Comparison of Pyloric Intervention Strategies at the Time of Esophagectomy: Is More Better?

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Background. Controversy remains regarding the role of pyloric drainage procedures after esophagectomy with gastric conduit reconstruction. We aimed to compare the effect of pyloric drainage strategies upon subsequent risk of complications suggestive of conduit distention, including aspiration and anastomotic leak.

Methods. A retrospective study was conducted reviewing patients undergoing esophagectomy between January 2007 and April 2012. Prospectively collected data included baseline comorbidities, operative details, hospital course, and complications. Statistical comparisons were performed using analysis of variance for continuous variables and χ² testing for categorical variables.

Results. There were 361 esophagectomies performed during the study period; 68 were excluded from analysis (for prior esophagogastric surgery or benign disease or both). Among 293 esophagectomies included, emptying procedures were performed as follows: 44 (15%), no drainage procedure; 197 (67%), pyloromyotomy/pyloroplasty; 8 (3%), dilation alone; 44 (15%), dilation plus onabotulinumtoxinA. Aspiration occurred more frequently when no pyloric intervention was performed (5 of 44 [11.4%] versus 6 of 249 [2.4%], p = 0.030). The incidences of anastomotic leak (18 [6.1%]) and gastric outlet obstruction (5 [1.7%]) were statistically similar among groups. Subgroup analysis demonstrated persistence of these findings when limiting the comparison to transthoracic esophagectomies. Major complications directly related to pyloroplasty/pyloromyotomy occurred in 2 patients (0.6%), including 1 death (0.3%).

Conclusions. These data suggest that omission of pyloric intervention at the index operation results in more frequent aspiration events. The combination of dilation plus onabotulinumtoxinA provided for a similar complication profile compared with surgical drainage. Future prospective comparisons are needed to evaluate these short-term effects of pyloric intervention as well as long-term sequelae such as dumping syndrome and bile reflux.

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For patients with potentially curable disease, surgical resection plays a significant role in the treatment of esophageal cancer. Although several technical approaches exist for performing esophagectomy, all are associated with significant comorbidities, operative mortality, in the ranges of 50% to 60% and 5% to 18%, respectively [1, 2]. Regardless of the surgical approach, pull-up with gastric conduit remains the most common reconstruction. Although vagal-sparing esophagectomy has been described for patients with benign disease or early stage malignancy [3–5], this technique is not ideal for locally advanced cancers. For most patients, bilateral vagotomies are inherent in the conduction of the operation, rendering these patients susceptible to problems related to impaired gastric emptying and contributing to the burden of postoperative morbidity attributed to esophagectomy with gastric conduit reconstruction.

The association of bilateral vagotomy with delayed gastric emptying and gastric outlet obstruction originates from early publications documenting the physiologic effects of vagotomies performed in the surgical treatment of peptic ulcer disease [6]. Significantly delayed gastric emptying is generally believed to occur in approximately 15% of patients who undergo esophagectomy with gastric pull-up, with reports of this problem ranging from 4% to 50% [7–13]. Delayed gastric emptying after esophagectomy has been associated with increased aspiration, prolonged hospital stay, and decreased patient satisfaction [14, 15].

Proponents of pyloric drainage argue that procedures such as pyloroplasty or pyloromyotomy can prevent gastric outlet obstruction, thereby lowering the risk of aspiration events, with resultant decrease in postoperative morbidity and mortality [12]. However, although two large meta-analyses supported pyloric drainage on the basis of decreased gastric outlet
obstruction and improved gastric emptying, overall complication rates and operative mortality were unaffected by pyloric drainage [13, 16, 17]. Further, increasing reports of minimally invasive esophagectomies have shown that, when conducted by experienced surgeons, these procedures have comparable outcomes to open procedures, despite rare inclusion of pyloric drainage [16, 18, 19].

As potential downfalls of pyloromyotomy/pyloroplasty have been weighed against the proposed benefits of improved gastric drainage, additional tools for improving pyloric drainage have entered the thoracic surgeon’s armamentarium. A number of researches have suggested that endoscopic balloon dilation and botulinum toxin may effectively reduce gastric outlet obstruction and, furthermore, may allow avoidance of risks specifically inherent to pyloroplasty/pyloromyotomy [9, 12, 15, 20–23].

In our institution, several methods of addressing pyloric drainage have been used, including omission of pyloric drainage in a portion of patients. In this study, we sought to assess the impact of current pyloric drainage techniques upon subsequent risk of aspiration and anastomotic leak. Furthermore, we aimed to compare outcomes among these techniques, with the ultimate goal of identifying an optimal management strategy with regard to the issue of pyloric drainage at the time of esophagectomy. In particular, with recent increase in our use of botulinum and its anecdotally favorable complication profile, we sought to specifically demonstrate noninferiority of botulinum versus surgical drainage with regard to potential complications related to delayed gastric emptying.

Patients and Methods

After Institutional Review Board approval, a retrospective review was conducted of prospectively gathered data for all patients who underwent esophagectomy at a single institution between January 2007 and April 2012. Patients were excluded if esophagectomies were performed for benign disease or if they had undergone previous esophagogastric surgery. Data were retrieved from The Society of Thoracic Surgeons (STS) database maintained by the surgical division and supplemented with clinical information from patient medical records and the Social Security Death Index.

Patients underwent various pyloric drainage procedures according to surgeon preference. Pyloromyotomy and pyloroplasty were performed in adherence to routine operative technique. Manual pyloric dilation, when used in isolation, was applied by digitally stretching the pylorus and evert ing it between the thumb and forefinger. OnabotulinumtoxinA (Botox; Allergan, Irvine, CA) was injected as 200 mg in 8 mL, delivered in equal parts circumferentially into the pylorus, and accompanied by either digital pyloric dilation or endoscopic balloon dilation. Endoscopic dilation, when employed in the postoperative setting, was performed with fiberoptic esphagogastroduodenoscopy and using standard manufactured esophagogastrroduodenoscopy pneumatic balloons.

Aspiration was deemed to have occurred if it was witnessed at the bedside (vomiting or regurgitation noted to precede coughing, gagging, or acute decompensation in respiratory status) or evident on contrast esophagography. Pneumonia diagnosis was based on strict criteria as defined by STS guidelines, as were all other postoperative outcome definitions, when applicable [24]. Anastomotic leakage was defined by presence of contrast extravasation on esophagography or visualization of an anastomotic breakdown on endoscopy. Presence of gastric outlet obstruction, delayed gastric emptying, and dumping syndrome were based on patient reported symptoms upon follow-up. We did not routinely perform radiographic studies to objectively assess the degree of delayed gastric emptying.

Clinical data were analyzed using SPSS 21.0 for Windows (SPSS, Chicago, IL). Descriptive statistics were expressed as mean ± SE, and comparisons were made with paired, two-tailed t tests and single-factor analysis of variance tests for means of normally distributed continuous variables. Categorical data were expressed as counts and percentages, with Fisher’s exact test and χ² testing used to analyze differences, with α = 0.05 considered significant.

Results

Patients

In all, 361 esophagectomies were performed during the study period, with 293 patients meeting inclusion criteria. Mean age was 61.8 ± 0.6 years, and 248 (84.6%) were male. For 44 patients (15.0%), no pyloric intervention was performed at the index operation. Among the remainder, pyloromyotomy was performed in 161 (54.9%), pyloroplasty in 36 (12.3%), digital dilation in 8 (2.7%), and botulinum toxin in 44 (15.0%). Pyloric drainage strategy trends over time are shown in Figure 1. Demographics and comorbidities, as shown in Table 1, were not...
significantly different among groups as stratified by pyloric drainage strategy.

**Operative Procedures**

Esophagectomies were performed by six surgeons, with 164 (56.0%) transthoracic and 129 (44.0%) transhiatal approaches. Considerable variability in operative time was present among all techniques (Table 2). Patients who underwent dilation with botulinum injection had significantly longer operations than did patients in the other groups. These were predominantly Ivor-Lewis esophagectomies, which, in general, took more time than transhiatal esophagectomies. Operative time tended to vary most by surgeon, and did not vary significantly by pyloric drainage strategy within same-surgeon groups. Of the patients included in this study, 289 (98.6%) underwent gastric pull-up as the conduit used for reconstruction, with a tubularized stomach (rather than whole stomach) employed in all 289 of these patients. All tubularized stomachs were created with the goal of a 4 cm to 5 cm wide conduit. There were no significant differences in type of conduit used, type of anastomosis performed, American Society of Anesthesiologists class, or need for intraoperative transfusion among the groups as defined by pyloric drainage.

**Postoperative Course**

The average lengths of intensive care unit and overall hospital stay did not differ among groups, and are shown in Table 2. There were 102 patients (34.8%) who returned to the operating room before discharge; overall likelihood of returning to the operating room was not dependent upon pyloric drainage procedure ($p = 0.278$). Delayed gastric emptying was documented for only 5 patients (1.7%), and it did not differ among pyloric drainage strategies. However, differences were seen among complications potentially related to poor gastric emptying. Need for postoperative pyloric dilation during the index hospitalization was significantly reduced by the inclusion of any pyloric drainage technique during the esophagectomy ($7 \times 15.9\%$ versus $8 \times 3.2\%$, $p = 0.008$). Likewise, risk of aspiration was also reduced when any

### Table 1. Patient Demographics and Comorbidities

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Intervention</th>
<th>Pyloroplasty/ Pyloromyotomy</th>
<th>Dilation</th>
<th>Dilation + Botulinum Toxin</th>
<th>Total</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>44</td>
<td>197</td>
<td>8</td>
<td>44</td>
<td>293</td>
<td></td>
</tr>
<tr>
<td>Age, years</td>
<td>61.1 ± 1.4</td>
<td>61.4 ± 0.7</td>
<td>59.8 ± 3.7</td>
<td>64.7 ± 1.4</td>
<td>61.8 ± 0.6</td>
<td>0.174</td>
</tr>
<tr>
<td>Male</td>
<td>38 (86.4)</td>
<td>162 (82.2)</td>
<td>7 (87.5)</td>
<td>41 (93.2)</td>
<td>248 (84.6)</td>
<td>0.321</td>
</tr>
<tr>
<td>Body mass index, kg/m$^2$</td>
<td>27.6 ± 0.8</td>
<td>27.7 ± 0.4</td>
<td>28.6 ± 2.1</td>
<td>28.9 ± 0.7</td>
<td>27.9 ± 0.3</td>
<td>0.514</td>
</tr>
<tr>
<td>Current smoker</td>
<td>7 (15.9)</td>
<td>42 (21.3)</td>
<td>1 (12.5)</td>
<td>4 (9.1)</td>
<td>54 (18.4)</td>
<td>0.582</td>
</tr>
<tr>
<td>Previous smoker</td>
<td>24 (54.5)</td>
<td>102 (51.8)</td>
<td>4 (50.0)</td>
<td>24 (54.5)</td>
<td>154 (52.6)</td>
<td></td>
</tr>
<tr>
<td>Pack-year smoking</td>
<td>30.0 ± 5.6</td>
<td>32.6 ± 2.2</td>
<td>22.3 ± 7.3</td>
<td>25.3 ± 4.3</td>
<td>30.8 ± 1.8</td>
<td>0.453</td>
</tr>
<tr>
<td>COPD</td>
<td>3 (6.8)</td>
<td>24 (12.2)</td>
<td>1 (12.5)</td>
<td>4 (9.1)</td>
<td>32 (10.9)</td>
<td>0.74</td>
</tr>
<tr>
<td>GERD</td>
<td>24 (54.5)</td>
<td>108 (54.8)</td>
<td>5 (62.5)</td>
<td>23 (52.3)</td>
<td>160 (54.6)</td>
<td>0.96</td>
</tr>
<tr>
<td>Barrett's esophagus</td>
<td>8 (18.2)</td>
<td>36 (18.3)</td>
<td>2 (25.0)</td>
<td>9 (20.5)</td>
<td>55 (18.8)</td>
<td>0.962</td>
</tr>
<tr>
<td>Hypertension</td>
<td>22 (50.0)</td>
<td>104 (52.8)</td>
<td>3 (37.5)</td>
<td>30 (68.2)</td>
<td>159 (54.3)</td>
<td>0.184</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>10 (22.7)</td>
<td>30 (15.2)</td>
<td>1 (12.5)</td>
<td>10 (22.7)</td>
<td>51 (17.4)</td>
<td>0.472</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>8 (18.2)</td>
<td>24 (12.2)</td>
<td>3 (37.5)</td>
<td>10 (22.7)</td>
<td>45 (15.4)</td>
<td>0.084</td>
</tr>
<tr>
<td>Preoperative chemotherapy</td>
<td>25 (57)</td>
<td>96 (49)</td>
<td>6 (75)</td>
<td>23 (52)</td>
<td>150 (51.2)</td>
<td>0.412</td>
</tr>
<tr>
<td>Preoperative radiation therapy</td>
<td>23 (52)</td>
<td>101 (51)</td>
<td>6 (75)</td>
<td>21 (48)</td>
<td>151 (51.5)</td>
<td>0.565</td>
</tr>
</tbody>
</table>

Data are n (%) or mean ± SD.

COPD = chronic obstructive pulmonary disease; GERD = gastroesophageal reflux disease.

### Table 2. Operative and Hospitalization Resource Utilization

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Intervention</th>
<th>Pyloroplasty/ Pyloromyotomy</th>
<th>Dilation</th>
<th>Dilation + Botulinum Toxin</th>
<th>Total</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>44</td>
<td>197</td>
<td>8</td>
<td>44</td>
<td>293</td>
<td></td>
</tr>
<tr>
<td>Operative time, hours:minutes</td>
<td>3:44 ± 9:38</td>
<td>4:55 ± 0:07</td>
<td>2:55 ± 0:07</td>
<td>6:23 ± 0:15</td>
<td>4:54 ± 0:06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intensive care unit LOS, days</td>
<td>2.18 ± 0.5</td>
<td>4.16 ± 0.4</td>
<td>3.00 ± 1.5</td>
<td>5.14 ± 2.03</td>
<td>3.98 ± 0.4</td>
<td>0.279</td>
</tr>
<tr>
<td>Hospital LOS, days</td>
<td>12.7 ± 1.0</td>
<td>13.6 ± 0.6</td>
<td>15.3 ± 3.0</td>
<td>16.5 ± 2.62</td>
<td>13.9 ± 0.6</td>
<td>0.284</td>
</tr>
</tbody>
</table>

Data are mean ± SD.

LOS = length of stay.
pyloric drainage strategy was employed (5 [11.4%] versus 6 [2.4%], \( p = 0.030 \)). When performing analysis of variance to assess differences in these outcomes among all pyloric drainage strategies, these findings persist (Table 3, Fig 2). Furthermore, there were no significant differences seen when comparing complications of the various pyloric drainage strategies in a head-to-head comparison.

Of significant interest, early during the study period, two severe complications were observed directly related to pyloric drainage procedures. During the pyloromyotomy of 1 patient who had undergone induction therapy followed by Ivor-Lewis esophagectomy, the mucosa was inadvertently entered. The myotomy was converted to a pyloroplasty, and a routine esophagram on postoperative day 7 demonstrated a leak from the site of the pyloroplasty, which persisted, ultimately requiring stent placement across the pylorus on postoperative day 17 and further reexplorations. The patient’s postoperative course continued to be complicated, and he ultimately died on postoperative day 68. For a second patient who underwent pyloromyotomy, reexploration was required on postoperative day 1 when bilious drainage was noted from the midline abdominal incision. Operative findings included a pinpoint hole at the pyloromyotomy. This patient was also converted to a pyloroplasty. Thus, serious complications directly related to pyloroplasty/pyloromyotomy occurred in 2 patients (0.6%), including 1 death (0.3%).

### Long-Term Outcomes

Late postoperative data were available for 272 patients (92.8%) from the 0 to 6-month period, for 157 (53.6%) from 6 to 12 months, and for 140 (47.8%) past 12 months. Neither the inclusion of a pyloric drainage procedure nor the specific type of drainage performed significantly impacted the need for subsequent dilation of the pylorus during the follow-up period (Table 4). Likewise, the prevalence of symptoms of dumping syndrome and bile reflux at each time point were similar among all groups, with no significant differences found in our analyses.

### Comment

In this study, patients who did not receive pyloric drainage procedures at the time of esophagectomy were prone to increased risk of aspiration during the postoperative period and were more likely to need pyloric dilation before discharge from the hospital. We did not demonstrate any clear benefit of one pyloric drainage strategy over others in prevention of gastric outlet obstruction-related complications. However, of significant importance, major complications directly related to pyloroplasty/pyloromyotomy occurred in 2 patients (0.6%), including 1 death (0.3%).

![Fig 2. Postoperative complication development by drainage procedure type. Patients who did not undergo any pyloric drainage intervention were at increased risk of aspiration (solid bars) as well as need for pyloric drainage procedure (hatched bars) before discharge from index hospitalization.](image)
Table 4. Long-Term Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>No Intervention</th>
<th>Pyloroplasty/ Pyloromyotomy</th>
<th>Dilation</th>
<th>Dilation + Botulinum Toxin</th>
<th>Total</th>
<th>p Value</th>
</tr>
</thead>
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<tr>
<td>Number of patients</td>
<td>44</td>
<td>197</td>
<td>8</td>
<td>44</td>
<td>293</td>
<td></td>
</tr>
<tr>
<td>Pylorically dilation required</td>
<td>5 (11)</td>
<td>23 (12)</td>
<td>2 (5)</td>
<td>8 (18)</td>
<td>38 (13.0)</td>
<td>0.479</td>
</tr>
<tr>
<td>Dumping 0–6 months</td>
<td>5/39 (13)</td>
<td>26/187 (14)</td>
<td>1/7 (14)</td>
<td>5/39 (13)</td>
<td>37/272 (13.6)</td>
<td>0.996</td>
</tr>
<tr>
<td>Dumping 6–12 months</td>
<td>1/18 (6)</td>
<td>19/111 (17)</td>
<td>1/1 (100)</td>
<td>5/27 (19)</td>
<td>26/167 (15.6)</td>
<td>0.082</td>
</tr>
<tr>
<td>Dumping &gt;12 months</td>
<td>0/14</td>
<td>23/111 (21)</td>
<td>0/0</td>
<td>2/15 (13)</td>
<td>25/140 (17.9)</td>
<td>0.144</td>
</tr>
</tbody>
</table>

Data are n (%).

events, although rare, may occur after pyloroplasty/ pyloromyotomy [25]. Zieren and colleagues [26] described 1 death and 1 case of severe stricture formation secondary to surgical pyloric drainage, accounting for 3.8% of their study group.

In addition to such infrequent, serious complications of pyloric drainage, less severe side effects may occur with a greater prevalence. Patients undergoing pyloric drainage may make a tradeoff, exchanging poor gastric motility for bile reflux and dumping syndrome [25, 27, 28]. Wang and associates [28] found that patients with pyloroplasty have greater incidences of both of these undesirable outcomes (Table 5).

With such mixed results, the utility of pyloric drainage has been an area of particular interest to esophageal surgeons. Meta-analyses performed by Urschel and co-workers [13] and Khan and associates [17] both suggested a reduced rate of early postoperative gastric outlet obstruction among patients who underwent pyloric drainage procedures; however, patients had no consequent improvement in other related outcomes (Table 5). In 2013, another meta-analysis aimed to readdress the issues, evaluating outcomes from studies performed within the last decade [11, 22, 29, 30]. Each of the studies considered in this publication suggested that pyloric drainage was unnecessary and could be omitted. Reasons for the shift in paradigm may be related to an evolution over time with regard to the type of gastric conduit used, as it has been shown that use of whole stomach pull-ups has a greater tendency toward gastric outlet obstruction as it has been shown that use of whole stomach pull-ups over time with regard to the type of gastric conduit used, for the shift in paradigm may be related to an evolution.

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In this study, we describe the use of botulinum toxin injection as an alternative to pyloroplasty and pyloromyotomy, which, in part, is attractive due to the decreased risk of leak from the pylorus. Other strategies have been described in attempts to minimize risk of pyloric disruption, such as the circular stapled pyloroplasty [32, 33]. Although this technique has been shown to reduce risks of leak as well as conduit shortening when compared with standard pyloroplasty, there are further advantages that are unique to botulinum injection. Each of the invasive surgical strategies for pyloric drainage, regardless of specific risk of perforation, tends to have permanent effects. However, physiologic studies have suggested that foregut function after esophagectomy improves with time, regardless of the anastomotic level or the inclusion of pyloric drainage procedures [16, 34–36]. Consequently, the transient nature of the botulinum injection offers additional benefits that may not be attainable by simply altering the technical approach to pyloroplasty.

We acknowledge that this study is subject to several limitations. These data were retrospectively retrieved from a prospective database, rather than obtained by randomization. Choice of gastric emptying strategy was decided by surgeon preference, and there may some inherent selection bias in terms of the different practices and experiences of the surgeons in the group. In addition, in considering need for pyloric dilation as an outcome of
<table>
<thead>
<tr>
<th>First Author</th>
<th>Year</th>
<th>Methodology</th>
<th>n</th>
<th>Outcomes Significantly Affected by Pyloric Intervention</th>
<th>Outcomes Unaffected by Pyloric Drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang</td>
<td>1992</td>
<td>Retrospective review</td>
<td>368</td>
<td>Bile reflux: 55.6% pyloroplasty vs 8.6% no pyloroplasty. Dumping syndrome: 33.3% pyloroplasty vs 6.9% no pyloroplasty.</td>
<td>No differences in respiratory complications, failure to thrive, anastomotic leaks, or long-term gastric emptying</td>
</tr>
<tr>
<td>Urschel</td>
<td>2002</td>
<td>Metaanalysis</td>
<td>553</td>
<td>Early postoperative gastric outlet obstruction: decreased with pyloric drainage vs no drainage ($p = 0.046$).</td>
<td>No differences in anastomotic leak rate, pulmonary complications, or operative mortality</td>
</tr>
<tr>
<td>Khan</td>
<td>2007</td>
<td>Metaanalysis</td>
<td>1,063</td>
<td>Gastric motility: faster with pyloric drainage. Gastric outlet obstruction: less frequent with pyloric drainage.</td>
<td>Pyloric drainage associated with nonsignificant trend for delayed gastric emptying and bile reflux, no impact on dumping, leaks, pulmonary complications, hospital stay, and overall morbidity</td>
</tr>
<tr>
<td>Gaur</td>
<td>2013</td>
<td>Meta-analysis</td>
<td>668</td>
<td></td>
<td>Pyloromyotomy vs no pyloromyotomy with no difference in gastric outlet obstruction, pneumonia, respiratory failure, or length of stay</td>
</tr>
<tr>
<td>Lanuti</td>
<td>2007</td>
<td>Retrospective review</td>
<td>242</td>
<td>Pyloric dilation improved gastric outlet obstruction in 96.7%</td>
<td></td>
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<tr>
<td>Kim</td>
<td>2008</td>
<td>Prospective observational</td>
<td>257</td>
<td>Pyloric dilation improved symptoms of delayed gastric emptying in 100%. Pyloric dilation increased rates of gastric emptying on radioisotope imaging in 67%</td>
<td></td>
</tr>
<tr>
<td>Lanuti</td>
<td>2011</td>
<td>Retrospective review</td>
<td>436</td>
<td>Pyloric dilation 95% successful in patients with delayed gastric emptying</td>
<td></td>
</tr>
<tr>
<td>Kent</td>
<td>2007</td>
<td>Prospective pilot study</td>
<td>15</td>
<td>After botulinum injection, 0 patients had delayed gastric emptying or aspiration pneumonia</td>
<td></td>
</tr>
<tr>
<td>Cerfolio</td>
<td>2009</td>
<td>Retrospective review</td>
<td>221</td>
<td>Delayed gastric emptying: 93% pyloromyotomy, 96% pyloroplasty, 96% no drainage procedure, 59% botulinum injection ($p = 0.002$). Biliary reflux at follow-up (mean 40 months) lowest in botulinum group ($p = 0.024$). Hospital stay and operative times shorter for botulinum injection ($p = 0.015$ and 0.037, respectively).</td>
<td></td>
</tr>
</tbody>
</table>
interest, we recognize the lack of objective criteria in determining requirement for intervention. Reasons for pyloric dilation included slow progression of contrast through the pylorus on esophagography or symptoms of delayed gastric emptying. It is conceivable that, for patients already undergoing endoscopy for alternative reasons, there may have been a lower threshold to proceed with concurrent pyloric dilation. Additionally, we acknowledge that our stringent definition of aspiration, requiring either a witnessed event or radiographic evidence, has the potential to miss some episodes. We presume that this likelihood is similar for all groups regardless of pyloric drainage strategy. Finally, we acknowledge that this study may be underpowered to detect differences among various drainage strategies for the defined postoperative outcomes, and we aim to conduct large-scale prospective studies in the future.

In this study, we aimed to investigate the ongoing utility of pyloric drainage for patients undergoing esophagectomy for cancer with tubularized gastric reconstruction. We further sought to compare benefits and risk profiles of various pyloric drainage strategies. This study carries several strengths, in that it is a large review of prospectively gathered data obtained in the modern era. We found that inclusion of pyloric drainage procedures helped reduce risk of aspiration and need for pyloric dilation before discharge. All pyloric drainage strategies were essentially similarly effective; however, we found botulinum injection to result in comparable benefits with minimal inherent risk, as compared with pyloroplasty/pyloromyotomy. Botulinum toxin injection serves as a promising adjunct to esophageal surgery, and future trials investigating perioperative outcomes, long-term follow-up, and quality of life metrics are warranted.

References

DISCUSSION

DR FELIX FERNANDEZ (Atlanta, GA): Mara, congratulations on an excellent presentation and thank you for providing me with a well-written manuscript in advance. This is an important study, because the relative emptying of the gastric conduit can impact both short-term and long-term morbidity after esophagectomy and we lack strong evidence to inform our practice. You do a very nice job of contrasting the potential risks and benefits of each pyloric intervention strategy. However, this study may be underpowered to detect small but important differences between approaches. I have two questions and I will ask them to you one at a time.

First, although not statistically significant, the rate of aspiration was greater after Botox injection than with surgical drainage and a larger sample may show a significant difference. There was only 1 death related to complications after surgical drainage in 197 patients. So it would not take many excess aspiration deaths in the Botox group to outweigh any potential benefit of decreased surgical complications. So what were the overall mortality rates in the Botox and surgical drainage patients and how many mortalities were attributable to aspiration or respiratory failure in each group?

DR ANTONOFF: Thank you very much for your detailed comments and taking the time to read our manuscript. We agree. We, too, are concerned with the potential impact of aspiration, and we recognize that this could be a detrimental problem if patients experienced more frequent aspiration events with a particular drainage approach. With regard to your question about mortality, our overall 30-day mortality was 1.4%. This included 2 deaths in the group of patients who underwent pyloroplasty or pyloromyotomy and 1 death in the botulinum injection group, for a rate of 0.7%. I would like to be clear that that patient who died in the botulinum group did not have an aspiration event noted. But we agree that these are important considerations, and as we embark upon future studies, it will be critical to keep track of these types of data.

DR FERNANDEZ: Your group has also reported that the use of retrograde gastric decompression after an esophagectomy decreases postoperative aspiration events by 66% compared to a standard nasogastric decompression of the gastric conduit. Do you think that the use of retrograde gastric drainage reduces the risk of aspiration after Botox injection down to the risk that’s seen with surgical drainage of the pylorus? In what percentage of patients was retrograde gastric drainage utilized and did this differ by group? Again, congratulations on an excellent presentation.

DR ANTONOFF: Thank you very much. With regard to retrograde gastric decompression, thank you for referencing Dr Puri’s 2011 paper from the *Annals of Thoracic Surgery*. As you stated, in this paper, we were able to see significant decreases in negative respiratory outcomes among patients who had retrograde gastric decompression. The patient cohort used for that paper overlapped partially with our study set. Those patients were assessed between the years 2000 and 2008, whereas the patients reported in our paper today underwent operations between 2007 and 2012. In the study sample that I have described today, among those patients who underwent pyloroplasty or pyloromyotomy, 90% had retrograde gastric decompression. Also, among those patients in this study who did not have any pyloric intervention performed at the time of esophagectomy, the same proportion—90%—had retrograde gastric decompression. Interestingly, in the botulinum injection group, only 43% of our patients had a retrograde gastrostomy tube. So one would actually expect that since the publication of Dr Puri’s paper and our adoption of much greater use of the retrograde gastrostomy tube, the actual benefit of botulinum toxin injection has been underrepresented through this study in that our current practices would be to use retrograde gastrostomy tubes much more frequently.

DR WAYNE L. HOFSTETTER (Houston, TX): Very nice paper and very detailed. When assessing differences in outcomes, we have to ask the appropriate questions. In addition to the indices that you mentioned, I think that some of the long-term indices of the quality of our gastric conduit have to be queried and included in your study. I might consider indices such as nocturnal aspiration (long term), episodes of any aspiration, gastric conduit dysfunction including quality of life, regurgitation, and dysphagia, distension of the gastric conduit, and the ability to tolerate larger meals.

DR ANTONOFF: Thank you very much for your comment. We absolutely agree. I think, as we embark on future studies, it will be of critical importance to include some of these excellent validated quality metrics that have been established.

DR DOUGLAS E. WOOD (Seattle, WA): Dr Antonoff, a very nice presentation, and I appreciate your acknowledgement that the fact that the drainage procedure was selected by the surgeon may imply that the results are due to individual surgeons rather than necessarily the drainage procedure, but I think your outcomes are certainly suggestive.

I am wondering why you combined pyloromyotomy and pyloroplasty into one group. I would see those as very different procedures and with different outcomes, meaning a pyloroplasty is probably a little bit better drainage procedure than a pyloromyotomy and also, therefore, has some of the negative secondary consequences of an excellent drainage procedure, that is,
a higher incidence of dumping and a higher incidence of bile reflux. So have you considered separating those groups and analyzing the difference between two different styles of surgical drainage procedure?

DR ANTONOFF: Thank you very much for your comment, Dr Wood. We actually did separate out both the pyloromyotomy and the pyloroplasty groups, and when we split them from one another, we found that our outcomes did not change. We do recognize that others have found differing results from pyloromyotomy and pyloroplasty; however, in our hands, we found that the results are very similar between those two groups. In addition, we also recognize that a number of patients in whom a pyloromyotomy is initially attempted, they may end up ultimately undergoing a pyloroplasty due to mucosal entry, anyway. We recognize that these two groups have been different in other people’s hands, but, in ours, they have been very similar.

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