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Laparoscopic Reversal of Roux-en-Y Gastric Bypass: Technique and Utility for Treatment of Endocrine Complications

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Abstract

Background—The anatomical and physiological changes with Roux-en-Y gastric bypass (RYGB) may lead to uncommon but occasionally difficult to treat complications such as hyperinsulinemic hypoglycemia with neuroglycopenia and recalcitrant hypocalcemia associated to hypoparathyroidism. Medical management of these complications is challenging. Laparoscopic reversal of RYGB anatomy with restoration of pyloric function and duodenal continuity is a potential treatment.

Objective—To present the indications, surgical technique and clinical outcomes of laparoscopic reversal of RYGB.

Setting—Tertiary Academic Medical Center, United States.

Methods—Prospective study of consecutive patients offered laparoscopic reversal of RYGB.

Results—Five patients with remote laparoscopic RYGB underwent laparoscopic reversal of RYGB to normal anatomy (n=2) or modified sleeve gastrectomy (n=3). Indications were medically refractory hyperinsulinemic hypoglycemia with neuroglycopenia (n=3), recalcitrant hypocalcemia with hypoparathyroidism (n=1) and both conditions simultaneously (n=1). Prior to reversal all patients had a gastrostomy tube placed in the excluded stomach to document improvement of symptoms. Laparoscopic reversal was accomplished successfully in all patients. Three post-operative complications occurred; bleeding that required transfusion, gallstone pancreatitis and a superficial trocar site infection. Average length of stay was 3 days. At a mean follow-up of 12 months (range 3 to 22), no additional episodes of neuroglycopenia occurred, average number of

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hypoglycemic episodes per week decreased from 18.5 ± 12.4 to 1.5 ± 1.9 ($p=0.05$) and hypocalcemia became responsive to oral replacement therapy in both patients.

Conclusions—Laparoscopic reversal of RYGB to normal anatomy or modified sleeve gastrectomy is feasible and may be a therapeutic option for selected patients with medically refractory hyperinsulinemic hypoglycemia and/or recalcitrant hypocalcemia associated to hypoparathyroidism.

Keywords

Hypoglycemia; hyperinsulinemic hypoglycemia; hypocalcemia; gastric bypass; reversal; sleeve gastrectomy; GLP-1; hypoparathyroidism; nesidioblastosis; laparoscopic reversal; bariatric surgery

INTRODUCTION

The anatomical changes with Roux-en-Y gastric bypass (RYGB) allows the food bolus to promptly reach the small bowel after passing through the gastrojejunostomy, and the excluded stomach and duodenum have no contact with the food bolus. These changes lead to alterations in glucose kinetics¹, absorption of micronutrients and minerals² and post-prandial levels of a variety of gastrointestinal (GI) and pancreatic hormones³. With standard micronutrients and minerals supplementation and dietary modifications, most patients adapt and benefit from these changes after RYGB; as exemplified by low rates of nutritional complications⁴ and the outstanding remission and also prevention rates of type 2 diabetes observed after RYGB^{5, 6}. However, these anatomical changes may lead to uncommon, but challenging to treat complications, such as hyperinsulinemic hypoglycemia with or without hypoglycemia unawareness^{7, 8} and recalcitrant hypocalcemia related to hypoparathyroidism and inadvertent parathyroidectomy^{9, 10}. The etiology hyperinsulinemic hypoglycemia remains controversial and best treatment recommendations for these conditions is unknown. In patients with recalcitrant post-RYGB hyperinsulinemic hypoglycemia, surgical treatment with sub-total or total pancreatectomy has been offered in selected cases^{11, 12}, as the condition has been linked to de novo post-RYGB nesidioblastosis, or pancreatic islet overgrowth as its potential cause¹². However, this pathologic finding has been challenged by other groups and clinical results with pancreatectomy are sub-optimal^{13–15}. Lastly, recalcitrant hypocalcemia with associated hypoparathyroidism has been recently described in patients with RYGB^{10, 16} and no standard treatment is available.

Laparoscopic reversal of RYGB anatomy with restoration of pyloric function and duodenal continuity may be a last resort therapeutic option in these rare cases. In this manuscript we present examples of these unique medical indications, guidelines for pre-operative clinical evaluation, details of surgical technique and clinical outcomes of laparoscopic reversal of RYGB. This represents a novel approach to rare but challenging endocrine complications after RYGB surgery.

MATERIAL AND METHODS

We conducted a prospective study of patients that had prior remote RYGB and presented with medically refractory and well documented episodes of hyperinsulinemic hypoglycemia with hypoglycemia unawareness and/or patients with recalcitrant hypocalcemia related to hypoparathyroidism due to previous inadvertent parathyroidectomy. Patients were jointly evaluated by the Section of Foregut and Bariatric Surgery and Endocrinology Service. Patient's demographics prior to RYGB, RYGB technique and other pertinent history were obtained by review of medical records. Patients' demographics, pre and post-operative symptom evaluation, diagnostic and therapeutic strategy, and clinical outcomes were prospectively collected.

The diagnosis of hyperinsulinemic hypoglycemia with neuroglycopenia was based on medical history and documentation of multiple episodes of hypoglycemia, normal fasting c-peptide and insulin levels, review of data from glucometer and/or continuous glucose monitoring study (CGMS) and testing as indicated below. Pre-operative clinical data were obtained while patients were on maximally tolerated medical therapy. Post-operative clinical data were obtained at last follow-up visit. Prior to medical treatment patients had an upper GI endoscopy to document the RYGB anatomy and an abdominal and pelvic computed tomographic (CT) scan to exclude other possible causes for the symptoms. In addition, a 2-hour 75 g oral glucose tolerance test (OGTT) was obtained to document post-prandial hyperinsulinemia and hypoglycemia.

Patients with hyperinsulinemic hypoglycemia were initially treated with standard dietary modifications, consisting of minimizing intake of simple carbohydrates and increasing intake of fiber and protein. In addition, pharmacologic treatment was attempted with escalating doses and combinations of acarbose, diazoxide, and/or verapamil. Glucagon was used as needed for neuroglycopenia.

The diagnosis of recalcitrant hypocalcemia related to hypoparathyroidism due to previous inadvertent parathyroidectomy was based on medical history, documentation of multiple episodes of hypocalcemia and a low intact parathyroid hormone (PTH) level. Patients were initially treated with escalating doses of calcium citrate tablets, calcium carbonate (CaCO₃) suspension, calcitriol, ergocalciferol, and/or subcutaneous recombinant parathyroid hormone (rPTH). Both patients required frequent hospital admissions for intravenous calcium infusions as well.

After failed attempts of medical management, a laparoscopic gastrostomy tube (G-tube) was inserted in the excluded stomach. The tube was used to deliver nutrients and/or calcium supplementation to the excluded stomach and the duodenum. Patients had the gastrostomy tube in place for 8–12 weeks prior to reversal surgery. If nutritional and medication administration through the G-tube resulted in symptom improvement, patients were then considered candidates for reversal. After G-tube insertion we recommended 3 times daily administration of a standardized nutritional supplementation through the G-tube consisting of 450 kcal in 150 mL liquid containing 9.9 g of simple sugars in a total of 38 g carbohydrate, 10 g of fat, and 15 g of protein. Patients were monitored clinically for two

weeks for symptoms of hypoglycemia. At 4 weeks after G-tube insertion, all patients underwent a Meal Tolerance Test (MTT), by administering, through the G-tube, a standardized 300 kcal in 100 mL liquid meal containing 9.9 g of simple sugars in a total of 38 g carbohydrate, 10 g of fat, and 15 g of protein. Blood samples, obtained through an intravenous catheter inserted in the forearm, were drawn at 0, +5, +15, +30, +60 +120, and +180 minutes relative to the end of the meal administration. After collection, the samples were processed on site and stored at -70°C for subsequent batch analysis of glucose levels.

The surgical treatment was offered under the guidelines for innovative medical therapy¹⁷ and a clinical research project to study symptom improvement after laparoscopic reversal was approved by the Institutional Review Board and Clinical Research Center (CRC) Advisory Committee. Written consent was obtained from each participant.

Technique for Laparoscopic Reversal of RYGB: circular stapled gastro-gastrostomy with the trans-oral anvil

Under general anesthesia and in a modified lithotomy position, pneumoperitoneum was obtained at 15mmHg using a direct trocar insertion or Hasson technique. Additional two 5 mm trocars (subxyphoid for liver retraction and left flank for retraction), and three 12 mm trocars (left upper quadrant for dissection and insertion of circular stapler; right flank and left to the umbilicus for dissection and linear stapling) were inserted. Dissection of adhesions from the undersurface of the left lobe of the liver was done using a combination of sharp and ultrasonic dissection and a liver retractor placed. After taking down the gastrostomy site, the gastrojejunostomy was identified; the alimentary limb was measured to the jejunum-jejunostomy and from the jejunum-jejunostomy to the ileo-cecal valve. The gastrojejunostomy was dissected free circumferentially to allow space for a 4.8mm linear stapler to divide the gastric pouch at a location immediately above the gastrojejunostomy (Figure 1). After ascertaining presence of a minimum of 3.0 meters from the jejunum-jejunostomy to the ileo-cecal valve, the alimentary limb was excised using ultrasonic coagulation and 2.5mm linear staplers; preserving the jejunum-jejunostomy (Figure 1). The greater curvature of the stomach was opened to accommodate the circular stapler. The gastro-gastric anastomosis was performed using a 25-mm anvil (OrVil, Autosuture, Norwalk, CT, USA) passed trans-orally through a small opening in the stapled gastric pouch (Figure 2), using a technique similar to the one used to create a standard gastrojejunostomy, but with a 4.8mm staple height stapler. The OrVil™ 25-mm combines the anvil head, secured in the tilted position, mounted on a 90-cm long polyvinyl chloride (PVC) delivery tube and secured to the tube with a suture. The PVC delivery tube is inserted through the patient's mouth, delivered through a small opening in the stapled gastric pouch and pulled from one of the abdominal port sites to assist bringing the anvil shaft into the gastric pouch. Once the anvil shaft has been exteriorized through the gastric pouch, the suture that holds it to the delivery tube is cut and the tube is disconnected from the anvil while holding the anvil in place. The anastomosis was completed by joining the anvil to an end-to-end circular stapler (EEA XL 25 mm with 4.8-mm staples, Autosuture, Norwalk, CT, USA), inserted into an opening of the greater curvature of the stomach (Figure 2). Then, the EEA stapler and anvil were removed, and the anastomosis was inspected and reinforced at the corners with 2-0 braided polyester sutures. If reversal without a sleeve gastrectomy was chosen, the greater

curvature of the stomach opening was closed using an additional firing of a 3.5-mm linear stapler (Figure 3). If reversal with a sleeve gastrectomy was chosen, the gastroepiploic arcade was divided about 4 cm from the pylorus and the gastric fundus completely mobilized. A 12mm (36FR) gastroscope was inserted under direct endoscopic visualization through the gastro-gastric anastomosis into the duodenum and the sleeve created by sequential firings of linear staplers (4.8mm height in the gastric antrum and 3.5 mm height in the gastric body and fundus) while taking care not to encroach on the newly created gastro-gastric anastomosis (Figures 4 and 5). Suture line reinforcement was routinely used while creating the modified sleeve and a leak test was performed.

Post-operative care

On POD # 1, all patients underwent an upper GI radiological examination under fluoroscopic guidance with gastrografen initially, followed by thin diluted barium. After imaging was reviewed, a liquid diet was started and patients were discharged when tolerating a pureed diet.

Statistical Analysis

Data are summarized as mean and standard deviation unless otherwise stated. Changes in continuous variables were compared within patients using two-tailed paired t tests. Statistical significance was considered to be $p < 0.05$. SPSS, version 13.0.1 (SPSS Inc, Chicago, IL, USA), was used for all statistical analyses.

RESULTS

From March 2011 to October 2012, five patients underwent laparoscopic reversal of RYGB to normal anatomy ($n=2$) or modified sleeve gastrectomy ($n=3$). Mean age was 43 (range, 38–49), 4 female and 1 male, mean Body Mass Index (BMI, weight in kilograms divided by the square of height in meters) prior to index RYGB was 43 (range 38–49), and index RYGB was on average done 4.6 years (range 3 to 8 years) before reversal. Average BMI immediately prior to reversal was 28 (range 25–33).

The indications for reversal were medically refractory hyperinsulinemic hypoglycemia ($n=3$), recalcitrant hypocalcemia with hypoparathyroidism ($n=1$) and hyperinsulinemic hypoglycemia combined with recalcitrant hypocalcemia with hypoparathyroidism ($n=1$).

All patients with hyperinsulinemic hypoglycemia had multiple documented episodes of hypoglycemia unawareness/neuroglycopenia and/or seizures. The average documented number of hypoglycemic events per week were 18.5 (range 8 to 35). Prior to reversal, OGTT documented normal fasting levels of insulin (6.1 ± 2.9 microU/mL) and glucose (82.6 ± 10.9 mg/dL), followed by hyperinsulinemia at 30 minutes (227.3 ± 113.3 microU/mL) and hypoglycemia at 60 to 120 minutes (50 ± 11.3 mg/dL).

Both patients with recalcitrant hypoparathyroidism had multiple hospital admissions and/or emergency room visits for severe, symptomatic hypocalcemia despite maximum oral replacement.

Prior to reversal all patients had a laparoscopic G-tube placed in the excluded stomach. During the two weeks while receiving nutritional supplementation through the G-tube, the patients with medically refractory hyperinsulinemic hypoglycemia reported no hypoglycemia symptoms. No patient developed hypoglycemia during the MTT administered through the G-tube.

Laparoscopic reversal was offered 8 to 12 weeks after laparoscopic G-tube was placed. Laparoscopic reversal was successfully accomplished in all patients. The average laparoscopic reversal surgery duration was 175 min (range 125 to 230 min) and estimated blood loss 50 mL (range 30 to 100 mL). Three 30-day post-operative complications occurred; a limited postoperative bleed (without GI manifestations, most likely from intra-abdominal stapler lines or dissection sites) that required transfusion of 3 units of red blood cell, a superficial trocar site infection and a readmission for gallstone pancreatitis that was treated by laparoscopic cholecystectomy. Average length of stay was 3 days (range 2 to 5). One patient developed a symptomatic trocar site hernia at 9 months follow-up that was treated with surgery.

At a mean follow-up of 12 months (range 3 to 22 months), no additional episodes of neuroglycopenia occurred. The average number of documented hypoglycemic events per week decreased to 1.5 ± 1.9 , range 0 to 4 ($p=0.05$). Patients had no or minimal symptoms with the documented episodes. Hypoparathyroidism became amenable to oral replacement therapy. Both patients are maintaining serum calcium at a goal of around 8 mg/dL, one receives calcium citrate 600 mg/day, calcitriol 2 mcg/day and vitamin D2; the other calcium citrate 1200 mg/day, calcitriol 1 mcg/day and vitamin D2.

The average BMI at last follow-up after reversal was 28.4 (range 21 to 41), thus did not change significantly from before reversal ($p=0.9$). Two patients gained weight; one with reversal to normal anatomy (pre-reversal BMI of 25 to BMI of 31 at 22 months follow-up) and one patient after a modified sleeve gastrectomy (pre-reversal BMI of 33 to BMI of 41 at 10 month follow-up); while the other 3 patients lost weight (BMI 26 to 21, 33 to 26 and 29 to 23).

DISCUSSION

In this study we describe the technique for laparoscopic reversal of RYGB to normal anatomy or modified sleeve gastrectomy using a circular stapler for the gastro-gastrostomy. We also show that laparoscopic reversal may be a therapeutic option for selected patients with medically refractory hyperinsulinemic hypoglycemia with hypoglycemia unawareness and/or recalcitrant hypocalcemia secondary to hypoparathyroidism.

Laparoscopic reversal of RYGB to normal anatomy for reasons other than hypoglycemia¹⁸ or sleeve gastrectomy for weight regain after RYGB¹⁹ has originally been published by a Belgium group, and laparoscopic reversal of RYGB to sleeve gastrectomy has been recently been described as an option for 'intractable dumping syndrome' and excessive weight loss²⁰. To our knowledge, this is the first case series of laparoscopic reversal of RYGB used to treat hyperinsulinemic hypoglycemia with hypoglycemia unawareness and/or recalcitrant

hypocalcemia due to hypoparathyroidism. In addition, our technique for reconstruction, using a circular stapler for the gastro-gastrostomy is, in our opinion, simpler, safe and reproducible in most hands. The resection of the alimentary limb may not be necessary or desired; thus a possible safe technical alternative could be to divide the jejuno-jejunostomy and re-connect the bilio-pancreatic limb to the proximal end of the alimentary limb. There were some post-surgical complications, but all were resolved in a short time frame with appropriate intervention. Overall, the treatment required for any post-operative complications was relatively minimal in comparison to that needed for their pre-operative endocrine conditions. In view of the symptomatic improvement in all patients, we propose that laparoscopic reversal of RYGB should be considered as a safe treatment option for hyperinsulinemic hypoglycemia with hypoglycemic unawareness and for recurrent severe hypocalcemia due to hypoparathyroidism.

The etiology, prevalence, diagnostic algorithm and treatment recommendations for hyperinsulinemic hypoglycemia after RYGB are still controversial²¹. The prevalence of symptomatic hyperinsulinemic hypoglycemia after RYGB is estimated to be from 0.3 to 1%²², while asymptomatic postprandial hypoglycemia may have a prevalence of up to 72% after ingestion of large amounts of carbohydrate^{23, 24}. Symptomatic hyperinsulinemic hypoglycemia has been described many years ago and is known to most gastrointestinal and general surgeons and the general medical community as part of the commonly described 'Dumping Syndrome' after gastric resection^{25, 26}. For most RYGB patients 'dumping' symptoms may be beneficial as they learn to avoid dense foods with simple carbohydrates and even when persistent, these symptoms can be managed with additional dietetic counseling and medications, without revisional surgery in the majority of patients²⁷. It has been demonstrated that the anatomical changes with RYGB, i.e. the small gastric pouch connected without a sphincter to the jejunum, lead to changes in postprandial glucose kinetics¹ and gastrointestinal and pancreatic hormones that are known to regulate blood glucose and affect other glucose regulatory mechanisms²⁸. Though these changes are beneficial in the majority of patients with type 2 diabetes and also non-diabetics given their underlying insulin resistance²⁸, it may lead to recurrent symptoms of hyperinsulinemic hypoglycemia in a few patients. In the small subset of patients that develop postprandial hypoglycemia after RYGB that is recalcitrant to dietary and medical therapy, recurrent hypoglycemia can lead to hypoglycemic unawareness, seizures, and significant disability.

Hypoglycaemia is important because it is associated with deprivation of the sole source of fuel to the brain, which shows detectable malfunction at plasma glucose of around 54 mg/dl. With persistence of hypoglycemia this can evolve to confusion, reduced conscious level, coma, seizures and even death. The standard regulatory mechanisms activated to respond to hypoglycemia involve reduction in endogenous insulin secretion, increased release of pancreatic glucagon, increase in hepatic and glucose production by glycolysis and gluconeogenesis, activation of the sympathetic nervous system with adrenaline release, growth hormone, cortisol, among others²⁹. After RYGB these regulatory mechanisms are affected by the changes related to RYGB anatomy. The postprandial changes in glucose kinetics, GI and pancreatic hormones likely affect some of the dynamics involved in the body response to hypoglycemia and thus add to the difficulty in treating some of these patients.

Earlier reports suggested that increased pancreatic beta cell mass or nesidioblastosis was causative in patients with hyperinsulinemic hypoglycemia¹² and some centers have offered subtotal or total pancreatectomy as a surgical solution for medically refractory hyperinsulinemic hypoglycemia^{12, 27, 30}. However, the data from the original publication that supported the existence of novo nesidioblastosis after RYGB¹² has been disputed using a different control group from autopsy specimens¹³, so it remains unclear whether pancreatectomy actually addresses the underlying pathophysiology leading to hypoglycemia. Sub-total or total pancreatectomy has elevated perioperative morbidity and may lead to brittle diabetes and other dysfunction related to extensive or complete pancreatic resection^{31, 32}. Additionally, partial pancreatectomy does not lead to resolution of symptoms in some patients³⁰. Therefore, we propose that laparoscopic reversal of RYGB provides a safer and potentially more effective treatment option for recalcitrant hypoglycemia.

After RYGB, calcium and vitamin D absorption is impaired and patients with combined hypoparathyroidism and RYGB are at greater risk for persistent and recurrent severe hypocalcemia^{16, 33}, as exemplified in our patients. Hypoparathyroidism is a known complication of total thyroidectomy and with high volume endocrine surgeons the risk of definitive hypoparathyroidism is low at around 0.7%. However higher rates are reported when thyroidectomy is done by lower volume surgeons³⁴. The risk of hypoparathyroidism is acceptable in a normal population as the traditional treatment of hypoparathyroidism following total thyroidectomy is successful in most patients with ingestion and absorption of high doses of calcium and vitamin D. However in patients with RYGB, total thyroidectomy needs to be carefully considered. For example, one of our patients had a total thyroidectomy after RYGB for a benign goiter, which may not be a necessary surgery given the potential risks. If necessary, we suggest total thyroidectomy in patients with a history of RYGB should be performed only by experienced surgeons, after obtaining informed consent regarding the increased morbidity of potential of hypoparathyroidism. In addition, we suggest that patients considering RYGB need to be carefully screened for history of total thyroidectomy and/or hypoparathyroidism. Our two patients had severe recurrent hypocalcemia, requiring frequent intravenous calcium infusions, hospitalizations, and disability. Post-operatively, they were controlled with traditional oral calcium and vitamin D replacement. We propose that laparoscopic reversal of RYGB is a safe, effective treatment for life-threatening hypocalcemia due to hypoparathyroidism in individuals with RYGB.

A common concern of all patients was weight regain, but all opted for revisional surgery in view of their debilitating symptoms. Laparoscopic reversal to a modified sleeve gastrectomy may offer the better chance to decrease the possibility for weight regain. However, sleeve gastrectomy is also associated with changes in glucose kinetics, gut and pancreatic hormones, which are to a lesser degree than what is seen after RYGB, but may possibly leave these patients still at some risk for hypoglycemic events³⁵. For these reasons, two patients in our series opted for reversal to normal anatomy as opposed to reversal to sleeve gastrectomy. In addition, the insertion of a G-Tube may not be an essential step in all these patients, but further research is needed to define best practices. Limitations of our study include a small sample size, relatively short follow-up and lack of detailed metabolic data to document the changes in glucose kinetics, calcium and hormone levels.

CONCLUSION

In view of these limitations, we have shown that laparoscopic reversal of RYGB to normal anatomy or modified sleeve gastrectomy is feasible and may successfully reduce hypoglycemic events and significantly improve symptoms in selected patients with medically refractory hyperinsulinemic hypoglycemia and/or recalcitrant hypocalcemia with hypoparathyroidism.

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Figure 1.
Division of the gastro-jejunosomy and Alimentary Limb just above the jejuno-jejunosomy using linear staplers.

Figure 2.
Gastro-gastric anastomosis: 25mm trans-oral anvil in the gastric pouch being connected to the 4.8mm, 25 mm circular stapler inserted in the excluded stomach.

Figure 3.
Final aspect – Laparoscopic reversal to “normal” anatomy.

Figure 4.
Final aspect – Laparoscopic reversal to modified sleeve gastrectomy.

Figure 5.