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Mini-invasive Surgery

Review

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Prevention of bariatric complications: best practices

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Abstract

The prevalence of obesity in both the United States and worldwide has grown significantly over the last several decades. With this growing pandemic, more patients are seeking surgical alternatives to achieve weight loss goals. Bariatric surgery has multiple proven health benefits, including weight loss and resolution of several co-morbidities, including diabetes. Advances in surgical techniques, including laparoscopy, have allowed bariatric surgery to increase in popularity among obese patients. However, bariatric surgery is not without complications. Key to successful weight loss surgery includes appropriate pre-operative laboratory workup, a multidisciplinary approach with other health care providers, proper peri-operative techniques as well as close post-operative follow up. This article will highlight several important criteria bariatric surgeons should bear in mind when evaluating patients in pre-operative, peri-operative and post-operative states to help prevent common complications seen in weight loss surgery.

Keywords: Bariatric complications, prevention, best practices, nutrition, ulcers, DVT

INTRODUCTION

It is estimated that over 500 million adults worldwide are obese with numbers no longer confined to rich countries[1]. In the United States, an estimated 42.4% of Americans are obese with 9.2% of Americans meeting criteria for severe obesity[2]. Obesity is a growing pandemic in the United States amounting to a significant financial burden on the health care system, with an estimated annual medical cost of 147 billion

dollars in 2008[2]. In 2019, an estimated 256,000 patients underwent bariatric surgery in the United States, an increase of nearly 63% from 2011[3]. Weight loss surgery has multiple proven benefits, including the improvement of type 2 diabetes as well as hypertension and sleep apnea. A 2017 guideline published by the American Diabetes Association recommends metabolic surgery for patients with BMI ≥ 40 kg/m^2 independent of glycemic control and also for patients with BMI ≥ 35 kg/m^2 not controlled on medications[4]. Even with these proven benefits, weight loss surgery is not a procedure to take lightly, requiring a multidisciplinary approach. Weight loss surgery can also have multiple peri-operative and post-operative complications requiring close preparation, planning and follow up for both the patient and surgeon. This article will focus on common preventable bariatric surgery complications and current best practices guidelines to achieve results.

PRE-OPERATIVE MANAGEMENT

Pregnancy

Weight loss surgery has many proven benefits for obese women of childbearing age. It has been shown to increase fertility, decrease risk of pregnancy-related complications and leads to fewer fetal complications[5]. Bariatric surgery is associated with reduced risks of gestational diabetes and excessive fetal growth[6]. However, most bariatric surgeons advise against pregnancy pre-procedure and for twelve to eighteen months post procedure due to an emphasis on weight stability[7]. Contraception options should be reviewed with an appropriate provider as different options may be recommended depending on the procedure performed. Patients undergoing malabsorptive surgeries such as the Roux-en-Y gastric bypass (RYGB) or a biliopancreatic diversion with duodenal switch (BPS/DS) should be counseled on non-oral contraception options as the effectiveness of the absorption of oral medications cannot be assessed. Patients who do become pregnant must have their nutritional status followed closely with surveillance for nutritional deficiencies obtained every trimester[7]. Vitamin B12 and folate are especially important given the association with fetal neural tube defects. Vitamin B12 levels should be kept above 600pg/mL and folate levels should be above 15ng/mL[5].

Psychiatric Evaluation

All patients planning to undergo weight loss surgery should undergo a formal psychosocial behavioral evaluation by a trained provider[7]. Areas that should be evaluated should include weight history, family history, social support, stressors, personality traits and temperament[7]. Patients with a known or suspected history of psychiatric illness including self-harm, suicide or substance abuse, should also undergo formal evaluation prior to any surgical intervention[7]. While the majority of obese individuals do not have a psychological illness, the prevalence of psychiatric disorders in this population is well documented. Studies have shown that up to 40% of obese individuals suffer from at least one psychiatric disorder[8]. The majority of these patients suffer from axis I disorders such as depression, eating disorders and anxiety. Patients with BMIs greater than 40 kg/m^2 are also prone to depression with reports suggesting that they are five times more likely to have a depressive episode within the past year when compared to normal weight individuals[5]. While mental illness in itself is not an absolute contraindication for weight loss surgery, it has been shown to be a negative predictor of weight loss. A linear relationship has been noted between the number of psychiatric illnesses and post one year weight changes. Patients with two or more psychiatric disorders are more likely to experience weight loss cessation or weight re-gain one year post surgery[9]. Post-operative psychological follow up in the weight loss patient is also of equal importance. Studies have shown a positive relationship between the percentage of excess weight loss and the total number of psychological and behavioral services completed after surgery[10]. It was shown that patients who completed more psychological and behavioral support services after surgery, experienced greater weight loss than those who did not.

Airway Management and Obstructive Sleep Apnea

Weight loss surgery has proven benefits in patients with obstructive sleep apnea. Weight loss of approximately 27 to 47% resulted in a 49 to 98% reduction in the apnea-hypopnea index[7]. However, airway management can be difficult to manage in the peri-operative setting, particularly in patients with a history of obstructive sleep apnea (OSA). OSA has been described to be a risk factor for adverse events, including an increased risk of post-operative hypoxemia, respiratory failure and longer hospitalization[11]. Current consensus guidelines on OSA in bariatric surgery recommend the screening of all patients before weight loss procedures with the STOP-BANG score or the Berlin Questionnaire to help identify and diagnose OSA[12]. Continuous positive airway pressure (CPAP) is generally recommended for patients with moderate to severe OSA[11]. Studies have shown that peri-operative use of CPAP can lead to reduced pulmonary complications, including pneumonia and atelectasis[11]. Patients should be encouraged to bring their own machines and masks from home when admitted to the hospital following their procedure. In 2015, the Difficult Airway Society published guidelines for the management of unanticipated difficult intubation in adults. Obesity was described within the context of ramping position, pre-oxygenation with the head elevated and use of CPAP[4]. CPAP was recommended to be used post-operatively in those with a prior history of use along with continuous pulse oximetry and head of bed elevation[4].

Smoking Cessation

Current practice guidelines recommend the cessation of tobacco products preferably one year prior to weight loss surgery but at the minimum, a duration of six weeks prior to the procedure[7]. Early referral to a smoking cessation program should be initiated for all weight loss patients. Tobacco use has long been known to be a significant contributor to morbidity in post-operative surgical patients. In a study of over 30,000 laparoscopic bariatric procedures, smoking was shown to have increased the odds of prolonged intubation, re-intubation, sepsis, shock, organ space infection and increased length of hospital stay in bariatric patients[13]. Cigarette smoke is known to contain toxins that can cause the detachment of endothelial cells from the lumen of blood vessels[13]. The loss of these endothelial cells removes a protective barrier against tissue swelling, platelet aggregation and the prevention of vasospasm. Nicotine and carbon monoxide in cigarette smoke also leads to hyper coagulation and tissue hypoxia which delays all aspects of tissue healing. A systemic review of current studies noted that smoking within one year prior to weight loss surgery was found to be an independent predictor for increased 30-day mortality, wound and pulmonary complications, as well as an independent predictor of marginal ulcers and bone fractures[14]. Nicotine replacement in the form of gum, lozenges, patches, inhalers and nasal sprays are safe alternatives to smoking tobacco. There is currently no evidence that nicotine replacement therapies increase the risk of delayed wound healing or cardiovascular complications as seen with tobacco smoking[13].

Pre-operative Weight Loss

Many insurance programs currently mandate bariatric candidates to undergo a monitored weight loss program prior to approval for surgical intervention. These programs run from anywhere from four to twelve months in length and require monthly weight documentation and dietary counseling. Bariatric surgical candidates are expected to follow these programs for the allotted amount of time and must demonstrate "failure" or a less than 10% weight loss prior to insurance approval of bariatric surgery[12]. Studies analyzing pre-operative weight loss regiments have shown mixed results with post-operative weight loss or surgical outcomes. A retrospective study was performed comparing patients with insurance-mandated pre-operative weight loss programs to patients without and found no significant difference in weight loss outcomes for up to two years post procedure[15]. In 2016, the American Society for Metabolic and Bariatric Surgery (ASMBS) took a position based on current clinical studies that there was no evidence that pre-operative weight loss had any impact on post-operative outcomes[12]. Failure to lose weight pre-operatively should not preclude obese patients from potential weight loss surgery. However, these

insurance-mandated weight loss programs should not be confused with short-term pre-operative weight loss regiments recommended by many bariatric surgeons. These regiments are usually two to twelve weeks in length and are designed to ease the technical aspects of surgery by decreasing liver volume and overall body fat[12]. However, non-surgical interventions do have the potential for long-term weight loss. The Look AHEAD trial published in 2014 showed that comprehensive lifestyle intervention resulted in a 5% weight loss over 8 years in over half of its participants. The majority of these participants achieved weight loss during the first year of the trial and spent the duration of the trial working on maintaining that weight loss[16]. In 2018, the results of a prospective trial examined non-surgical interventions in morbidly obese patients and noted a weight loss of 13% at three years follow up[17]. However, the interventional program required adherence to a very low calorie diet along with the placement of an intra-gastric balloon.

PERI-OPERATIVE MANAGEMENT

VTE Prophylaxis

Venous thromboembolism (VTE) is a leading cause of bariatric complications and co-morbidity and mortality in the post-surgical patient and includes both deep vein thrombosis (DVT) and pulmonary embolus (PE). PE is thought to be the second leading cause of peri-operative mortality in bariatric patients and is believed to be the cause of 40% of deaths in the first 30 days post procedure[18]. It is known that obesity induces a pro-thrombotic state, placing the bariatric patient at a higher risk for VTE. The incidence of VTE post-operatively was noted to be 0.5% with 80% of cases occurring after hospital discharge[18]. Risk factors include BMI > 60 kg/m^2, age > 50, open procedures, nicotine use, estrogen therapy, previous history of DVTs and hyper-coagulable disorders such as protein C or S deficiency[7]. Studies have shown that every 10 kg/m^2 increase in BMI resulted in a 37% increase in the risk of developing a VTE following weight loss surgery[19]. Estrogen is a known procoagulant and as such, oral contraceptives increase VTE risk, especially in the obese patient. Obese women using estrogen containing oral contraceptives have a 24 fold increased risk of developing VTE when compared to non-obese women not on oral contraception[12]. In patients planning for weight loss surgery, it is recommended to stop estrogen containing contraceptives one month prior to their procedure[12]. Progestins are less associated with thrombosis and progestin containing contraception should be considered as a first-line treatment for obese women with a BMI > 30 kg/m^2.

DVT prophylaxis is recommended for all bariatric patients post procedure. At a minimum, mechanical prophylaxis with sequential compression devices should be placed on post-operative patients and early ambulation should be encouraged. Chemical prophylaxis with either low molecular weight heparin or subcutaneous unfractionated heparin should be administered within 24 hours after the procedure and continued during their hospital stay barring any contraindications[7]. A study comparing chemical prophylaxis agents found that low molecular weight heparin was more effective than subcutaneous unfractionated heparin for the prevention of post-operative VTE in bariatric patients while also noting no significant difference in the rates of bleeding[20]. Extended chemical prophylaxis post discharge should be considered for high-risk patients such as those with a prior history of DVTs, hypercoaguability or difficulty with ambulation. Data regarding pre-operative placement of inferior vena cava filters are unclear, but the placement has been associated with higher rates of post-operative DVTs and mortality[7].

Sleeve Gastrectomy Complications

Complications of sleeve gastrectomy (SG) can include bleeding, staple line leaks and narrowing or stenosis at the gastroesophageal junction. Staple line leaks have become the most feared complication with the incidence ranging from 1 to 2%[21]. Techniques developed to help decrease the incidence of post-operative leaks include oversewing the staple line and application of tissue sealant or fibrin glue. The use of staple line reinforcement such as absorbable polymer membrane or non-absorbable bovine pericardium has been proposed to help decrease the incidence of post-operative leaks. It is controversial with most studies

reporting no statistical difference in leak rates between patients who underwent staple line reinforcement and those who did not[21]. However, the benefits of staple line reinforcement with post-operative bleeding are well known. Studies have shown decreased rates of post-operative bleeding in patients who underwent staple line reinforcement compared to those that did not[21]. Current guidelines from the International Sleeve Gastrectomy Expert Panel Consensus Statement advocate the use of staple line reinforcement to help reduce bleeding along the staple line[22]. However, there has been no consensus to date on the use of staple line reinforcement to help reduce post-operative leak rates.

Bougie size used during sleeve calibration is also linked to post-operative leak rates. Sizes commonly used range anywhere from 32 to 60 french. Controversy exists with beliefs that smaller sizes lead to greater weight loss, but increased risk of strictures and larger sizes lead to decreased rates of strictures but decreased weight loss[5]. A study noted decreased leak rates in surgeons who had used a 40 french bougie or greater. This review noted a statistically significant result in where surgeons who used a 40 french bougie or greater had a 0.6% leak rate compared to 2.8% in surgeons who used less than 40 french[23]. When compared with larger bougie sizes, a 40 french bougie was noted not only to have improved weight loss but also improved resolution of co-morbidities. Another study also noted increased percentage of excess body mass index loss along with greater resolution in hyperlipidemia, hypertension and type 2 diabetes in patients treated with a 40 french bougie compared with a 50 french bougie[24].

Internal Hernias and Small Bowel Obstruction

Small bowel obstruction secondary to internal hernias is a common complication that can occur in post weight loss surgery patients. It has been reported to occur in up to 3.3% of patients undergoing a laparoscopic RYGB or BPS/DS[25]. Internal hernias can occur commonly through Petersen's defect, which is found between the mesentery of the jejunal limb brought up to the gastric pouch and the transverse colon. It can also occur near the jejunojejunal or ileoileal anastomosis in the RYGB or BPS/DS[26]. Closing these mesenteric defects will help reduce the occurrence of internal hernias. A systematic review of over 12,000 patients who underwent a laparoscopic RYGB showed that patients with closure of mesenteric defects had a lower rate of internal hernias along with a lower rate of re-operation due to small bowel obstruction when compared to non-closure[27]. Petersen's defect was also noted to be the most common area of internal herniation (50% of cases) followed by the jejunojejunal defect (35% of cases)[27]. A meta-analysis was also performed, which included over 16,000 patients and noted a statistically significant result in where closure of mesenteric defects was associated with a lower incidence of internal hernias, small bowel obstruction and re-operations[28]. Another meta-analysis also noted decreased rates of bowel obstructions in RYGB patients who underwent antecolic approaches when compared to retrocolic approaches[29]. Benefits of an antecolic approach for gastrojejunal anastomosis included the elimination of the transverse mesocolic mesenteric defect along with no risk of mesocolic stricture or stenosis[29]. Signs and symptoms suspicious of small bowel obstruction in the bariatric patient should be closely followed. Post-surgical patients with sudden onset of abdominal pain and recurrent episodes should be evaluated with an abdominal pelvic computed tomography (CT) scan. They should also be considered for a diagnostic laparoscopy or exploratory laparotomy as CT scans can often miss internal hernias.

Special consideration should also be given to post-surgical pregnant patients who present with abdominal pain due to an increased risk of internal hernias and the need for surgical intervention. In 2017, a cohort study was performed, noting an increased rate of abdominal surgery in pregnant patients who had bariatric surgery compared with obese women (BMI > 35) who did not[30]. Post-surgical pregnant patients were found to have a 34 fold increased risk of undergoing surgery due to intestinal obstruction along with an 11 fold increased risk of undergoing an exploratory laparotomy or diagnostic laparoscopy during their pregnancy. A cohort study performed in Denmark and published in 2017, noted an internal hernia occurrence rate of

almost 10% in post RYGB pregnant patients who presented with upper abdominal pain[31]. These post-surgical pregnant women who presented with upper abdominal pain also had an increased risk of pre-term birth when compared to pregnant women who did not. Intestinal obstruction secondary to internal hernias in the pregnant patient can be attributed to an increase in intra-abdominal pressure along with displacement of organs due to an enlarged uterus[30-31]. The displacement of bowel can then increase the chances of herniation through a mesenteric defect. The importance of recognizing these complications has been documented in several studies. A case series in 2012 noted a maternal and fetal death rate of 9% and 15% respectively, highlighting the need for a high index of suspicion for post RYGB pregnant patients presenting with abdominal pain[32]. Nausea, vomiting and general abdominal pain are not uncommon symptoms in pregnancy and providers must be aware of potential complications when evaluating the pregnant post bariatric surgical patient.

POST-OPERATIVE COMPLICATIONS

Nutritional Complications

One of the most common complications of weight loss surgery in the post-operative period is nutritional deficiencies. As per the ASMBS, all bariatric patients are recommended to meet with a registered dietitian prior to surgery to identify pre-operative nutritional deficiencies as well as to help identify and manage post-operative deficiencies[33]. Pre-operative laboratory workup is also recommended, including serum thiamine, iron, folate, calcium, zinc, copper, and vitamins A, D, E, K, B12[33].

Vitamin D/Calcium

Obesity has been associated with multiple nutritional deficiencies, including vitamin D. Rates as high as 90% of obese individuals have been reported to be found with vitamin D deficiency[33]. While the association between obesity and vitamin D deficiency has not been well defined, it has been shown that for every 1 kg/m^2 increase in BMI, a 1.15% decrease of 25-hydroxy Vitamin D was seen[34]. Malabsorptive procedures such as an RYGB or a BPS/DS hinder the absorption of vitamin D and calcium by bypassing areas where they are typically absorbed and place the patient at risk for deficiencies. Pre-operative deficiency in vitamin D and calcium can put the bariatric patient at risk for complications, including long-term osteoporosis and fractures. While some practices and centers may assess pre-operative bone mineral density with dual-energy x-ray absorptiometry, there is currently insufficient evidence recommending the routine use of these exams[34]. All post-operative weight loss patients should have routine surveillance of vitamin D and calcium along with routine supplementation.

Iron

The association between iron deficiency in obese patients has been known for decades. Up to 45% of obese individuals have been reported to have iron deficiency[33]. Iron deficiency has been seen in approximately 32% of patients undergoing restrictive procedures and up to 52% of patients undergoing malabsorptive procedures[5]. Post-operative supplementation recommendations include 18mg of daily iron for patients considered low risk (no prior history of anemia) whereas menstruating females and patients who had BPD/DS, RYGB and SG should receive 45-60mg of iron daily[33]. Vitamin C has also been shown to help increase iron absorption after weight loss surgery and can be considered as an additional supplement[35]. Routine post-operative surveillance labs include iron studies within three months after the procedure followed by every three to six months for a year and then followed by annual surveillance[33].

Thiamine (Vitamin B1)

Thiamine deficiency is associated with Wernicke-Korsakoff Syndrome (WKS), a neurological disorder associated with the classic triad of ataxia, nystagmus and confusion. In bariatric surgery, thiamine deficiency

is usually seen in the post-surgical patient suffering from prolonged vomiting without appropriate dietary vitamin supplementation[33]. Suspicion in the post-surgical patient requires immediate attention with oral or IV repletion. Close monitoring must be present when evaluating post-surgical patients in the emergency room or outpatient office complaining of nausea or vomiting. Infusing these patients with fluids containing dextrose without thiamine supplementation will further deplete the patient's stores aggravating WKS and increasing the chances of neurological manifestations. Routine post-operative surveillance is recommended in high-risk individuals, including females, African-Americans, patients with gastrointestinal symptoms, patients who missed a nutritional follow up appointment and patients with heart failure or excessive alcohol use[33]. Follow up testing includes serum levels within the first six months and then every three to six months until symptoms resolve.

Vitamin B12/Folate

In the post-surgical weight loss patient, B12 deficiency is typically due to the body's inability to absorb the free vitamin. B12 absorption requires intrinsic factor as a cofactor to be absorbed in the distal ileum. Intrinsic factor is produced in the parietal cells in the stomach and weight loss procedures such as an SG or RYGB limit the production of intrinsic factor. Vitamin B12 deficiency has been reported in up to 18% of post-surgical patients and symptoms include fatigue, tingling in fingers and toes, mood changes and dementia[36]. Routine post-operative screening is recommended in all patients with procedures that exclude the lower part of their stomach (SG, RYGB)[7]. Patients on medications that can increase the risk of B12 deficiency such as proton pump inhibitors, metformin, colchicine, neomycin and seizure medications require more frequent screening (every three months) in the first post-operative year and then annually afterwards[33]. Post operative supplementation is recommended in all weight loss patients with the amount corresponding to the route of administration. Folate deficiency has been reported in up to 65% of post-surgical weight loss patients[33]. Close attention must be paid to women of childbearing age due to the association with fetal neural tube defects.

Zinc/Copper

Zinc deficiency manifests with poor wound healing, changes in taste, hair loss and diarrhea. Weight loss patients undergoing BPD/DS and RYGB are at a higher risk of zinc deficiency, and these patients should be screened annually[37]. 70% of BPD/DS patients and 40% of RYGB patients have been found to be deficient in zinc. Zinc supplementation can also place the patient at risk of copper deficiency, so a ratio of 1 mg of copper is recommended for every 8-15mg of zinc received[33]. Copper deficiency leads to fatigue, skin sores and hair discoloration. The prevalence of copper deficiency has been reported to be as high as 90% in post BPD/DS patients[33]. Post-operative annual screening via serum copper and ceruloplasmin is recommended in all BPD/DS and RYGB patients regardless of symptoms.

Vitamin A/E/K

The risk of deficiency of fat-soluble vitamins is increased in malabsorptive procedures, likely due to shorter common channels decreasing fat absorption. Vitamin A deficiency can lead to night blindness, dry eyes, dry skin and hair. Up to 70% of BPD/DS and RYGB patients have been reported to have vitamin A deficiency post operatively[33]. Post-operative screening is recommended for all patients regardless of symptoms. Vitamin E and K deficiencies are uncommon in post-surgical patients. Vitamin E deficiency can manifest as hair loss and pain or tingling in the extremities. Vitamin K deficiency can lead to coagulopathy and bruising. Guidelines recommend routine supplementation and screening in symptomatic patients.

Ulcers

Marginal ulcers can be found in patients post RYGB with rates as high as 25%[38]. Risk factors include pouch size and position, NSAIDs, smoking and alcohol use. Smoking cessation and counseling pre-operatively are recommended to help prevent this complication. There has also been a documented relationship with H. pylori with patients testing positive having a tenfold increase in the development of marginal ulcers post RYGB[7]. Pre-operative testing for H. pylori in prevalent areas along with upper endoscopy may be helpful and is recommended[7]. Marginal ulcers typically form within the first twelve months post procedure and prophylactic administration of proton pump inhibitors should be provided for the first year in high-risk patients[7].

Roux-en-Y Gastric Bypass Complications

Post-Operative Leak/Bleeding

Post-operative leak in the RYGB patient remains one of the most dreaded complications for the bariatric surgeon. Most leaks are reported to occur within the first 7 days, but can often occur for up to 28 days post procedure[5]. Fortunately, the incidence of this devastating complication is rare with current studies reporting an overall leak rate of less than 1%[39-40]. An analysis of MBSAQIP data in 2015 reported an overall leak rate of 0.6% which was associated with a mortality rate of 1.5%. Post-surgical leaks were also found to be associated with a statistically significant increased rate of further complications, including pneumonia, surgical site infections, acute kidney injury and bleeding[39]. Leaks were also more commonly reported to be found in the gastrojejunal anastomosis[41]. Independent predictors of leak include a prior history of PE along with poor functional status. However, increased levels of albumin have been shown to be a protective variable against post-operative leaks highlighting the importance of pre-operative nutrition optimization in the bariatric patient[39].

Bleeding in post RYGB patients has been reported to occur in less than 2% of patients[41]. While a relatively uncommon occurrence, post-operative bleeding is a significant contributor to morbidity and mortality in the post RYGB patient. Bleeding can occur at multiple time intervals, with early bleeding usually defined as less than 30 days post-surgery and late bleeding defined as greater than 30 days post-surgery. Early bleeding is usually associated with bleeding from the anastomosis sites and late bleeding is associated with gastritis and marginal ulcers in the gastric pouch, remnant stomach or duodenum and may require a return to the OR for exploration[42]. Independent predictive factors for an increased risk of post-operative bleeding have been found to include a prior history of DVTs, renal failure, use of therapeutic anticoagulation, conversion to open and revisional surgery[41]. Additional risk factors for marginal ulcers include the use of NSAIDs, smoking and H. pylori highlighting the importance of patient pre-optimization, education and testing prior to surgery. Diagnosis of the location of post-operative bleeding is of upmost importance and patient presentations can often provide clues. Melena often originates from the gastric remnant while hematochezia is associated with bleeding from the Roux limb[42]. Further investigation with endoscopy can help localize the bleed. Intra-luminal bleeding from the anastomosis site can be treated via endoscopy with electrocoagulation, hemostatic endoclips, epinephrine injections and can be repeated as necessary[26].

Motility Disorders Post Surgery

Esophageal motility disorders are prevalent among the morbidly obese population with the most common being gastroesophageal reflux disorder (GERD). Studies have shown a high prevalence of manometric abnormalities in the obese population with the most common being a hypotensive lower esophageal sphincter (LES)[43]. Achalasia has been reported to be a common long-term post-operative complication in weight loss surgery with an incidence of up to 8% and often occurring up to 12 years after surgery[44]. It is proposed to occur due to a high pressure gastric zone created in the post-operative gastric pouch created after RYGB. In the post-operative SG, the increased esophageal after load acts as a functional obstruction

distal to the LES that can create an achalasia like pattern[44]. Studies have shown a substantially shorter median time of performance of manometry for patients post SG (2.2 years) when compared to RYGB (9.4 years) suggesting that SG patients may become symptomatic earlier than other surgical groups[44]. These studies highlight the time dependent association of achalasia with bariatric surgery and the need for long-term clinical surveillance in weight loss patients.

Studies have shown that patients who had an SG were at a higher risk of developing GERD post operatively. Guidelines published by the International Sleeve Gastrectomy Expert Panel noted an average post-operative GERD development rate of 12%[22]. Additional risk factors identified included female gender, older age and tobacco use[45]. Studies have shown that SG not only worsens GERD symptoms but also puts the bariatric patient at a higher risk of developing de novo GERD. These patients were also found to have a higher risk of developing erosive esophagitis and Barrett's Esophagus[46]. Additional studies using manometry saw that patients who had SG had an increased relaxation time of the LES as well as a higher DeMeester score likely secondary to an increase in acid reflux[47]. Mechanisms proposed for the increased risk of developing GERD include a change in the angle of His during creation of the sleeve which shortens the LES and decreases resting tone allowing for the reflux process to occur[47]. Other proposals include a decrease in gastric compliance leading to a higher intra-gastric pressure leading to acid reflux[48]. These same studies also noted a lower risk of GERD after RYGB, making it a procedure of choice for obese patients with a prior history of acid reflux[45]. This effect is most likely due to the smaller amount of parietal cells in the gastric pouch, which minimize the secretion of acid into the esophagus.

Dumping Syndrome

Dumping syndrome is a common post-operative complication seen in patients who undergo some type of gastrectomy either partial or total. As such, it can be seen in patients post RYGB or even SG. Reports indicate that up to 40% of patients undergoing RYGB or SG suffer from dumping syndrome and its complications[48]. Dumping syndrome is characterized by vasomotor and GI symptoms due to alterations in gastric anatomy leading to rapid gastric emptying and exposure of the small intestine to nutrients. Dumping syndrome is divided into two types, early symptoms and late. In early dumping syndrome, symptoms usually occur within the first hour after a meal, often occurring within 15-30 minutes[5]. It is characterized by GI symptoms such as nausea, abdominal pain, bloating, diarrhea and vasomotor symptoms like tachycardia, flushing, palpitations and dizziness. Early dumping syndrome is the most common type of dumping syndrome and is due to the rapid passage of hyperosmotic nutrients to the small bowel due to alterations in gastric anatomy from surgery. The rapid delivery of hyperosmotic nutrients to the small bowel causes a shift of fluid from the intravascular compartment to the intestinal lumen causing vasomotor symptoms such as tachycardia. The fluid shifts into the small bowel can also cause distention of the small bowel leading to the GI symptoms of bloating and nausea[49]. These fluid shifts are reported to be accompanied with the release of GI hormones such as vasoactive intestinal polypeptide, neurotensin, peptide YY, incretins, insulin and glucagon, which can affect GI motility and hemodynamics[49-50].

Late dumping syndrome usually occurs 1-3 hours after a meal and is characterized by hypoglycemic symptoms such as palpitations, confusion, perspiration and weakness. It occurs due to the high carbohydrate load delivered to the small intestine due to rapid gastric emptying. This creates a hyperinsulinemic response and due to the long half-life of insulin, a hypoglycemic state is induced after all the available glucose is absorbed[48]. Incretin hormones are believed to play a role in this pathology. It is known that enteral glucose induces an increased secretion of insulin when compared to intravenous forms due to incretin hormones such as glucagon-like peptide-1 (GLP-1) and gastric inhibitory polypeptide (GIP). An increased release of GLP-1 has been reported to occur after gastric surgery, which can help explain the

hypoglycemic symptoms seen in late dumping syndrome[49].

Initial treatment of dumping syndrome revolves around dietary changes. Patients are encouraged to consume frequent smaller high protein and fiber meals throughout the day (up to 6), to avoid drinking liquids with meals and for up to 2 hours after. Patients are encouraged to avoid concentrated sweets not only to help with weight loss but also to help prevent symptoms of dumping syndrome[7]. Pharmacological interventions include acarbose, an alpha-glycosidase hydrolase inhibitor. It helps slow carbohydrate digestion in the small intestine, helping to blunt the hyperglycemic effect seen after meals and the hypoglycemic symptoms that follows[50]. Its use is limited as it is only effective in late dumping syndrome, and it can also cause symptoms of carbohydrate maldigestion such as bloating and diarrhea. Somatostatin analogues are also an effective treatment option for patients who fail dietary modification and acarbose treatment. These analogues help delay gastric emptying and inhibit GI hormones such as insulin and GLP-1 blunting the incretin effect[49-51]. They can help reduce symptoms of both early and late dumping syndrome but have not yet received regulatory approval.

Food Intolerance

Food intolerance is a common complication in patients who undergo RYGB. The most common food intolerance reported includes red meat followed by rice and leafy vegetables[52]. Studies have shown that up to 40% of post-surgical patients had a food intolerance to red meat up to 4 years after their procedure[52]. Intolerance to red meat and protein ingestion in particular can have detrimental effects in the post-surgical patient, affecting overall energy levels, serum iron levels and weight loss. It can also account for the high incidence of iron deficiency seen in post RYGB patients. Due to food intolerances, patients can opt for high calorie, high carbohydrate food substitutes that are easier to digest which can then affect their weight loss goals. Intolerance to protein and red meat can be attributed to the partial gastrectomy performed in RYGB which results in a change in the amount of pepsin secreted, the enzyme responsible for protein digestion. Studies have also shown an association between the number of chewing cycles, length of time spent chewing and food tolerance[53]. It was seen that food tolerances in post RYGB patients increased as the number of chewing cycles and time spent chewing food increased.

CONCLUSION

Weight loss surgery has many proven benefits including the improvement and resolution of many co-morbidities in the obese patient. When compared to non-surgical interventions, the benefits of bariatric surgery include greater weight loss, higher resolution of diabetes and improved quality of life. Although major complications are rare, it requires diligent preparation and follow up for both the patient and surgeon. Pre-operative evaluation and intervention play a key role in the success of weight loss surgery with many potential complications avoided by simple measures. This article outlines current best practice guidelines to help prevent these common bariatric complications.

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All authors declared that there are no conflicts of interest.

Ethical Approval and Consent to Participate
Not applicable.

Consent for Publication
Not Applicable.

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