mannitol or

2-3 mL/kg 7.5% NaCl is administered, followed by mild hyperventilation, adequate head-up position (10-20 degrees), and intravenous anesthesia propofol. The blood pressure should be maintained in normotension or mild hypertension (MAP 100 mmHg), and brain retractors must be avoided. 13-18

Conclusions

The risk of anesthesia and surgery is higher in obese patients than in the normal population

as the induction and maintenance anesthesia and oxygenation, intubation and pain management can be challenging in these patients. There also a higher risk for postoperative complications. Anesthetists must assess these patients comprehensively before the surgery to identify anesthesia-related potential risk factors and prepare for management during the surgery. Patients with high risk for brain tumor surgery in a morbid obese state can be handled properly if good planning and implementation are carried out.

WORKS CITED

- Sabharwal A, Christelis N. Anaesthesia for bariatric surgery. *Continuing Education in Anaesthesia, Critical Care & Pain* 2010 ;10(4):99-103
- Malhotra G, Eckmann DM. Anesthesia for bariatric surgery. In: Gropper MA, Cohen NA, Eriksson LI, Fleisher LA, Leslie K, Wiener-Kronish JP, eds. *Miller's Anesthesia*, 9th ed. Elsevier; 2020,1911
- Brodsky JB. *Anesthesia for Bariatric Surgery*. Stanford University Medical Center Stanford, California. Feb 2018. jbrodsky@stanford.edu.
- Brodsky JB. Recent advances in anesthesia of the obese patients. *F1000Research* 2018,7
- da Silva AC, da Silva KG, Costa TT, de Oliveira Dutra M, de Oliveira AB, de Sousa Silva RM, Tunes RA, de Barros SC, da Costa MG, Araújo WM. The Importance of Preventive Medicine in Reducing Chronic Diseases. *Revista de Gestão Social e Ambiental*. 2024;18(2):e04380-.
- Soleimanpour H, Safari S, Sanaie S, Nazari M, Alavian SM. Anesthetic considerations in patients undergoing bariatric surgery: a review article. *Anesth Pain Med*. 2017 August; 7(4): e57568.
- Stenberg E, Thorell A. Bariatric Surgery. In: Olle Ljungqvist O, Francis NK, Urman RD, eds. *Enhanced Recovery After Surgery*. Springer Nature Switzerland AG; 2020
- Lotia S, Bellamy MC. Anaesthesia and morbid obesity. *BJA education*. *Continuing Education in Anaesthesia Critical Care & Pain* 2008; 8(5):151-56
- Wynn-Hebden A, Bouch DC. Anaesthesia for the obese patient. *BJA Education*, 2020; 20(11): 388e395
- Fyneface-Ogan S, Abam DS, Numbere C. Anaesthetic management of a super morbidly obese patient for total abdominal hysterectomy: a few more lessons to learn. *Afr Health Sci*. 2012 Jun; 12(2): 181-85
- Rooney KD. Obesity & Anesthesia. *WFSA Tutorial outline* 12th October 2007
- Wynn-Hebden A, Bouch DC. Anaesthesia for the obese patient. *BJA Education* 2020; 20(11): 388e395
- Demirel I, Bolat E, Altun AY. Obesity and Anesthesia Management. <http://dx.doi.org/10.5772/65920>
- Bisri DY, Bisri T. *Anesthesia For Brain Tumor Surgery: Supratentorial and Infratentorial*, First ed. Bandung: Medical Faculty, Universitas Padjadjaran; 2016
- Bruder NJ, Ravussin P, Schoettker P. Supratentorial Masses: Anesthetic Considerations. In: Cottrell JE, Patel P, eds. *Cottrell and Patel's NEUROANESTHESIA*. Edinburg: Elsevier; 2017,189
- Bruder NJ, Ravussin PA. Anesthesia for Supratentorial Tumors. In: Niewfield P, Cottrell JE, *Handbook of Neuroanesthesia*, 5th ed, Philadelphia: Wolter Kluwer;2012, 115
- Lemkuil BP, Drummond JC, Patel PM, Lam A. Anesthesia for neurologic surgery and neurointervention. In: Gropper MA, Cohen NA, Eriksson LI, Fleisher LA, Leslie K, Wiener-Kronish JP, eds. *Miller's Anesthesia*, 9th ed. Elsevier; 2020,1868
- Rodrigues MA, Barbosa FC, Lopes GC, Santacrose L, Lopes PC. Intersection Between Spirituality and Neuroscience: Biological Bases of Transcendental Experiences. *Revista de Gestão Social e Ambiental*. 2023 Sep 22;17(9):e04148-.