Roux-en-Y Gastric Bypass Surgery for Morbid Obesity: Long-term Metabolic and Nutritional Effects

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1 Introduction

Gastric bypass surgery for morbid obesity was introduced more than 40 years ago but increased in popularity since 1994, when surgeons began to perform the operation using minimally invasive laparoscopic techniques and well known personalities went public with their disease and surgical treatment (Mason & Ito, 1967; Wittgrove et al., 1994). Since that time, more than one million people have had the surgery performed, many of them young and in otherwise reasonably good health. It has become the most commonly performed operation for the treatment of morbid obesity in the United States. Most published studies have focused on the early surgical complications related to the operation itself. The long-term benefits of weight loss and improvement in obesity-related conditions such as hypertension, sleep apnea, diabetes, and stress incontinence have also been carefully studied (Edholm et al., 2012). Gastric bypass surgery has been proven to increase patient longevity, compared to obese patients who have not had the operation. In addition, the advantages of gastric bypass surgery in the improvement of the quality of life are well accepted by physicians, third-party payers and patients. Edholm et al. (2012) reported that 11.4 years after gastric bypass surgery, the body mass index had decreased to 32.5 kg/m², corresponding to an excess body mass index loss of 63.3% (Adams et al., 2007). Orally treated diabetes resolved in 72% and sleep apnea and hyperlipidemia were improved. The overall result was satisfactory for 79% of the patients and 92% would recommend Roux-en-Y gastric bypass to a friend. Attendance to the annual checkups was 37%. Vitamin supplements were taken by 72% and multivitamins by 24%. However, surprisingly few patients were compliant with the recommendation of lifelong supplements and yearly evaluations. Over the last few years, important side effects are being reported and are important to understand in considering whether to advise this surgery to any prospective patient. Patients may be at risk for some of these complications for a lifetime.

1.1 Long-term Complications

The anatomic, pathophysiologic and nutritional effects of patients who have had partial gastrectomy for peptic ulcer disease for neoplasia are well understood. It would be expected that patients might have similar effects following Roux-en-Y gastric bypass operation. However, patients who undergo bariatric operations are generally younger and a lifetime of these potential side effects would take a long time of longitudinal study following surgery. This might present some difficulties as surgical follow-up of these patients generally decreases with time, unless a particular problem has developed. Few studies follow gastric bypass patients beyond 5 years. The overwhelming majority of patients have done very well after surgery, without any medical problems or the need for any related medical or surgical intervention. Nevertheless, in the past 15 years, there have been reports of numerous long-term complications that have been attributed to Roux-en-Y gastric bypass operations.

Table 1 lists the types of long-term side effects of Roux-en-Y gastric bypass surgery for morbid obesity.

1.2 Gastrointestinal

Intestinal obstruction following gastric bypass surgery may be difficult to diagnose and have a higher risk of major morbidity or mortality due to the surgically altered anatomy. The creation of the Roux-en-Y usually prevents gaseous distension of the biliopancreatic limb or gastric remnant. This inhibits the ability to make diagnosis on plain abdominal radiograph and may rapidly lead to intestinal infarction because
of the closed loop created by the bypass. The long-term incidence of intestinal obstruction has been reported to be as high as 9.7 percent (Capella et al., 2006). Obstructions due to adhesions are common from any abdominal operation but a frequent cause of obstruction following gastric bypass is due to internal hernia. Rogula reported that internal hernia through the transverse mesocolon was the most frequent cause (Rogula et al., 2007). Patients universally present with abdominal pain and nausea and emesis is present in 63 percent (Carmody et al., 2005). While the placement of the alimentary limb through the transverse mesocolon was frequently performed following gastric resection to promote drainage, an antecolic anastomosis may help to prevent internal hernia the transverse mesocolon (Taylor et al., 2006). Most patients with internal hernia present two years or more after gastric bypass surgery. It is suggested that the loss of fat in the mesentery and omentum, concomitant with the weight loss, is the explanation why this late complication might develop. All potential internal hernias should be closed at the initial surgery. An antecolic gastro-jejunostomy does not appear to cause difficulties with drainage of the gastric pouch and might reduce the rate of internal hernia by eliminating the iatrogenic opening of the transverse mesocolon.

Intestinal infarction may be the result of mechanical mesenteric vascular etiologies (Swartz & Felix, 2004). It may result in the need to perform massive intestinal resection, resulting in malnutrition, or death. CT scan with oral contrast is recommended in all patients in whom intestinal obstruction following

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Table 1: Types of long-term complications reported in patients who underwent gastric bypass surgery for morbid obesity
gastric bypass surgery is of concern (Yu et al., 2004). Rapid operative intervention and decompression of mechanical small bowel obstruction is usually required.

Marginal ulceration typically occurs in the alimentary in limb and has been reported to occur in up to 12.3 percent of patients following gastric bypass (Csendes et al., 2009). It is thought to be acid-induced as a result of gastric contents moving directly into the jejunum without neutralization by duodenal or pancreatic secretions. It has also been associated with non-steroidal anti-inflammatory and ethanol use. While Rasmussen reported that it was often the result of Helicobacter pylori infection (Rasmussen et al., 2007) this has not been confirmed by others (Yang et al., 2006). Marginal ulcer should be evaluated endoscopically and the majority of patients may be managed medically. Proton pump inhibitors (Gumbs et al., 2006) and sucralfate oral suspension solutions are usually effective (Dallal & Bailey, 2006). Surgery is usually reserved for patients with intractable pain, bleeding or perforation and is necessary in less than one-third of patients (Patel et al., 2009). Gastrointestinal hemorrhage following Roux-en-Y gastric bypass surgery has been reported to occur in up to three percent of patients may difficult to localize using standard endoscopic techniques as it may occur in the excluded stomach or duodenum (Jamil et al., 2008). This might require nuclear scintigraphy, percutaneous endoscopy of the gastric remnant or operative exploration to identify and treat the site of bleeding (Gill et al., 2008).

Some long-term weight gain following obesity surgery is considered to be normal or physiologic. Significant weight gain years following surgery can be heartbreaking for patients and may be the result of dietary indiscretion. However, anatomic causes such as dilation of the gastric pouch or gastro-jejunal anastomosis and gastro-gastric fistula have become an increasing concern (Campos et al., 2008). Silicone banding at the time of gastric bypass may prevent weight gain due to dilation. Gastro-gastric fistula has been reported to occur in one to four percent of patients, but may be underreported or asymptomatic until patients are evaluated for causes of for failure to lose weight (Carrodeguas et al., 2005). Significant weight gain has been reported in up to twenty-five percent of patients following gastric bypass surgery (Shah et al., 2006). Re-operation can present significant technical challenges to the surgeon and result in appreciable morbidity or mortality (Hallowell et al., 2009). Newer technologies such as endoscopic plication (Herron et al., 2008) or injection with sodium morrhuate have been recently employed to minimize the need to operatively revise the gastro-jejunostomy.

Anastomotic stricture, most commonly at the gastro-jejunostomy is a frequent complication following gastric bypass surgery. They most typically occur less than one year after operation. The reported anastomotic stricture rate is one to ten percent. There is a greater incidence of stricture in laparoscopic gastric bypass surgery using an EEA stapler (particularly the 21 mm device) compared to an open, hand-sewn anastomosis or laparoscopic anastomosis using a GIA stapling technique (Mathew et al., 2008; Takata et al., 2007). Ischemic changes are generally considered to be the cause of most gastro-jejunal and jejuno-jejunal strictures. Almost all proximal anastomotic strictures may be successfully dilated by endoscopic technique and only rarely require surgical revision (Leyba et al., 2008).

1.3 Biliary Tract

Gallstone formation is especially common in obese patients and may also be related to rapid massive and rapid weight loss. More than twenty percent of bariatric surgery patients have had cholecystectomy prior to their gastric bypass operation (Patel et al., 2009). Historically, surgeons previously performed prophylactic cholecystectomy during the time of gastric bypass surgery but more recently, a selective approach has been advised (Taylor et al., 2006). About 21 percent of patients will be found to have gallstones immediately preoperatively or at the time of bariatric surgery and those patients should undergo cholecys-
tectomy at the time of gastric bypass operation (Nougou et al., 2008). Fifteen percent or more of patients will develop symptomatic gallstones following surgery (Swartz & Felix, 2005). Proponents for routine prophylactic cholecystectomy cite this high incidence of subsequent biliary tract disease. While laparoscopic cholecystectomy is usually technically possible following gastric bypass surgery (Tucker et al., 2008), patients with infrequent concomitant choledocholithiasis present an especially difficult challenge for the minimally invasive surgeon, given the limitations of access via endoscopic retrograde cholangiopancreatography (ERCP) resulting from the long biliopancreatic limb and excluded duodenum. However, access via the gastric remnant or percutaneous transhepatic routes are usually successful (Ahmed et al., 2007). Non-alcoholic pancreatitis is exceptionally rare and patients do not appear to be at an increased risk for biliary pancreas (Morino et al., 2007).

2 Long-Term Nutritional Complications

Patients must be consistently observed for nutritional deficiencies as they may cause serious morbidity. In one study, more than one-third of patients required supplementation to restore normal levels with more than just a standard multivitamin (Gasteyger et al., 2008). Because the duodenum is excluded, there is concern about the long-term risk of bone loss as a result of impaired calcium absorption, especially in females. While there are reports of a greater incidence of metabolic bone disease, it is still felt to be due to inadequate calcium or vitamin D intake (Duran de Campos et al., 2008). Eighty percent of obese patients undergoing RYGBP had preoperative serum 25-OH vitamin D levels of less than 32 ng/ml. After gastric bypass surgery 45% of these patients continued being vitamin D insufficient despite the treatment. Mahlay et al. (2008) demonstrated a statistically significant inverse correlation between BMI and 25-OH vitamin D levels. Patients should be encouraged to maintain adequate intake. Serum calcium levels may not predict total body calcium levels but measurement of 25-OH vitamin D and intact parathyroid hormone levels should reflect whether calcium intake is adequate (Avgerinos et al., 2007). Patients should receive supplementation with calcium citrate (1200 mg per day) and 400 IU of vitamin D (Youssef et al., 2007). Over the counter combination formulations are available.

Magnesium deficiency is very rare following gastric bypass surgery and levels have actually been found to increase in some patients (Johansson et al., 2008).

Like calcium, iron absorption is similarly impaired and anemia is a more frequent clinical concern. In addition, the food bolus does not encounter normal amounts of gastric acid secreted by the distal stomach, which results in impaired conversion of ingested ferric iron to absorbable ferrous iron (Vargas-Ruiz et al., 2008). Disturbing behaviors such as pica (eating of non-food substances) and pagophagia (excessive ice-eating) have been observed in patients with anemia following gastric bypass surgery (Kushner et al., 2005). Typical laboratory findings include low serum ferritin, elevated total iron binding capacity, low mean corpuscular volume, and decreased intracellular hemoglobin concentration. As such, iron deficiency anemia is typically hypochromic and microcytic (Avinoah et al., 1992). Severe iron deficiency anemia is often the result of menstruation or other occult blood losses and may require parenteral injection of iron or even packed red blood cell transfusion. A decreased amount of gastric acid further inhibits the absorption of iron. Anemia following gastric bypass surgery occurs in about ten percent of patients about correlates serum transferrin saturation (Coupaye et al., 2009). Patients should receive 200 – 400 mg of ferrous sulfate per day with vitamin C (to promote absorption) (Avgerinos et al., 2010).
Copper deficiency is very rare but may be a cause of hematological, myelodysplastic or neurological disease (Griffith et al., 2009). Patients may present with ataxia, anemia and neutropenia (Griffith et al., 2009). While clinically significant long-term sequelae are rare, deficiencies in zinc and selenium have been reported and should be supplemented (Gong et al., 2008). These minerals are typically available in sufficient quantity in daily multi-vitamins.

Thiamine deficiency may result from bacterial overgrowth in the small intestine and cause neurological complication. Inadequate levels are exceptionally rare and usually treated with supplementation and oral antibiotics (Lakhani et al., 2008). Protein malnutrition is also a very rare long-term consequence following a standard Roux-en-Y gastric bypass operation, occurring in less than one percent of patients (Skroubis et al., 2006).

Vitamin B12 deficiency has been reported to occur in up to one-third of bariatric surgery patients but is usually not by itself associated with anemia (Toh et al., 2008). Megaloblastic anemia resulting from gastric bypass surgery is very rare and has not been reported for decades (Drummond et al., 1985). While some have advocated prophylactic administration of probiotics to prevent it, simple sublingual or oral supplementation is successful (Woodard et al., 2009). A recent study has demonstrated a progressive decrease in vitamin A levels in up to thirty percent of patients following gastric bypass surgery, which has the long-term potential of a greater risk of maculopathy, osteoporosis and cardiovascular disease (Granado-Lorencio et al., 2009). Vitamin C deficiency has been reported in up to 32 percent of patients (Clements et al., 2006). Other vitamin deficiencies, riboflavin and vitamin E, are very rarely reported following gastric bypass surgery (Aasheim et al., 2009).

Neurological Complications

Potentially devastating, neurological complications have been reported to occur in up to 4 percent of patients after gastric bypass surgery. They are almost always the result of a micro-nutritional deficiency. Peripheral mono- and polyneuropathy, Wernicke's encephalopathy, and Guillain-Barre syndrome have been reported (Koffman et al., 2006). Wernicke syndrome is a rare neurological pathology due to a deficit in vitamin B1. The syndrome is common among alcohol abusers, patients with malignant tumor or gastrointestinal diseases, those who undergo hemodialysis or long-term peritoneal dialysis, pregnant women with hyperemesis, women who breast-feed, patients with hyperthyroidism or anorexia nervosa and gastric bypass surgery for obesity, patients submitted to prolonged total parenteral nutrition or pro-
longed intravenous therapy. It is often preceded by intractable emesis. In one study, symptoms commonly began one decade after surgery and were not associated with a specific nutritional deficiency. Nutritional repletion did not always result in resolution of the neurological complication and the best outcome was associated with reversal of the gastric bypass (Juhasz-Pocsine et al., 2007). Cerebral dry beriberi, while rare, is due to thiamine deficiency and might be more common in adolescent patients that undergo gastric bypass surgery than in adults (Towbin et al., 2004). Patients with new neurological symptoms should be screened with a comprehensive nutritional panel and be immediately referred to a neurologist.

4 Renal Complications

Kidney stones are reported with relative frequency during the first few months following gastric bypass operation. In one study, 7.7 percent of gastric bypass patients developed renal calculi compared to a matched control group 3.6 percent of patients over a three-year period (Matlaga et al., 2009). Rare long-term renal failure has been reported due to hyperoxaluria. It is postulated that rare fat malabsorption is the etiology. This most often occurs in patients with underlying renal disease, hypertension and diabetes (Nasr et al., 2008).

5 Hepatic Complications

Hepatic steatosis is common among patients with morbid obesity and generally improves after gastric bypass surgery. Rare reports of disease progression, without clear etiology, have suggested that rare patients may advance to liver failure and have had to undergo liver transplantation (D'Albuquerque et al., 2008).

6 Long-Term Endocrine Effect

Hypoglycemia is common in the early post-operative course and is typically remedied with a low carbohydrate diet (Bantle et al., 2007). However, insulin regulation and glucose metabolism continues to be abnormal in many patients, years after gastric bypass surgery (Kim et al., 2009). It is postulated that glucagon-like peptide 1 (GLP-1) response and a disruption of the relationship between insulin sensitivity and insulin secretion required maintaining plasma glucose in the normal range is affected by changes resulting following gastric bypass surgery. The mechanism is postulated by some to be the result of an exaggerated postprandial GLP-1 and blunted insulin-tropic peptide secretion (Korner et al., 2007). Low serum glucose and high C-insulin peptide levels are the hallmark of the diagnosis. Patients with refractory disease may require pharmacological treatment with verapamil and acarbose. Although the GLP-1 response to meal intake is steadily elevated after RYGBP, this does not result over time in the development of an inappropriate insulin secretion relative to the prevailing insulin sensitivity or the occurrence of hypoglycemic episodes. Changes in levels of five enteric hormones have been recently associated with early postoperative glycemic control following Roux-en-Y gastric bypass. The strongest effects are seen with variations in glucagon-like peptide-1, glucose-dependent insulin tropic peptide and ghrelin. The anatomic restriction and dynamic absorptive following gastric bypass explains the short-term and long-term
resolution of diabetes in patients undergoing Roux-en-Y gastric bypass. Mingrone et al. (2009) postulated that gastric bypass surgery promotes incretin secretion, which, in turn, stimulates insulin secretion while insulin sensitivity is slightly improved.Rarely, the long-term effect of incretin hypersecretion might result in hypertrophy and hyperplasia of the islets of Langerhans, which is otherwise known as nesidioblastosis, associated with hyperinsulinaemia and even severe postprandial hypoglycemia. Hypoglycemia from pancreatic nesidioblastosis has been reported but appears to be different from the neonatal syndrome. This is thought to occur as a result of the lack of gastric restriction, resulting in dumping. The treatment remains controversial (Service et al., 2005). Banding of the gastro-jejunal anastomosis has been reported to be successful with only the most severe cases subjected to partial pancreatic resection (Z'graggen et al., 2008). When pancreatic resection is performed, some advocate near total pancreatectomy to restore euglycemia to the most symptomatic cases (Clancy et al., 2006).

Change in gut hormones levels have been measured and appear to contribute to weight loss by mediating eating behaviors by reducing food intake. Le Roux reported that there are increased levels of pancreatic peptide YY (PYY) following gastric bypass surgery (le Roux et al., 2006). These increased levels of PYY promote weight loss by also decrease intestinal transit time (Suzuki et al., 2005). A failure to sustain elevated PYY levels has been shown to be a factor in weight regain years after gastric bypass and occurs in about twenty percent of patients (Meguid et al., 2008).

7 Female Reproductive Consequences

The majorities of patients that undergo bariatric surgery are female and most are of reproductive age. Females between the ages of 18 and 45 represent 49 percent of all patients that undergo gastric bypass operation. Clearly there is a benefit to women with infertility secondary to their obesity. On the other hand, despite years of experience there are still some remaining controversies regarding recommendations for pregnancy. Intra-uterine growth retardation is still reported despite careful pre-natal follow-up (Guelinckx et al., 2009). Congenital anomalies were reported early in the experience with pregnancies soon after gastric bypass surgery. Neural tube defects (meningomyelecele, spina bifida and anencephaly) have been reported but are fortunately very rare (Knudsen et al., 1986). Most are presumed to be the result of folate deficiency and this should be supplemented and blood levels checked six months prior to conception (Moliterno et al., 2008). A recent meta-analysis of pregnancies after gastric bypass has clearly demonstrated that pregnancy is safe and in many cases safer than in morbidly obese patients that have not had bariatric surgery. Pregnant patients had a lower maternal complication rate after bariatric surgery than in obese women without bariatric surgery and the rates approach those of non-obese patients. No differences in neonatal outcomes were found after gastric bypass compared with non-obese controls for premature delivery, low birth weight, or for macrosomia (Maggard et al., 2008). Current recommendations are to wait 18 months after surgery prior to conception (Wax et al., 2008).

8 Musculoskeletal Manifestations

Musculoskeletal problems and arthritis are prevalent among morbidly obese patients. Gastric bypass operations predispose patients to severe vitamin D deficiency and osteomalacia in the absence of inadequate pharmacologic doses of vitamin D therapy. A concern about increased skeletal fragility secondary to ac-
celerated bone loss following bariatric procedures has arisen. Bone density outcomes following bariatric surgical treatment for morbid obesity have demonstrated evidence of hip and lumbar spine areal bone mineral density (aBMD) reductions primarily in women despite calcium and vitamin D supplementation. Femoral neck aBMD declines of 9-11% and lumbar spine aBMD reductions up to 8% were reported by Scibora et al. (2012) at the first post-operative year following gastric bypass surgery. Of those studies reporting development of osteoporosis following gastric bypass, one woman became osteoporotic after 1 year. Despite observed bone loss in the hip region post-surgery, the data do not conclusively support increased incidence of osteoporosis or increased fracture risk in post-bariatric patients. Current supplementation recommendations are inadequate in this high-risk population, and the clinical presentation of osteomalacia is both nonspecific and often misleading, according to Al-Shoha et al. (2009). Bruno et al. (2010) measured bone specific alkaline phosphatase (BAP), N-telopeptide of type 1 collagen (NTX), PTH, 25-hydroxy vitamin D, and leptin. They found that serum calcium, phosphate, and PTH levels were unchanged at 18 months, but that 25-hydroxy vitamin D was increased. In addition, the increase in NTX correlated with reduction in serum leptin. Serum BAP and NTX were increased. Calcium, phosphate, and PTH were unchanged, but 25-hydroxy vitamin D increased with supplementation. The increase in NTX correlated with reduction in BMI and leptin and the increase in serum 25-hydroxy vitamin D. They also reported that reduction in leptin was a significant predictor of increase in NTX, but changes in BMI and 25-hydroxy vitamin D were not.

While rhabomyolysis has been observed as a result of prolonged immobilization during prolonged gastric bypass surgery, it is rare and it is rare following surgery. Muscle mass is well preserved in patients and would only be expected to be affected in the rare patient with hypoproteinemia. Similarly, gastric bypass patients should not be an increased risk for bone loss, if adequate calcium intake is maintained.

Patients with severe arthritic changes before surgery should be cautioned about taking non-steroidal anti-inflammatory agents for their symptoms because these medications have been associated with an increased risk of marginal ulcer and gastrointestinal bleeding (Felix et al., 2008). In general, musculoskeletal problems improve in patients after bariatric surgery (Hooper et al., 2007).

9 Long-Term Cancer Risks

Gastric carcinoma several years after gastrectomy for peptic ulcer disease has increased concerns of the potential for there to be an increased incidence of gastric cancer several years after Roux-en-Y gastric bypass surgery for morbid obesity. This association was published almost three decades ago by Welch and others decades ago (Orlando et al., 1981). These cancers developed an average of 18 years after surgery. This might be due to changes in mucosal exposure to gastric acid and oral intake. Alkaline bile reflux, achlorhydria and bacterial colonization were suggested as possible causes. While the site of the carcinoma is typically at or near the gastro-jejunal anastomosis, it is expected that some patients would be expected to develop cancer of the gastric remnant. However, endoscopic evaluation of the gastric remnant is not easily performed. Thus far, reports of carcinoma of the stomach following gastric bypass surgery are only sporadic but may be diagnosed at a more advanced stage (Sun et al., 2008; Watkins et al., 2007; Escalona et al., 2005). A Roux-en-Y alimentary limb would be expected to produce less alkaline gastritis than a Billroth II anastomosis and therefore the long-term incidence of gastric carcinoma follow-
ing gastric bypass should be much less. Percutaneous endoscopy of the gastric remnant and CT may assist in establishing the diagnosis (Carucci et al., 2007).

10 Conclusions

Roux-en-Y gastric bypass surgery for the treatment of morbid obesity has had an excellent safety record over the past 15 years. More than a million patients have had tremendous benefit from this operation. Weight loss is sufficient and generally predictable. It has resulted in durable weight loss, reversal of severe co-morbid conditions, and increase in longevity and improvement in the quality of life. Most patients will not require a serious medical or surgical intervention for an early or late complication. Nevertheless, prospective patients must be aware that they require lifelong follow-up and surveillance for untoward clinical events resulting from this operation. Compliance with required vitamin supplementation is essential. Many complications may be avoided with proper nutritional monitoring. Most serious problems are rare, and may be treated with prompt and careful clinical evaluation by knowledgeable practitioners and proper patient compliance. Physicians and surgeons who treat patients after gastric bypass surgery need to be aware of these long-term side effects.

References


