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Review Article

Perioperative Management of Morbidly Obese Patients during Major Abdominal Surgery

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ABSTRACT

The population with obesity is seeing a steady increase globally. Obesity is known to be associated with morbidity and mortality after major abdominal surgery, and this correlation becomes more prominent in morbidly obese (MO) patients. Accordingly, adequate preoperative evaluation and preparation should be performed with an understanding of the pathophysiological changes associated with the MO. Precise surgery and adequate postoperative management are also mandatory to reduce complications and unplanned readmissions. However, adequate guidelines for the perioperative management of MO patients undergoing major abdominal surgery are lacking. We provide an overview of the pathophysiologic changes and practical guidelines on the perioperative management of major abdominal surgery in MO patients.

Keywords: Obesity; Preoperative care; Surgery

INTRODUCTION

Obesity has attained epidemic status, with at least 2.8 million deaths attributable to overweight or obesity annually. In 2014, more than 1.9 billion adults (≥18 years of age) were overweight worldwide, while over 600 million were obese [1].

Body weight can be classified into different categories, ranging from underweight to morbidly obese (MO), according to body mass index (BMI). BMI is calculated by dividing the total body weight (TBW) in kilograms by the square of the height in meters. MO patients have a BMI≥40 kg/m^2.

Obesity is a well-established risk factor for hypertension, cardiovascular diseases, diabetes, hyperlipidemia, osteoarthritis, and several cancers including colon, endometrium, breast, and ovary [2]. MO patients are at a higher risk of developing these co-morbidities. In surgical patients, obesity was associated with increased perioperative morbidity, and MO was a risk factor for mortality [3].

We recently performed a pylorus-preserving pancreaticoduodenectomy (PPPD) in a 67-year-old man from Mongolia with recurrent ampulla of Vater (AoV) cancer and morbid obesity (height, 176 cm; weight, 160 kg; BMI, 51.7 kg/m^2). The patient initially underwent a trans-duodenal ampullectomy for localized AoV cancer at other hospital; however, local recurrence developed 8 months later. We believed that performing PPPD as a definite treatment right away should be risky because of his MO. Therefore, we encouraged him to lose weight by diet control and exercise for 1 month (weight, 148.3 kg; BMI, 47.8 kg/m^2). We considered the proper perioperative management components such as ventilator care, optimal fluid or drug dose, a positioning bed on which the patient was able to be placed during surgery, and even a stretcher cart. These considerations were unfamiliar and difficult to us because such a severe obese patient with cancer was the first time in our institution. Nevertheless, we

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performed the PPPD with careful dissection to avoid bleeding and transfusion, and the patient was discharged on the 31st postoperative day without any serious complications. The patient is now doing well without any recurrence for 36 months (weight, 126.6 kg; BMI, 40.8 kg/m^2). Because these MO patients are unaccustomed in clinical practice, herein, we provide the overview of the pathophysiologic changes and the guidelines of perioperative managements of major abdominal surgery in the MO patients.

FUNCTIONAL AND PATHOPHYSIOLOGIC CHANGES IN MORBIDLY OBESE PATIENTS

1. Cardiovascular changes

Obesity contributes to hemodynamic alterations predisposing to alterations in cardiac morphology and ventricular function, which increase the stroke volume and cardiac output (CO) but decrease systemic vascular resistance (SVR) [4,5]. Ultimately, obesity adversely affects the cardiovascular structure and leads to left ventricular hypertrophy (LVH) as well as left ventricular (LV) systolic and diastolic dysfunction. Furthermore, these changes worsen as the magnitude of obesity increases [6]. Previous studies demonstrated LV enlargement (40% of participants), left atrial enlargement (50% of participants), and increased thickening of the LV wall (56% of participants) in MO patients [4,7]. The prevalence of heart failure (HF) also likely increases in obese patients. The major reason for this is that increased CO attributed to the increased blood volume may lead to elevated filling pressures, which eventually cause adverse remodeling of both cardiac function and structure [8]. Moreover, increased CO may cause the right ventricular hypertrophy and enlargement, which may result in right ventricular failure [4]. Based on these mechanisms, weight reduction may benefit cardiac function, but limited data are available to support the effect of intentional weight loss in patients with HF [9].

2. Respiratory changes

Increased abdominal pressure may result from increased abdominal and visceral adipose tissue deposition [10]. For this reason, the chest capacity of the MO patient is reduced due to the diaphragm compressed cranially compared to a non-obese patient. Since pulmonary compliance decreases in MO patients, the functional residual capacity (FRC) also decreases while the work of breathing (WOB) increases. Moreover, oxygen consumption in MO patients is 1.5-times higher than that in non-obese patients; therefore, sufficient oxygenation could be more difficult in MO patients [11]. Obese patients can also produce excessive carbon dioxide because of increased oxygen consumption. Biring et al. [12] showed that MO was associated with reduced forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1). In another study, the obese group (BMI, 39±6 kg/m^2) had a significantly lower mean maximal inspiratory pressure than the control group (BMI, 23±3 kg/m^2) [13]. Therefore, these functional impairments are more likely to develop as rapid shallow breathing in the MO patient, resulting in respiratory failure. This typical pattern was also confirmed in previous studies involving obese patients [14,15]. Consequently, postoperative atelectasis frequently develops in MO patients.

Sleep-disordered breathing often occurs in an obese patient. This condition ranges from obstructive sleep apnea (OSA) to obesity hypoventilation syndrome (OHS). OSA correlates with the incidence of postoperative desaturation, respiratory failure, and cardiac events [16]. When it is confirmed preoperatively using polysomnography or overnight oximetry testing, proper treatment with continuous positive airway pressure (CPAP) can reduce the risk of complications [17]. In addition to these tests, the loud Snoring, Tiredness, Observed apnea, high blood Pressure (STOP)-Body mass index, Age, Neck circumference and Gender (BANG) score was validated for detecting OSA in obese surgical patients [18]. When OSA remains untreated, it may progress to OHS, which is defined as a state of combined obesity (BMI ≥30 kg/m^2), daytime hypercapnia ($PaCO_2$ >45 mmHg), and disordered breathing during sleep (after the exclusion of other disorders that might cause alveolar hypoventilation) [19].

3. Pharmacologic changes

Obesity affects physiobiological factors such as plasma proteins, drug metabolizing enzymes, drug transporters, and blood flow that are known to determine drug absorption, distribution, metabolism, and excretion [20]. First, regarding absorption, the increased splanchnic blood flow in obese patients may enhance oral drug absorption [21]. However, few studies in obese patients reported increased oral drug absorption. Although CO increases in an obese patient, the blood flow rate per gram of fat tissue is significantly lower than that of a non-obese subject, which may delay the absorption of a subcutaneously administered drug [22]. Second, the distribution in an obese patient mostly relies on the drug's lipophilicity. Lipophilic drugs tend to distribute into fat tissue, whereas hydrophilic drugs distribute into lean body tissue [23]. Moreover, serum protein concentrations and drug–protein affinities can be affected by obesity. The plasma fraction of drugs binding to albumin is not altered in obesity [24], while that of drugs binding to α_1-acid glycoprotein correlated with obesity can be affected [25]. Third, histopathologic changes in the liver (fibrosis, cirrhosis, fat infiltration) and alterations in cytochrome activity can be caused by obesity and may affect drug metabolizing enzymes [26,27]. Phase I cytochrome P450 (CYPs)–mediated drug metabolism (oxidation, reduction, hydrolysis) are usually increased or unchanged, while the metabolism of drugs through phase II reactions (glucuronidation, acetylation, methylation, and sulfation) is mostly increased in obesity [28]. Moreover, previous studies showed that plasma fatty acid could affect various nuclear receptors, transcription factors, and membrane compositions of the endoplasmic reticulum (ER), leading to modulate the expression and catalytic function of CYPs [29]. Finally, obese patients have a higher creatinine clearance (CrCl) than non-obese patients [30]. Bauer et al. [31] showed that the CrCl of vancomycin in MO patients increased with body weight. Increases in the number or size of nephrons and blood flow to the kidney were suggested as possible reasons [32]; however, the exact cause of the increased clearance is unknown. For these reasons, a "one size fits all" dosing strategy according to drug type in obese patients may cause problems such as antibiotic treatment failure; thus, the proper dose should be considered. Although the dose of cephalosporins commonly used in surgical prophylaxis remains controversial, the higher doses based on body weight and dose in the upper limit of the normal range seems adequate for obese patients [33]. Among the penicillins, piperacillin/tazobactam has been extensively used in patients undergoing hepatobiliary pancreatic surgery. High-dose prolonged piperacillin/tazobactam infusion (4.5 g every 8 hours) is suggested because of increased distribution and clearance in obese patients [33]. A consistent initial dosing of vancomycin in obese patients could be the loading dose to 20~25 mg per TBW and be adjusted according to therapeutic drug monitoring [34].

4. Thromboembolism

Obesity is a prothrombotic state that increases morbidity and mortality owing to the development of myocardial infarction, stroke, and venous thromboembolism (VTE) [35-37]. The risk of VTE increases progressively with BMI in obese women compared to their non-obese counterparts [35]. Among the myriad of metabolic abnormalities related to obesity, chronic inflammation and impaired fibrinolysis are considered responsible for obesity-induced thrombosis [38]. Therefore more intensive perioperative anti-thromboembolic management should be considered for the MO patients.

PERIOPERATIVE MANAGEMENT

1. Preoperative management

The importance of the perioperative evaluation and management of MO patients has been emphasized because of the increasing morbidity and mortality associated with functional status and comorbidities such as hypertension, diabetes, dyslipidemia, and cardiovascular disease [3,39]. For this reason, the preoperative evaluation should be preceded by a comprehensive history-taking, physical examination, assessment of functional capacity, and laboratory test to assess the surgical risk. Moreover, this process should be performed with a multidisciplinary approach consisting of surgeons, anesthesiologists, nurses, and other healthcare providers. The anesthesia assessment can be completed with the experienced anesthesiologist for intra- and postoperative management. Nurses perform the admission assessment for patient BMI and skin care. Other healthcare providers including dietitians/nutritionists and exercise program specialist assess the nutritional status and physical condition and educate the patients about healthy eating habits and patient-specific exercise. The MO patient's weight and calculated BMI should be followed regularly since it is helpful to adjust the operation date and ensure the suitable patient's gowns and types of equipment such as operation room bed, stretchers, and big and long operative instruments. It is necessary to arrange the additional personnel when positioning and transporting the patient to avoid accidents. It is beneficial to preoperatively estimate IBW, lean body weight, and adjusted body weight to help with calculations of medication doses and fluid amounts.

1) Cardiovascular system

Preoperative risk factors for coronary artery disease including diabetes, hypertension, dyslipidemia, inflammation, and a hypercoagulable state are fully evaluated. A patient's functional status can be deduced from his ability to perform daily activities because the increased cardiorespiratory fitness (established by metabolic equivalents [METs]) decreases the risk of major adverse cardiac events (MACEs) [40]. For patients with elevated cardiac risk and poor or unknown functional capacity, exercise testing and cardiac imaging are adequate assessment options [41]. However, under the weight limitations of diagnostic equipment, the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) Risk Index, estimating cardiac risk, can identify patients at high risk of major cardiac complications [18]. Echocardiography could be necessary to detect the hypertrophic and dilated cardiomyopathy as well as valvular heart disease.

2) Respiratory system

All patients should stop smoking and use incentive spirometry before and after surgery. MO patients with confirmed or suspected OSA should initiate CPAP preoperatively to improve or optimize their perioperative physical status [42]. The observational study showed that the preoperative CPAP could contribute to a lower risk of severe postoperative complications (cardiac events, respiratory failure, urgent respiratory support) [43]. The airway, nasopharyngeal anatomy, neck circumference, and tongue volume should be examined for cases that involve difficult and failing intubation.

3) Weight control

The use of very-low-energy diets (VLED) is common in obese patients before bariatric surgery since it provides rapid weight loss without compromising immune function or wound healing [44-46]. A VLED includes the ingestion of 3 shakes/day of a commercial product formulating very-low-calorie diet (456 kcal) with 52 g protein, 7 g fat, and 45 g carbohydrate plus the recommended daily intake of vitamins, minerals, and trace elements for 12 weeks [47,48]. The intake of low-starch vegetables (up to 250 g) and ≥2 L/day of

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water or other calorie-free beverages is encouraged to ensure that the total calorie intake ranges from 456~680 kcal/day. Rapid weight loss reduces liver volume and facilitates access to the stomach and esophageal hiatus, thereby improving the technical ease of bariatric surgery [48,49]. This concept has been broadened into other surgical specialties, including other upper abdominal operations, colorectal surgery, and cardiac procedures [50]. However, this is not a consistent finding in the literature and requires further validation.

There is also extensive knowledge that exercise can improve cardiopulmonary function, physical fitness, and quality of life (QoL) [51]. Previous reviews reported that exercise could reduce patient weight by 1.5~3.5 kg [52,53]. The exercise program for MO patients can include daily routine activities, such as brisk walking or cycling, walking a certain number of steps each day or climbing stairs. Although most studies appraising exercise intensity in obese patients described bariatric surgery, the effective exercise program for weight loss could be achieved with a median intensity of 65% of peak heart rate or the maximum rate of oxygen consumption (VO_{2max}) with at least partial supervision for a median of 12 weeks [54]. With preoperative diet and exercise, more than 5%~10% of weight loss is recommended for MO patients waiting for major abdominal operation. However for cancer patients, 3 months interval may be harmful due to the possibility of disease progression. The optimal program for MO patients depends on the patient's physical ability and disease status.

4) Antibiotic prophylaxis

A 2-g dose of prophylactic cefazolin at the time of anesthesia induction has been suggested without adjustment for weight [55]. Due to insufficient high-level evidence, the optimal dosing of antibiotic-related prophylaxis in obese patients remains challenging.

5) Thromboprophylaxis

Patients with a history of deep vein thrombosis should undergo a diagnostic evaluation for it [41]. The use of a prophylactic vena cava filter may present a greater risk than benefit due to filter-related thrombosis [56]. Thus, prophylactic pharmaceuticals are the mainstay of preventing VTE in obese patients according to the following criteria: prolonged immobilization; total operation time >90 min; age >60 years; BMI >30 kg/m^2; cancer; dehydration; and a family history of VTE [56]. The American Society of Hematology guideline suggests dose selection of low molecular weight heparin (LMWH) based on TBW rather than a fixed maximum daily dose for obese patients [57].

2. Intraoperative management

Intraoperative considerations during major abdominal surgery for MO patients encompass proper positioning, intravenous or central line placement, monitoring, and pertinent anesthesia. Airway management, fluid administration, and the prevention of thrombotic complications, pressure sores, and peripheral nerve injuries remain challenging. Additionally, abdominal surgery for obese patients often leads to poor outcomes. In colorectal surgery, obesity can make it difficult to identify the surgical planes and increase the rate of conversion from minimally invasive to open surgery [58]. House et al. [59] showed that obese patients who underwent PPPD were more likely to have pancreatic fistula and wound infection than non-obese patients. Therefore, major abdominal surgery in MO patients is technically demanding.

1) Induction of general anesthesia and preparation

The patient should be placed in a ramping position with the tragus of the ear level with the sternum and the arms away from the chest to aid with oxygenation and ventilation. This position has been recommended as the default position during induction for MO patients owing to the improved view at laryngoscopy [60]. Experienced anesthesiologists are likely to prevent adverse events in these patients. Ideal body weight (IBW) should be used to determine endotracheal tube size and calculate the tidal volume during mechanical ventilation. The formula for calculating IBW is as follows: IBW (kg)=height (cm)–100 for a man and height (cm)–110 for a woman [61]. In MO patients, the optimal tidal volume should be calculated by the IBW, not by current body weight to avoid airway trauma. Tidal volume for MO patients is 6~8 mL/kg IBW with a Positive end-expiratory pressure (PEEP of 10 cmH_2O to avoid atelectasis. PEEP and a recruitment maneuver can prevent intra- or postoperative atelectasis. Given an obese patient's decreased FRC, the PEEP can prevent alveolar collapse; however, it cannot recruit the collapsed alveoli. Consequently, it is better to assess PEEP from the initiation of ventilation [62]. As intravenous access is often difficult in MO patients, portable ultrasonography may be useful for locating peripheral veins. If peripheral vein access is impossible, central line placement should be considered. Gel pads should be placed on pressure points to prevent pressure sores and peripheral nerve palsy.

2) Fluid therapy

Estimating cardiac filling pressures by monitoring central venous pressure (CVP) and pulmonary capillary wedge pressure during fluid administration in surgeries has low sensitivity and specificity [63]. Functional parameters (pulse pressure variation, stroke volume variation [SVV]) derived from an arterial pressure waveform analysis are more sensitive and specific [64]. Jain and Dutta [65] attempted to utilize SVV as an infusion trigger for intraoperative fluid management in a MO patient undergoing bariatric surgery. Moreover, Corcoran et al. [66] showed that the total amount of liberally administered fluid was not key in determining perioperative outcomes, while the titrating fluid volume meeting the functional parameters, and goal-directed fluid therapy (GDT), appeared to play a pivotal role in reducing renal complications, pneumonia, time to the first bowel movement, and length of stay. Goal-directed monitoring can provide information about fluid responsiveness when the fluid bolus is administered for organ perfusion. GDT can prevent the fluid accumulation that results from excessive fluid [67]. As a result, intraoperative SVV monitoring may warrant GDT in MO patients. Also, transthoracic echocardiography seems more informative for intraoperative fluid management in MO patients [68].

3) Operation technique

During open major surgery for MO patients, a sufficient abdominal incision should be made to ensure an adequate surgical field. As bleeding from the adjacent fat tissue complicates the operation, meticulous dissection and hemostasis should be performed. At the same time, operations should be completed quickly and accurately because MO patients are vulnerable to developing pressure sores from long operations. Since all tissues may be friable owing to fat deposition, an iatrogenic injury is likely to occur. In cases of PPPD, a fatty pancreas with a high BMI is a predisposing factor for pancreatic fistula formation [69]. To prevent fistula formation, stent placement in the pancreatic duct, fibrin glue application, and the use of a somatostatin analog may be helpful; however, the evidence is insufficient. Wound closure with drainage could prevent wound dehiscence in MO patients.

3. Postoperative management

After major surgery, the patient can be transferred to the post-anesthesia care unit or intensive care unit for immediate postoperative full monitoring. If possible, a sitting or semi-sitting positioning is preferentially recommended. The MO patient should be carefully extubated since spontaneous breathing may be difficult immediately after major abdominal surgery. To facilitate breathing, chest physiotherapy and noninvasive respiratory support should be considered.

1) Protective ventilation

A recent study reported that obese patients are ventilated with too-high tidal volumes in the postoperative period [70]. In both obese (including MO) and non-obese patients, the optimal tidal volume is 6∼8 mL/kg IBW with a PEEP of 10 cmH_2O to avoid atelectasis. Several studies demonstrated that respiratory mechanics and alveolar recruitment were significantly improved by the monitoring of PEEP in obese patients [10]. However, it is necessary to assess the hypotensive effects of a high PEEP due to compromised venous drainage. In the supine position, positional flow limitations and air trapping may impede respiratory management in obese patients [71]. Mahul et al. [72] indicated that T-piece and pressure support ventilation plus 0 cmH_2O of PEEP as weaning tests can be applicable to predict post-extubation inspiratory effort and WOB. Following extubation, CPAP or non-invasive ventilation might apply to the patient, even those without obstructive apnea syndrome. Postoperative atelectasis may be more likely to develop in MO patients due to the diminished FRC, which worsens in the supine position [12,14]. And supplemental oxygen is usually necessary [14]. The patient may return to the ward when the respiratory rate is normal and there are no periods of hypopnea or apnea for at least 1 hour and the arterial oxygen saturation comparable to the preoperative value [73]. Early mobilization also can facilitate the rapid improvement of atelectasis in MO patients with the aid of healthcare providers.

2) Fluid administration

Postoperative fluid administration in MO patients can be based on IBW or TBW; however, this therapy has double-edged implications. On the one hand, fluid restriction may result in acute tubular necrosis and organ dysfunction; on the other hand, excessive fluid may lead to postoperative complications such as pulmonary edema, hypertension, and an increased requirement and duration of ventilatory support despite improved organ perfusion [74,75]. A systematic review concluded that the liberal use of fluid causing a fluid overload state should be avoided in major surgery. Like an earlier mentioned intraoperative GDT, postoperative GDT could be tailored by the responsiveness of validated and objectively measurable variables, such as serum lactate, oxygen delivery index, and CO rather than conventional hemodynamic goals such as arterial blood pressure, urine output, or CVP. Close monitoring of these variables with adjustment for intravenous fluid administration may improve the tissue perfusion and decrease the complications.

3) Thromboembolism

Prophylactic regimens after major surgery mainly include sequential compression devices as well as LMWH. Mechanical prophylaxis could be used primarily for patients at high bleeding risk, and the use of aspirin alone for VTE chemoprophylaxis is not recommended [76]. Although strong evidence is lacking, extended chemoprophylaxis could be selected for patients at high risk of VTE after hospital discharge. A large cohort study for VTE after bariatric surgery demonstrated a 73% overall risk of VTE after hospital discharge [77]. This extended strategy should be decided based on individual risk factors at the time of discharge, including VTE or bleeding complications.

LIMITATIONS

This review has some limitations. Most papers cited here included studies of MO patients who underwent bariatric surgeries since those related to the perioperative management of MO patients undergoing major abdominal surgery are lacking. Moreover, we did not follow the systematic literature review methodologically. However, despite these limitations, this review can pave the way for future management protocols for major abdominal surgery for MO patients by reflecting those of bariatric surgery based on the perception of pathophysiological changes that occur in morbid obesity.

CONCLUSION

Morbid obesity often involves complicated comorbidities and physiological alterations. Perioperative careful considerations in detail and multidisciplinary managements are needed. The main cardiovascular change is LVH resulting in HF, and the reduction of FRC and increase in WOB is principal in respiratory function. OSA is a common problem in MO patients, who should receive perioperative CPAP. Understanding the pharmacological differences between obese and non-obese patients aids in the determination of dosages of perioperative drugs such as antibiotics. Preoperative optimization to achieve 5%~10% of weight loss with adequate diet and exercise is very important. The ramping position in airway management and protective ventilation with PEEP plus calculated TV based on IBW is mandatory. The perioperative GDT targeting functional parameters is supposed to be reliable for fluid administration. The administration of perioperative anticoagulant therapy using LMWH for preventing VTE is recommended in MO patients. Most important thing for the MO surgical patients is a meticulous dissection technique to avoid massive bleeding serious complication.

AUTHOR CONTRIBUTIONS

Conceptualization: SJP. Investigation: BGN. Methodology: BGN. Supervision: SJP. Writing – original draft: BGN. Writing – review & editing: SJP.

CONFLICTS OF INTEREST

The authors of this manuscript have no conflicts of interest to disclose.

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