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A Systematic Analysis On Opioid-Free General Anesthesia Versus Opioid-Based General Anesthesia For Bariatric Surgery

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Abstract

One-third of the American adult population is considered overweight, a figure that is still on the rise. Obesity negatively impacts every organ system in the human body. When minimally invasive strategies such as life style changes fail, bariatric surgery procedures have become the other option. The purpose of this systemic analysis is to look at the outcomes of post-operative pain, post-operative nausea and vomiting (PONV), and the length of stay required in the post-anesthesia care unit (PACU) in obese adults undergoing bariatric surgery using opioid-free general anesthesia compared to opioid-based general anesthesia. The studies included in this systematic analysis conclude that adequate post-operative pain management can be achieved with an opioid-free anesthetic plan or a decrease in opioid use, which in turn allows for extubation to occur in the operating room and less PONV. The length of stay in the PACU has been shown to be inconsistent. Some studies indicate no significant difference, whereas others show a slight decrease in length of stay in the PACU. However, a correlation between less post-operative complications, such as PONV incidences, and a decreased length of stay in the PACU can be seen. The studies are small and the research on the best anesthetic plan for obese patients undergoing bariatric surgery has yet to be established, but what is known is that the use of opioids adversely effects obese patients, and more so than non-obese patients. Many obese patients suffer from obstructive sleep apnea, decreased functional residual capacity and decreased lung compliance. This knowledge coupled with the understanding that this population is more sensitive to the respiratory depressant effects of opioids indicates that an opioid-free anesthetic may provide better post-operative outcomes.

A Literature Review on Opioid-Free General Anesthesia versus Opioid-Based General Anesthesia for Bariatric Surgery

Introduction

Obesity in the United States is an ever-growing epidemic that not only affects every system in the human body, but also has adverse economical and psychological impacts. As a result, obesity does not merely affect the individual alone, but an entire society. With a prevalence of one-third of adults considered to be overweight (not including childhood obesity, which is becoming an epidemic in its own right), more patients are turning to surgery as a solution. In 1992 there were 16,200 bariatric surgical procedures in the United States and by 2008 that number had increased to 220,000 (Schumann, 2010). This paper aims at answering the following question: "In obese adults undergoing bariatric surgery, how does opioid-free general anesthesia compare to opioid-based general anesthesia and its effect on post-operative outcomes in terms of post-operative pain, post-operative nausea and vomiting (PONV), and length of stay in the post-anesthesia care unit (PACU)?"

Bariatric surgery is the last resort for morbidly obese patients who have tried other options, such as diet and exercise, but have fallen short of obtaining their desired health goals. The surgery is safe and effective, but as with any surgery, there are risks involved. Furthermore, the National Institutes of Health (NIH) has put forth very specific criteria that must be met before bariatric surgery is approved. The Obesity Action Coalition (2016) lists the following NIH criteria:

1. Body Mass Index (BMI) greater than 40, severe obesity (or weight greater than 100 pounds over ideal body weight (IBW))

2. BMI 35-40 with significant obesity-related conditions (type two diabetes, high blood pressure, sleep apnea or high cholesterol)
3. No endocrine causes of obesity
4. Acceptable operative risk
5. Understands surgery and risks
6. Absence of drug or alcohol problem
7. No uncontrolled psychological conditions
8. Failed attempts at medical weight-loss (diet, other weight-loss options).

Once the patient has met the required criteria, there are several types of bariatric surgery, which include adjustable gastric band, vertical sleeve gastrectomy, Roux-en-Y, and biliopancreatic diversion with a duodenal switch.

Adjustable gastric banding is an example of a non-metabolic bariatric surgery because the physiology of storing fat is not altered. It involves the placement of a "belt" around the upper part of the stomach, creating a smaller upper pouch that is separated from the rest of the stomach (Ogunnaike & Whitten, 2013). This type of surgery also involves a balloon, which can be filled with fluid to decrease the space within the stomach and create the illusion of feeling full. Although it results in slower weight loss, it avoids the need to cut into the stomach or the intestines. Thus, it is minimal surgery that can most often be accomplished laparoscopically and avoids any complications with vitamin, mineral, and nutritional absorption problems (Obesity Action Coalition, 2016).

The vertical sleeve gastrectomy is a form of metabolic bariatric surgery because the gastrointestinal tract is altered. Most of these surgeries are performed laparoscopically and involve the removal of about 75% of the stomach, leaving a gastric "sleeve" and the intestines

intact (Obesity Action Coalition, 2016). This is classified as metabolic due to a decrease in ghrelin, which is known as the hunger hormone. It is a faster form of weight loss as the patient is able to achieve satiety with a smaller amount of intake, but it's also advantageous in that it does not bypass the intestine. As a result, these patients will not experience malabsorption (Obesity Action Coalition, 2016).

The Roux-en-Y procedure differs in that it works by creating a smaller pouch, which reduces the amount of intake but also allows the patient to achieve satiety sooner because a part of the small intestine is bypassed (Ogunnaike & Whitten, 2013). This type of surgery causes malabsorption and dumping syndrome (Obesity Action Coalition, 2016).

Lastly, biliopancreatic diversion with duodenal switch is usually performed open and involves the removal of two thirds of the stomach, but avoids dumping syndrome by bypassing the pancreatic and the bile drainage (Obesity Action Coalition, 2016). This form of bariatric surgery offers rapid weight loss by increasing the secretion of Glucagon-like peptide-1 (GLP-1), which increases satiety, and by decreasing absorption of fat. As with all bariatric surgeries, a commitment to lifestyle changes needs to be made if the patient is not to regain the lost weight.

The newest form of bariatric surgery is an example of a non-metabolic procedure that involves the implantation of electrodes. This is known as vBLOC neuromodulation therapy. The placement of the electrodes onto the lower stomach aims to block the vagus nerve, resulting in a signaling of feeling full (Obesity Action Coalition, 2016). Weight loss appears to be more gradual and complications seem to be rare. Less than four percent of patients have reported any complications with the device (Obesity Action Coalition, 2016).

The choices in bariatric surgeries are many, but the patient population presents with similar co-morbidities that can pose a challenge for the anesthesia provider. To understand the obese

patient and provide the best and safest anesthesia possible the anesthesia team needs to understand the physiological changes in this population, primarily those involving the cardiovascular system and the respiratory system. However, it is important to cognize that obesity affects every system in the body: gastrointestinal, genitourinary, neurologic, endocrine, hematology, musculoskeletal, as well as psychological effects.

Ogunnaike and Whitten (2013) explain that in an obese patient the total blood volume is increased and so is cardiac output. As a result, left ventricular hypertrophy, reduced compliance, and impaired filling is seen. The anesthesia provider needs to be cautious in preventing intraoperative ventricular failure, which can happen due to fluid overload and as a result of negative inotropy of anesthetic agents. Hypoxia or hypercapnia can also lead to pulmonary hypertension, further compromising the cardiovascular system. Other cardiac complications seen in this patient population include atherosclerosis, coronary artery disease, peripheral vascular disease, systemic hypertension, dysrhythmias, and sudden cardiac death (Ogunnaike &Whitten, 2013).

Respiratory changes include obstructive sleep apnea, obesity-hypoventilation syndrome, asthma, and pulmonary hypertension. Lung compliance is decreased, which leads to a decreased functional residual capacity (FRC), vital capacity, and total lung capacity. The decreased FRC is a result of a decrease in expiratory reserve volume (ERV). If the ERV is reduced, tidal volumes in the lungs are below the closing capacity, which is defined as the volume at which small airways begin to close. Ogunnaike and Whitten (2013) further explain that a decrease in ERV leads to small airway closure, ventilation-perfusion mismatch, right-to-left shunting, and arterial hypoxemia. Combine these physiological changes with anesthesia, which naturally results in a

respiratory depression of about 20% in the non-obese patient and 50% in the obese patient, and it becomes clear why it is necessary to try to prevent any further respiratory complications.

Thompson, Bordi, and Boytim (2011), as with many other researchers, agree that obesity alters the respiratory function and offer insight in non-pharmacological steps that can be helpful in managing this patient population. Due to a reduced FRC and decrease in oxygen reserves, oxygen desaturation during induction can be rapid and atelectasis is a continuous threat. Steps that have shown to help include pre-oxygenation using positive airway pressure and positive end-expiratory pressure (PEEP) along with mechanical ventilation via mask after induction (Thompson et al., 2011). Intra-operatively, the anesthesia provider is working against the effects of the pneumoperitoneum. Interventions, such as PEEP, high tidal volumes, alveolar recruitment, and higher oxygen concentration, have been studied, but no study has shown to be superior. Thompson et al. (2011) recommend the following during the maintenance phase of anesthesia: maintain a FiO2 less than 0.8, provide recruitment breaths using sustained pressure for 8-10 seconds greater or equal to 40 cmH_2O, use PEEP at 10-12 cmH_2O and avoid lung over distension by setting tidal volume at 6-10ml/kg using the patient's ideal body weight (IBW) and maintaining the peak-inspiratory pressure less than 30 cmH_2O. Post-operatively Thompson et al. (2011) recommend that immediately after extubation a continuous positive airway pressure (CPAP) or a bi-level positive airway pressure (BiPAP) should be used, along with elevating the head of the bed, maintaining good pain control, using incentive spirometry, and encouraging early ambulation. The use of opioids makes it more difficult to achieve recovery of respiratory function in this patient population.

Opioids are known to suppress the respiratory system in all patients, but obese patients are more sensitive to the respiratory depressant effect of opioids. Patients may do well intra-

operatively while intubated. However, when the time comes to extubate, research shows that opioid use in the obese patient places the patient at a higher risk of requiring post-operative ventilation in order to avoid hypoxic episodes. Patients receiving opioids are also more sedated in the PACU, making initiatives such as using an incentive spirometer and early ambulation an impossible task. Opioid-free general anesthesia is an alternative option to opioid use, and studies have shown that both techniques achieve the same level of pain control but without the side effects of the latter option.

Opioid-free general anesthesia, as the name indicates, is the avoidance of opioids in pain treatment pre-operatively, intra-operatively, and post-operatively in an attempt to reduce opioid-induced respiratory complications without sacrificing patient comfort. Mulier (2012) identifies some of the reasons to avoid opioids, besides respiratory depression to be: muscle weakness, excessive somnolence, post-operative nausea and vomiting, ileus and constipation, urinary retention, dizziness, obstructive breathing, negative inotropism, and the possibility of tolerance and addiction. Post-operatively, the patient's respiratory system may be too depressed to pass extubation criteria. If able to extubate, early mobilization may be difficult if the patient is too somnolent and experiencing dizziness or PONV, which leads to further complications. Another important benefit to opioid-free general anesthesia includes the prevention of opioid-induced hyperalgesia, which results in increased pain, thus requiring a higher dose of opioid use to adequately control pain. Wound healing can also be impaired, which in a population where diabetes is a co-morbidity, can be devastating (Mulier, 2012). Martin, Koodie, and Krishnan (2010) dedicated their study to describe how chronic morphine use inhibits wound healing by inhibiting immune cell recruitment to the wound. These are all valid reasons why opioids should be avoided in bariatric surgery. Leading this cause is Belgian anesthesiologist, Jan Paul Mulier.

Mulier's opioid-free technique has been referred to as the MuliMix, where one to three of the following techniques are used, as described by anesthesiologist Adrian Sultana (2016), a practicing anesthesiologist in Australia:

1. Sympatholysis, analgesia, and anesthesia (MAC reduction) with dexmedetomidine
2. Analgesia with low-dose ketamine
3. Co-anesthesia and sympatholysis with intravenous lignocaine
4. Profound neuromuscular blockade maintained up to the end of surgery and appropriately reversed
5. 0.7 -1.0 MAC desflurane in oxygen/air titrated to entropy or BIS EEG monitoring
6. Magnesium infusion as a further co-analgesic

Mulier's technique offers a guideline to alternatives to opioid anesthesia, and many anesthesia providers are sharing their modified Mulier's technique, including Sultana (2016). His modified Mulier's technique is as follows:

1. Pre-operatively patients are administered 2-3mg of IV Midazolam and an infusion of 5ug/kg/hr of dexmedetomidine is started.
2. Intubation is performed with 2mg/kg of IBW of Propofol and 1mg/kg IBW of Rocuronium.
3. Maintenance is then started with 0.5-1.0 MAC of Desflurane and 0.5mg/kg/hr of Rocuronium, which is continued for the duration of the pneumoperitoneum.
4. After the peritoneum is insufflated and trocar placement is achieved, dexmedetomidine infusion is decreased to 1ug/kg/hr and further titrated down to 0.5ug/kg/hr, until briefly stopped at the completion of surgery.

5. IV paracetamol and 40mg of parecoxib are also administered, as well as, local anesthetic at the surgical site.
6. Ondansetron and dexamethasone are administered for their antiemetic and adjunctive analgesic effects.

The research behind this technique includes several small studies, all of which have shown that patients receiving non-opioid analgesia, such as that of the MuliMix, fare better than those treated with opioid anesthesia.

The research into non-opioid anesthesia has brought dexmedetomidine, ketamine, lidocaine, magnesium, clonidine, and ketorolac into the forefront as alternative non-opioid anesthesia adjuncts. The mechanism of action of these adjuncts differs from one another, thus providing pain management by targeting multiple sites in the pain pathway. The ideal combination of these adjuncts may not be perfected at this time, but understanding the mechanism of action helps the anesthesia provider utilize such drugs to their full potential.

Dexmedetomidine is a central alpha-2 adrenergic agonist, which binds to the G-protein and inhibits the L-type calcium channels. Based on the location of the receptor, it can either result in sedation if in the locus ceruleus, or provide analgesia if in the spinal cord. The cardiovascular system is affected in one of two ways: decrease of tachycardia by inhibiting the cardioaccelerator nerve or causing bradycardia via a vagomimetic action (Kaur & Singh, 2011). Gaszynski, Czarnik, Laszinski, and Gaszynski (2016) randomly assigned forty-two patients undergoing bariatric surgery into either a low-opioid group using dexmedetomidine or a fentanyl-based anesthetic group. The researchers concluded that dexmedetomidine provided greater hemodynamic stability when compared to those patients intubated using fentanyl, while providing equal analgesia. The added benefit to using dexmedetomidine is no respiratory

depression, which is a major concern in the obese population. Post-operatively, patients who are continued on dexmedetomidine, even as ICU patients, appear to be sedated, but are easily aroused. These patients see as much as a 50% reduction in opioid use (Hofer et al., 2005).

Ketamine is also a non-respiratory depressant adjunct. It is an N-methyl-D-aspartate (NMDA) antagonist, which is the receptor responsible for the excitatory neurotransmitter glutamate. Some reports indicate that fentanyl can activate NMDA, causing an increase in pain sensitivity, but a low dose of ketamine can block this effect. It is important to cognize that high doses of ketamine can cause cardiovascular side effects and nightmares; thus, clonidine, an alpha-2 agonist, is recommended in conjunction with ketamine. Magnesium works on the same NMDA receptor, but in a different mechanism than ketamine; thus, the combination of the two is better than one over the other (Feld et al., 2003). Chan and Shetty (2016) looked at the relationship of ketamine and magnesium by comparing forty-four obese patients undergoing bariatric surgery. All patients received: intravenous acetaminophen, a short acting opiate (either remifentanil or fentanyl), a long acting opiate (either morphine or buprenorphine). The port sites were also infiltrated with a local anesthetic. The difference was that nine of the forty-four patients received only ketamine, five patients received only magnesium, whereas thirty patients received both ketamine and magnesium. The study concluded that rescue analgesia in the PACU was administered to 56.8% of the patients that received both ketamine and magnesium, whereas either ketamine or magnesium treated patients required rescue analgesia at a 71.4% rate. The study does have a small population sample, but the results indicate that although both ketamine and magnesium are helpful in pain management, the two adjuncts together appear to provide better pain control.

Lidocaine can be another important adjunct in opioid-free general anesthesia due to its ability to inhibit cytokine activity and inflammation in the intestines. The use of lidocaine results in decreased bowel recovery time, decreased post-operative pain and a decrease in hospital stay (Feld et al., 2003). There have been numerous studies on lidocaine used for pain management. De Oliveira, Duncan, and Fitzgerald (2014) performed a randomized, double-blinded placebo-controlled clinical trial to specifically assess pain control in patients undergoing bariatric surgery. Fifty patients were randomly divided into two groups. Group one received a lidocaine bolus administration of 1.5mg/kg, which was then followed by a 2mg/kg/h infusion intra-operatively. Group two was the control group, which received normal saline. The lidocaine group experienced a lower consumption of intravenous morphine than the control group, thus indicating that systemic lidocaine is an effective adjunct in pain management.

Ketorolac, a potent non-steroidal anti-inflammatory drug (NSAID), is yet another adjunct. When compared to opioid treated patients, patients on ketorolac experience less PONV, similar post-operative pain relief as that of fentanyl, less sedation, earlier bowel function, a decrease in hospital stay, and longer acting pain relief than morphine (Feld et al., 2003). Surgeons prefer to not use ketorolac in the bariatric population due to increased risk of gastric bleeding, but it is an option in the appropriate patient.

Literature Review

Feld, Laurito, and Beckerman (2003) randomized thirty obese patients undergoing gastric bypass into two groups: one receiving sevoflurane and fentanyl and the other receiving a sevoflurane and non-opioid regimen. The non-opioid regimen included ketorolac 30mg at the beginning and the end of the case, clonidine 300-500mcg within the first hour of anesthesia start, lidocaine 100mg bolus with induction and then 4mg.min-^{1} for the first hour, 3mg.min^{-1} for the

second hour, 2mg.min^{-1} until the end of the surgery, ketamine 0.17mg/kg with a maximum dose of 1mg/kg, magnesium sulfate 80mg/kg administered with IV fluids, and methylprednisolone 60mg bolus administered in the holding area. All calculations are based on the patient's ideal body weight (IBW). The data gathered by this study indicated that non-opioid analgesia provided adequate intra-operative pain relief and those in the non-opioid group required less morphine in the PACU. Also, the pain scores, measured by the visual analogue scale (VAS), were the same within the two groups. Another benefit seen was less sedation in the non-opioid group, which equated to less time spent in the PACU. Extubation was achieved on all fifteen non-opioid anesthesia patients, whereas two of the patients in the fentanyl group remained intubated in the PACU. Satisfaction was also measured by VAS and showed that the non-opioid group had higher satisfaction levels than the opioid group.

Monsour, Mahmoud, and Geddawy (2013) present their study, which included 28 patients randomly divided between the opioid and non-opioid group. Both groups received the following cocktail: ranitidine 50mg (H_2 receptor antagonist), metoclopramide 10mg IV and dexamethasone 8mg IV for PONV prevention, and midazolam 10mg PO for sedation. Induction in the non-opioid group was performed with propofol 2mg/kg, ketamine 0.5mg/kg, and rocuronium 0.5mg/kg. The same induction was performed in the opioid group with the exception of ketamine, which was replaced with fentanyl 2-5mcg/kg. Both groups were maintained with sevoflurane and ketamine or fentanyl infusion respectively. Post-operatively, the non-opioid group was treated with paracetamol, diclofenac, and tramadol, whereas the opioid group received paracetamol and fentanyl. Both groups had orders for emergent morphine 2-4mg every 2 hours as needed. The results of this study showed that not only were there no differences in heart rate, mean arterial pressure, O_2 sat, and end-tidal CO_2, but pain scores and nurse satisfaction were

better within the non-opioid group than its counterpart. A side effect experienced by the non-opioid group that was not seen in the opioid group were hallucinations. This, however, only occurred in 7.14% of the patients.

Lam and Mui (2016) applied a multimodal analgesia model in their bariatric patients, which included premedication with pantoprazole 40mg the night before and 2g PO paracetamol and 150mg or 300mg of PO pregabalin (depending on the BMI) two hours before surgery. Once in the operating room, 1-2mg of midazolam was administered; then a dexmedetomidine infusion was started at 0.2mcg/kg/hr based on the patient's lean body weight (LBW). Induction included the use of 100mcg of fentanyl, propofol, and either suxamethonium or rocuronium. After intubation was achieved, a loading dose of ketamine based on the patient's LBW was administered at a dose of 0.3mg/kg/hr. Parecoxib 40mg, tramadol 100mg, dexamethasone 8mg, and tropisetron 5mg were also administered after intubation. A rocuronium drip was titrated to maintain one twitch on a train-of-four and desflurane was titrated to maintain a Bispectral Index (BIS) value of 40-60. Once closing began, the dexmedetomidine was decreased to 0.1mcg/kg/hr then turned off when closure was completed. Once in the PACU, patients were observed for a minimal time of 30 minutes and rescue pain and PONV management was available as needed. Of the 30 patients that participated in this study, 14 (46.7%) required no further interventions in the PACU. Six (20%) patients were given rescue analgesia, but none after PACU discharge, whereas 10 (33.3%) patients were given rescue analgesia in the PACU and while on the floor. There was no control group in this study, thus making it difficult to compare the results; nonetheless this study is an important prospective observational case series that is able to demonstrate that about half of the patients did not require any further opioid use. It is also important to note that all 30 patients were able to be extubated prior to their arrival in the PACU. Again, Lam and Mui (2016)

do not provide any data that can demonstrate a reduction in respiratory complications, but it is a well-known fact that opioids have a respiratory depressant effect and that morbidly obese patients are more susceptible. Lam and Mui refer to the Taylor et al. study, which concludes that "the use of opioids per se is a risk factor for respiratory events in the first 24 hours after surgery" (2016, p. 431). The Ahmad et al. study is also referred by Lam and Mui. In the Ahmad et al. study 40 morbidly obese patients underwent laparoscopic bariatric surgery. Their anesthetic included desflurane and a remifentanil and morphine administration, which resulted in common hypoxic episodes in the first 24 hours. Of the 40 participants, 14 had more than five hypoxic episodes per hour (2016).

Hofer, Sprung, Sarr, and Wedel (2005) presented a case study of a 42-year-old male who is morbidly obese (433kg) presenting for bariatric surgery. His comorbidities included obstructive sleep apnea, pulmonary hypertension, lower extremity lymphedema, and gastroesophageal reflux. Arterial blood gas was obtained and the results were as follows: pH 7.39, PaO_2 69 mmHg, SaO_2 91%, bicarbonate 30mEq, and $PaCO_2$ 51 mmHg, and a pulmonary function test that indicated a severe restrictive pattern. The patient's intra-operative pain was strictly treated with dexmedetomidine. Post-operatively the patient was transferred to the ICU and remained intubated overnight due to not meeting extubation criteria, which he did meet two hours later, but the decision was made to leave the patient intubated overnight. Once extubated, the patient's opioid requirements were less, indicating that opioid-free anesthesia is an effective alternative pain relief while avoiding opioid-induced respiratory depression.

A study by Bakhamees, El-Halafawy and El-Kerdawy (2007) showed the same results as that of Hofer's et al. study, but in a larger pool of participants who were scheduled for elective laparoscopic Roux-en-Y. Eighty patients were divided into two groups of forty. One group

received dexmedetomidine, whereas the second group received a placebo. Intraoperatively the dexmedetomidine treated group required less fentanyl and propofol, and post operatively less pain was reported when compared to the placebo group.

Ziemann-Gimmel, Goldfarb, Koppman, and Marema (2014) looked at PONV in bariatric surgery using opioid-free total intravenous anesthesia. It is well known that this patient population is at an increased risk of PONV, even with the administration of dexamethasone, ondansetron and a scopolamine patch. The anesthetic plan in this randomized, parallel group, single center study included a premedication with 2-4mg of midazolam. Induction was performed using propofol and either succinylcholine or rocuronium in both groups. They also received 1,000 mg of acetaminophen intravascularly 20 minutes after induction and 30 mg of ketorolac 20 minutes before emergence. The classic group received fentanyl (0.5-1 mcg/kg) during induction, and general anesthesia was maintained with either sevoflurane or desflurane. Opioids, including fentanyl, morphine, or hydromorphone, were given intra-operative at the provider's judgment. In the TIVA group, a loading dose of dexmedetomidine (0.5 mcg/kg) was administered and then a drip was started at 0.1-0.3 mcg/kg, along with an infusion of propofol at 75-150 mcg/kg. The latter group had a BIS monitor on and drips were titrated to a BIS reading between 40 and 60. The study concluded that there was no significant difference in pain, indicating that a patient's pain can be managed without the use of any opioids. The PACU length of stay was also insignificant between the two groups, but there was a drastic improvement in PONV in the TIVA group when compared to the classic group. Of the 119 participants, 42.7% required antiemetic rescue treatment, despite the use of Decadron, Zofran and a scopolamine patch. Twenty-two of these patients were in the classic group versus twelve patients in the TIVA group. The former also experienced more retching. Overall, Ziemann-Gimmel, Goldfarb,

Koppman, and Marema (2014) report a 17.3% decrease in PONV and a decrease in severity of PONV.

Discussion

All of the studies indicate that post-operative pain management can be reached without any or a reduced amount of opioids, but without the opioid side effects. This aids in less PONV episodes and less complications from surgery, which can result in a decrease in length of stay in the PACU. The latter can be debated, as some studies have shown no statistical significance in the length of recovery in the PACU between opioid-free general anesthesia and opioid-based general anesthesia. What is well known, however, is that the respiratory function in obese patients is already compromised, thus making it imperative to avoid any further decrease in respiratory compliance. It is fair to extrapolate that less complications will result in less time spent in the PACU. The greatest limitation to these studies is sample size. Most of the studies have a small sample population, which can alter the results. Larger studies would be helpful in determining a set protocol, and more studies would help to create a greater database. Another important limitation is the inconsistency between studies, whether it is medications used, measuring tools, or length of observation in the PACU. Perhaps looking at the hospital length of stay, rather than only the recovery time in the PACU, might be a better indicator. The PACU recovery time can be dependent on different factors, such as bed availability or hospital policies. However, even with the various limitations for the obese patients undergoing bariatric surgery, the best and safest anesthesia seems to point to an opioid-free anesthesia plan.

Conclusion

Anesthesia providers are well versed in the complications that arise from bariatric surgery and the co-morbidities that obese patients present with. Understanding the pathophysiology of

the obese patients is imperative, but moving forward, improving the safety of anesthesia provided to this unique population needs to be further addressed. Using existing research, medications such as dexmedetomidine, ketamine, lidocaine, magnesium, and ketorolac have shown to be effective pain management alternatives to opioids. Anesthesia providers, such as Mulier and Sultana, extrapolated these results into bariatric surgery and reported better post-operative outcomes. The literature review conducted in this systematic analysis further indicates that pain in the obese patient can be managed with an opioid-free anesthetic plan, while avoiding opioid-induced complications. Opioid-free anesthesia might be the solution and the future of anesthesia management of the obese patient undergoing bariatric surgery, but more evidence-based research is needed in order to change the practice of anesthesia.

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