Simultaneous Robotic Placement of Gastric Electrical Neurostimulation System and Pyloroplasty in Gastroparesis Patients

Early diagnosis and treatment of gastroparesis eludes pharmacologic solutions. Gastroparesis starts as a clinical disorder which progresses to nausea and emesis resulting from chronic food retention and gastric distention. The negative feedback loop occurs when this disease becomes refractory to pharmacologic treatments, limited by multiple side effects and when pain results in narcotic dependence. The deteriorating condition leads to malnutrition and recurrent hospitalizations. Since the 1990’s Dr. Richard McCallum has been a pioneer in gastric electrical neurostimulation to interrupt the cycle of nausea and emesis. Over the last 6 years our experience at Texas Tech University Health Sciences Center, El Paso has led to the evolution of a robotic technique for simultaneous gastric electrical neurostimulation and pyloroplasty. This provides a concise algorithm for treatment with advocacy for early surgical intervention using a novel robotic platform that minimizes the surgical insult thus speeding recovery from this debilitating disorder.

Burden of Disease

Gastroparesis is a chronic motility disorder that affects an estimated 2-4% of the United States population.1 Gastroparesis and its symptoms can drastically affect a patient’s quality of life. Frequent episodes of vomiting up to dozens of times per week, frequent ED visits and hospitalizations result in a great economic burden in the setting of patient disability. In 2004, gastroparesis as the primary diagnosis for hospital admission amounted to more than 200 million dollars in hospital costs.5 This is an increase of 138% from the prior decade, and appears to be increasing as more recognition of this entity leads to more testing to diagnose and manage the disease.2

Initial Presentation

In gastroparesis the stomach is not able to empty at its normal rate, due to a variety of mechanisms, and a...
post-surgical (e.g. post-vagotomy). Early diagnosis is critical since they are susceptible to complications of nutrition which affects surgical wound healing; intervention will improve overall long-term morbidity and mortality.5

Pathophysiology of Disease
Suspected mechanisms of gastroparesis in diabetic patients include autonomic neuropathy, injured or depleted interstitial cells of Cajal, and impaired antral contractions. A recent report by Othman et al. (2015) described successful endoscopic ultrasound guided biopsies of the antral muscularis propria and demonstrate depletion of cells of Cajal in gastroparesis patients. This innovation may unlock one of the keys to early diagnosis since depletion of the cells of Cajal correlates strongly with response to gastric electrical stimulation.6

Initial Pharmacologic Therapy
Mainstays of treatment are optimizing oral nutritional support and pharmacologic therapy with pro-motility agents. The dopamine D2 receptor antagonist metoclopramide (Reglan) is the only FDA-approved medication used for the treatment of gastroparesis. Symptom improvement and accelerated gastric emptying have been noted in many small trials that studied metoclopramide versus placebo.7 Limiting factors for long-term use of this agent are potential side-effects which include acute dystonias and tardive dyskinesia. Domperidone (dopamine 2 antagonist) is used for the treatment of gastroparesis and has shown improvement in symptoms and overall reduction in hospital admissions and has none of the CNS side effects of metoclopramide. This medication is not FDA approved in the United States, and as such, is not readily available.8 Erythromycin, a macrolide antibiotic, acts as a motilin receptor agonist and promotes gastric motility – it is commonly used intravenously as a temporary treatment for delayed gastric emptying in critical care units. In various studies when given orally, it has been shown to significantly improve symptoms and accelerate gastric emptying in both idiopathic and diabetic gastroparesis initially but long-term use is limited by tachyphylaxis and as dose tolerance develops.9

Indications for Surgical Therapy
Traditional surgical therapy has included procedures extending from access for enteral nutrition to the radical options of subtotal and total gastrectomy. Enteral access (gastrostomy for venting of the stomach or jejunostomy) are largely temporizing measures to prevent muscular wasting. These enteral tubes fail to halt progression of the disease or prevent chronic overmedication for pain. These pain medications play a central confounding role since they inhibit gastric and small intestinal motility and the migratory motor complex (MMC). Subtotal and total gastrectomy procedures remove the source of chronic emesis. Despite the obvious logic behind removal of part or all of the stomach the resulting post operative side effects including chronic malnutrition has reduced acceptance of this radical option in addition to its own operative morbidity and mortality.10

Gastric Electrical Neurostimulation (GES) (Enterra Therapy)
This intervention has the best results to prevent the development of the complications of chronic gastroparesis. Gastric electrical stimulation has been pioneered for 20 years as the premier investigative
therapy to address the chronic cycle of symptoms. Enterra therapy (Medtronix Corp, Milwaukee, WI) remains under investigatory human device exemption (HDE) for use in IRB approved programs per FDA regulations. Gastric electrical stimulation is effective in the long-term reduction of nausea and emesis in up to 60% of patients. Overall reduction in nausea and emesis leads to decreased frequency of hospitalization and reduced utilization of anti-nausea and pain medication. Abell et al. have reported a therapeutic response to endoscopic placement of temporary gastric electrical stimulator leads for 4-5 days and this may have a role in predicting positive responses to long-term implantation therapy. The implantation of the gastric electrical stimulator has neither positive effects on morphology of the stomach nor improving gastric motility and gastric emptying or correcting electrical dysrhythmias.

The hypothesized function of the gastric stimulator is that it transmits signals through the afferent fibers in the vagus nerve to relay an inhibitory message to the chemo-receptor trigger zone in the hypothalamus which modulates the neural mechanism for reflex vomiting. The cycle of gastric retention followed by CNS modulated reflux emesis is interrupted allowing for better control of nausea and vomiting. In addition Enterra therapy also increases vagal function enhancing some relaxation of the proximal stomach facilitating some better food storage. However gastric emptying is not accelerated.

The Texas Tech University Health Science Center, El Paso experience has included 33 patients since 2010. Thirty presented for initial surgical treatment of gastroparesis, one presented for conversion to subtotal gastrectomy following unsuccessful GES therapy, another for replacement of GES antral stimulation leads and the third for pyloroplasty and jejunostomy following GES. Of the 30 who presented for initial GES therapy lead insertion techniques included: laparotomy (20), laparoscopy (6) and robotic (4) methods. Long-term mortality (>90 days from surgery) in this group was 12% (cardiac arrest, respiratory arrest from aspiration, sepsis from intestinal fistula formation, and necrotizing fasciitis from wound infection). Morbidity includes stimulator pocket (pulse-generator pocket) infection (6%) that required pulse generator removal. These infections occurred in 2 of our patients who also had psychiatric disorders that promoted self-contamination of these wounds.

### GES and Pyloroplasty

The Texas Tech El Paso experience with simultaneous GES placement and pyloroplasty began in 2013 (12 laparotomy, 3 robotic). Techniques for pyloroplasty included 8 Heineke Mikulicz procedures (5 laparotomy, 3 robotic) and 4 applications of a circular stapler at the pylorus. Although intra-operative endoscopy demonstrated increased confirmation of visual patency and improved early gastric emptying with the circular stapler technique, short-term clinical follow up has demonstrated an increased tendency for dumping syndrome symptoms compared with the Heineke Mikulicz technique. The addition of simultaneous pyloroplasty has not increased the incidence of wound infections and there has been no incidence of abscess or enteric fistulas from the pyloroplasty site. All cases were accompanied by intra-operative EGD exam to confirm placement of GES stimulator leads and examine the pylorus to prevent possible enteric drainage from the site of pyloric reconstruction. This series demonstrated the safety and efficacy of combined pyloric reconstruction with implantation of the gastric electrical stimulator.

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N=nausea, V=vomiting, B=bloating, F=fullness, ES=Early satiety, EP=Epigastric pain, TSS=total symptom score, GET=gastric emptying time.

Table 1. Mean Results Before and After Surgical Therapy
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which creates a radial incision through the pylorus with transverse closure of the enterotomy. This differs significantly from the Jaboulay and Finney modifications which are more commonly used with chronic strictures in the pyloric and duodenal bulb regions. Release of the pylorus muscular complex functionally accelerates delayed gastric emptying and allows faster transit of food boluses into the small bowel thus allowing for absorption and overcoming malnutrition.

Robotic Platform Efficacy

Treatment modalities have been prescribed separately or in combination depending on the patient’s constellation of symptoms. Sarosiek and Forster first wrote about the potential cure of gastroparesis using a combination of Enterra therapy and pyloroplasty.11 Gastric electrical stimulators in the past were typically placed first to control symptoms of repeat nausea and emesis that lead to a cycle of constant hospital readmission. The gastric stimulator surgery is then followed by pyloroplasty when, some months later, symptoms have not been adequately relieved by GES alone. Reasoning for providing these therapies during different operative settings is that implant placement can be complicated by the entry into the stomach and pyloric complex. Reports of contamination of Enterra leads at time of surgery have been linked to delayed stimulator pocket infections.16

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Operative Strategy

The robotic platform completes pyloroplasty and gastric electrical stimulator implantation with expected operative time of 180 minutes followed by discharge on post-operative day 2-3. The pulse generator site should be marked prior to surgery in the left transverse umbilical line. An 8.5 mm camera is placed in a sub-umbilical position. The port placement allows arms to operate at the points of an isosceles triangle or upside-down pyramid which point toward the operative site. The assist port should be in the left mid abdomen and will be used for insertion of the Enterra leads and the pulse generator pocket.

The pyloroplasty technique is described by Heineke-Mikulicz. The pylorus is divided in an axial direction with extension approximately 2 cm on the stomach and duodenum. This incision is then closed in a transverse fashion with an inner layer of running suture with full thickness mucosal to serosal bites. The second layer is created with interrupted Lembert stitches (Figure 1). An umbilical tape is then marked at 9.5 and 10.5 cm for measurement of distance on the greater curvature. Hook cautery is then used to mark lead insertion sites approximately 10 cm from the pylorus on the greater curvature. The tape is also used to mark 2 cm lead tracks to maintain a 1 cm distance between the two leads to achieve impedance between 500 and 800 Ohms.

Leads are then inserted through the assist port. Ski needles are grasped and inserted through the serosa into the submucosa for a distance of 2 cm. EGD is then performed to demonstrate a negative leak testing of the pyloroplasty and examine the antrum for inadvertent perforation of the stomach. Mucosal perforation can lead to pulse generator pocket infections and intermittent shocking sensations. The leads are then delivered along the submucosal tract. The leads are tested for proper impedance (500-800 Ohms) and then sutured to the serosa of the stomach (Figure 2).

The subdermal pulse generator pocket is then developed. Care should be taken to avoid use of electrocautery since electrical interference erases recorded settings on the pulse generator. Once the subdermal pocket has been developed the pulse generator is connected and impedance is recorded trans-dermally with the generator in its pocket. The generator is secured with permanent suture and the dermal incisions are closed. At this point the pulse-generator is turned on and programmed so that patients may experience significant symptom relief immediately following surgery. The first two patients underwent gastrografin swallow studies following surgery that we now feel are not necessary secondary to adequate leak testing at the time of EGD. The patient is started on a clear liquid diet on day one following surgery and can be discharged shortly thereafter.

Figure 2. Two gastric stimulator leads sutured to the greater curvature of the stomach one-centimeter apart and located at a distance of 9-10 cm from the pylorus on the greater curve of the stomach are demonstrated.
Complications of Surgical Therapy

Consensus of many investigators is that adverse events include dislodgement of electrodes, penetration through the gastric mucosa, lead insulation damage, lead erosion or migration and bowel obstruction. The robotic approach has been documented to reduce the incidence of gastric perforation and improved functional tissue handling has led to reductions in erosion and damage to insulation. The robotic platform also reduces the incidence of lead dislodgment since suturing skills are improved. The incidence of subsequent small bowel obstruction problems is low with laparoscopy and robotics since scar formation is reduced dramatically. The most troublesome complication is still the potential for infection at the pulse generator pocket site. Minimally invasive approaches also have fewer wound complications due to a lower incidence of surgical stress with improved post-operative control of blood sugars and the sympatho-adrenal response.

CONCLUSION

This report reviewing surgical approaches to treat refractory gastroparesis has focused on simultaneous pyloroplasty and gastric electrical neurostimulator placement demonstrating the safety and efficacy of combining these procedures. The benefits of pyloroplasty on gastric emptying times and the reduction in nausea and emesis by gastric neurostimulation have both been documented in the literature. We believe the combination of these techniques prevents the negative spiral of hospitalization and malnutrition that creates chronic debilitation and disability in gastroparesis. This ultimate solution returns full function of the stomach as a digestive conduit with a low risk profile in the face of high levels of co-morbidities. The robotic platform reduces the risks because of the improved wrist-like articulation that facilitates suturing and electrode placement. Evolution of treatment includes early diagnosis with an endoscopic (non-surgical) approach to obtain gastric smooth muscle to identify the status of the interstitial cells of Cajal followed by developing a treatment strategy that leads to surgery in some patients. The pioneering work of Richard McCallum and Dr. Sarosiek and their team of collaborators have led to this combination of diagnostic and therapeutic solutions that overcome chronic tube based enteral nutrition and total gastrectomy. The authors encourage our readers to observe this technique at our medical center. Future directions include the dissemination of this technique to the broader community of gastroenterologists and surgeons.