



Delayed Gastric Emptying after Esophagectomy: Management and Prevention

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The quality of life associated with eating is becoming an increasingly significant problem for patients who undergo esophagectomy as a result of the improved survival rate after esophageal cancer surgery. Delayed gastric emptying (DGE) is a common complication after esophagectomy. Although several strategies have been proposed for the management and prevention of DGE, no clear consensus exists. The purpose of this review is to present a brief overview of DGE and to help clinicians choose the most appropriate treatment through an analysis of DGE by cause. Furthermore, we would like to suggest some tips to prevent DGE based on our experience.

Keywords: Esophageal neoplasms, Esophagectomy, Gastric emptying, Pyloric intervention, Mediastinum

Introduction

The survival rate after esophageal cancer surgery has improved as a result of early cancer detection and advances in adjuvant therapy [1]. However, impaired quality of life (QOL) associated with eating remains a significant problem [2,3]. Delayed gastric emptying (DGE) after esophagectomy and reconstruction with a gastric conduit is a common complication that occurs in 15%–39% of patients [4-6]. Although the severity of DGE varies, symptoms arising from food retention in the thorax seriously worsen patients' QOL. In the short term, DGE can lead to anastomotic leak, pneumonia, and a longer hospital stay [5,7-9]. In the long-term, it is strongly associated with nutritional problems [10-13]. Therefore, considering these numerous sequelae, DGE should never be overlooked. The purpose of this review is to introduce DGE in a systematic manner and to help clinicians choose the most appropriate treatment through an analysis of DGE by cause. Furthermore, we would like to suggest some tips to prevent DGE.

Definition

Various studies have presented different definitions of DGE, and there are no clearly established criteria. In 1995, Finley et al. [14] defined DGE as barium retention in the gastric conduit for more than 15 minutes in a standing position after a barium swallow, and 11% of patients who underwent esophageal cancer surgery through right thoracotomy were diagnosed with DGE. In 2005, Lee et al. [15] considered DGE to be present when the 50% gastric emptying time (T50) exceeded 180 minutes in a 99m-DTPA scintigraphy study. Using this cutoff value, it was found that DGE occurred in 37.5% of patients after esophageal resection. The average T50 of this group was 422 minutes, showing a serious delay [15]. An optimal and universally accepted definition is needed to systematically classify the severity of DGE patients and to compare research results more objectively.

Pathophysiology

DGE is caused by a combination of anatomical and phys-



Table 1. Anatomical and physiological causes of delayed gastric emptying after esophagectomy

Causes
Relaxation dysfunction of the pylorus
Dysfunctional peristalsis (complete vagotomy)
Unfavorable pressure gradient : negative thoracic pressure, positive abdominal pressure
Torsion or angulation of the conduit
Redundant gastric conduit
Insufficient widening of esophageal hiatus

iological changes in the gastric conduit after esophageal resection [3,16]. Gastric motility itself is affected by alterations of smooth muscle cells (myogenic), enteric neurons (hormonal), and the autonomic nervous system (neural). These changes are summarized in Table 1.

Symptoms

As no unified definition or diagnostic criteria exist for DGE, different symptoms associated with DGE have been reported across studies [6,11,13,17,18]. Being well-informed of the symptoms related to DGE helps to educate patients regarding the changes in the body that take place in response to eating, and is useful for managing patients after surgery. When food remains in the intrathoracic gastric conduit for a long time, it can cause nausea, regurgitation, vomiting, dysphagia to solids, loss of appetite, coughing, pain, chest pressure, bloating, heartburn, early satiety, a large amount of gastric tube drainage fluid, or aspiration pneumonia [16]. The development of tools that can be used to evaluate the severity of DGE is necessary for managing those patients objectively.

Diagnosis

A chest X-ray is routinely performed during the postoperative period. Presence of the air-fluid level or dilatation in the gastric conduit strongly suggests DGE (Fig. 1). When DGE is clinically suspected, the clinician should investigate whether a mechanical obstruction may be causing the symptoms. Although there is still no clear indication for revisional surgery, if a mechanical obstruction is suspected, rather than an intrinsic functional problem of gastric conduit, it is more likely that reoperation will be appropriate.

Several diagnostic modalities can be used to differentiate DGE by cause. Chest computed tomography (CT) can play an important role in ruling out whether there is any sign of



Fig. 1. Thoracic stomach syndrome. This is a complication that can occur after esophagectomy with whole-stomach reconstruction. The main symptom is chest discomfort after eating.

mechanical obstruction in the upper gastrointestinal (GI) tract. For instance, a twisted conduit may be suspected if the lesser curve staple line is rotated on a CT scan [19]. Endoscopy is a useful tool to confirm the presence of an anastomotic stricture or narrow pyloric orifice. The presence of residual food in the gastric conduit during endoscopy despite proper fasting can also be an important clue that suggests DGE. The barium swallowing test is a non-invasive, relatively inexpensive, and easily accessible modality that can demonstrate any redundancy, kink, or herniation of the gastric conduit, as well as the level of mechanical obstruction [20]. However, this test is limited in that it can only visualize the flow of thick liquid, not solids. A quantitative evaluation provides an objective assessment of the severity of DGE. Scintigraphy using a mixed meal with a radioactive isotope has been used in several studies; this method has the advantage of being able to visualize the dynamic flow of solids, but the disadvantage of it being difficult to standardize different protocols for each institution [15,21,22]. A wireless capsule motility (Smart-Pill GI monitoring system; Smart Pill Corp., Buffalo, NY, USA) was designed to sense and transmit intraluminal pH, pressure, and temperature data from a capsule at regular intervals as it passes through the GI tract [23]. The diagnostic accuracy of this modality is comparable to that of gastric-emptying scintigraphy [24]. Manometry is used to access gastropyloric motor activity, which is quantified by calculating the motility index [25].

Management

In general, intrathoracic gastric motility gradually improves over a period of 6 months to 3 years after surgery [26]. Therefore, even if DGE is present, a less invasive approach, such as dietary modification, medication, or gastroscopic intervention, is considered first. In very severe cases, revisional surgery may be required to properly restore the function of the gastric conduit [19,27,28].

Dietary modifications to include smaller, more frequent, and more liquid-based meals help to reduce the severity of DGE. Soft and cooked foods consisting of low-fat and low-fiber ingredients are recommended. Isotonic food at a moderate temperature is encouraged to enhance gastric emptying [29].

Prokinetics are believed to play a role in promoting gastric contractility, enhancing gastric dysrhythmia, and improving the coordination of antral and duodenal movement [30]. Several studies have investigated various prokinetic drugs such as metoclopramide (a dopamine D2 receptor antagonist, the only drug approved by the Food and Drug Administration for the treatment of gastroparesis), domperidone (with a similar mode of action to that of metoclopramide, but not penetrating the blood-brain barrier), or cisapride [30], but there is still no clear evidence of benefits in patients with DGE after esophagectomy. In contrast, erythromycin, a motilin receptor agonist in the antrum and duodenum, proved its efficacy [21,25]. However, its use is limited by its tachyphylaxis, and its effects wane after a few weeks of daily use [31,32].

Increased pyloric resistance after complete vagotomy can be managed by endoscopic pyloric balloon dilatation (EPBD), which has been widely accepted as a safe and effective therapy [33,34]. Kim et al. [35] reported that 8% of esophagectomy patients who underwent pyloric finger fracture for pyloric drainage needed EPBD postoperatively. In a comparison of scintigraphy findings before and after the procedure, DGE improved in two-thirds of DGE patients with EPBD. Preoperative EPBD was introduced to replace the intraoperative pyloric drainage procedure [36]. Hadzijušufovic et al. [36] reported that preoperative EPBD reduced the postoperative pyloric dysfunction rate compared with the non-intervention group (13.2% versus 37.5%) and emphasized that a balloon size of 30 mm was more successful than a 20-mm balloon (93.3% versus 58.5%).

With the increasing prevalence of minimally invasive esophagectomy, intraoperative pyloric drainage procedures, including pyloroplasty, pyloromyotomy, or pyloric

finger fracture, have become time-consuming and difficult to put into practice. As an alternative, intra-pyloric injection of botulinum toxin (IPBT) has been proposed; it presented a high success rate for the prevention of DGE [37,38] and showed comparable results to a surgical pyloric procedure [17]. Theoretically, botulinum toxin could weaken the pyloric smooth muscles temporarily during the early post-operative period, and the relaxing effect might disappear along with potentially decreased bile reflux and dumping syndrome within 12 weeks. However, Eldaif et al. [39] reported that although the use of IPBT significantly decreased the operative time compared to pyloromyotomy and pyloroplasty, the patients who received IPBT suffered from more reflux symptoms, had more frequent use of promotility drugs, needed more frequent endoscopic pyloric interventions, and had no benefits compared to those who underwent pyloromyotomy and pyloroplasty in terms of reducing dumping symptoms. In a well-matched cohort study, Stewart et al. [40] demonstrated a similar incidence of DGE between patients who received no pyloric intervention and those who received IPBT in the setting of minimally invasive esophagectomy.

A few case reports have shown the feasibility of electrostimulation for intractable DGE after esophagectomy [41,42]. A battery-powered neurostimulator (Enterra; Medtronic, Minneapolis, MN, USA) was implanted in the subcutaneous pocket of the abdominal wall and connected to the intrathoracic gastric antrum with 2 stimulating electrodes. Although gastric electrical stimulation treatment is an approved method for patients with idiopathic and diabetic gastroparesis [43], more evidence is needed for this technique to be applied to patients with DGE after esophagectomy.

The condition of most DGE patients improves by dietary control, lifestyle modifications, medication, or an endoscopic intervention [44]. If a patient still has serious DGE symptoms despite these conservative therapies, revisional surgery may be needed for correctable anatomical problems. Kent et al. [19] reported that 4% of esophagectomy patients underwent a revisional operation, and the identified patients had a diaphragmatic hernia, redundant gastric conduit, or both. A mechanical obstruction was observed in 54% of patients with a redundant conduit. Revisional surgery aimed to reposition the herniated organ or the excessive conduit lying horizontally over the diaphragm into the abdomen. Depending on the patient's condition, widening of the narrow hiatal opening causing external obstruction, tailoring of the bulging conduit, or correction of the twisted conduit was performed. When performing

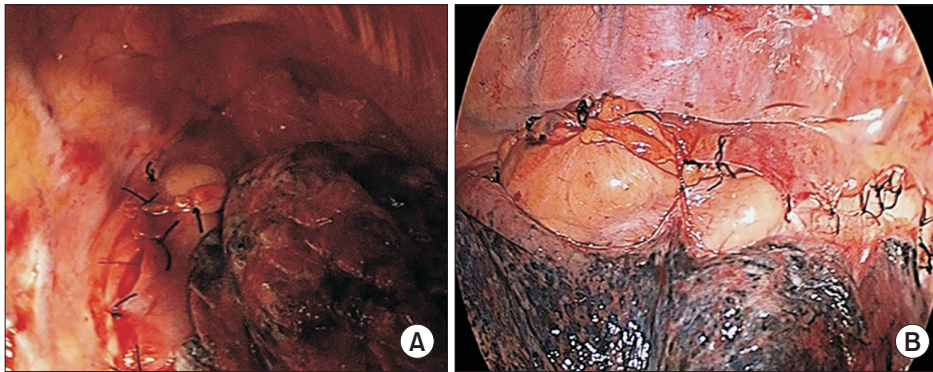


Fig. 2. Mediastinalization of the interposed stomach using mediastinal pleural coverage. To do this, the mediastinal pleura should be well preserved from the beginning of esophageal dissection. (A) Upper part of the conduit. (B) Middle and lower level of the conduit.

these complex operations, the vitality of the conduit should not be affected, so both a thoracic and abdominal approach is recommended for safe dissection [27,28].

Prevention

We believe that anticipatory measures to prevent DGE are more important than curative measures. However, it is not easy to determine which surgical technique or policy is preferable as a preventive method. Below are 4 factors to consider to reduce the incidence of DGE.

Whole stomach versus gastric tube

Both the gastric tube and whole-stomach approaches have been widely used as for conduit formation. Theoretically, the whole-stomach approach provides better preservation of the submucosal vessels and can slightly increase gastric capacity [20,45]. Advocates who prefer the whole-stomach approach showed that whole-stomach patients had fewer meals and snacks per day, with faster eating and fewer complaints of early satiety [20,26]. In contrast, Zhang et al. [46] insisted that a straight, narrow conduit avoiding redundancy can be constructed by gastric tube formation, with a lower incidence of postoperative reflux esophagitis and thoracic stomach syndrome. Other studies have shown that the anatomical structure of the gastric tube is more in line with physiological needs and could reduce the incidence of postoperative complications owing to the low anastomotic tension associated with this technique [47]. Barbera et al. [48] demonstrated that a more narrow stomach enhanced the test meal with a faster emptying rate. Lee et al. [49] developed a flow visualization experimental model of a gastric conduit with variable sizes of acrylic-based photopolymer tube grafts and pyloric-mimicking openings. The authors concluded that a narrow gastric

tube and/or a pyloric drainage procedure could improve gastric emptying. However, this debate has not yet been fully resolved.

Esophageal hiatus

Sufficient widening of the esophageal hiatus to 4 fingers' width has been widely accepted. However, care must be taken because an excessively widened esophageal hiatus may cause hiatal hernia after esophagectomy. Since hiatal hernia mainly occurs on the left side, it may be more advantageous to make an incision for hiatus widening on the right side.

Mediastinalization

The whole stomach is larger and more distensible than a gastric tube, and therefore more susceptible to DGE by Laplace's law [50]. Therefore, mediastinalization of the interposed stomach using mediastinal pleural coverage is an alternative method for maintaining alignment of the gastric conduit if the whole stomach is chosen as a conduit (Fig. 2). This technique is especially helpful to prevent bulging or redundancy in the whole-stomach conduit. However, if a gastric tube conduit or the McKeown operation is used, it may be omitted or non-feasible.

According to Laplace's law, reinforcing the gastric wall tension itself can lead to a rapid increase of intraluminal gastric pressure when the stomach is filled, facilitating gastric emptying [50]. The staple lines of the lesser curvature in the gastric conduit are frequently oversewn with a second layer of continuous Lembert sutures. If the surgeon thinks that the conduit is somewhat redundant after creating a gastric tube using a stapler, we recommend reducing the graft size and increasing the gastric wall tension through a continuous Lembert suture using a barbed mono-

filament (3-0 V-Loc 90; Medtronic). Maintenance of nasogastric tube (NGT) suction during the postoperative period can be used to keep the thoracic stomach decompressed until mediastinal fixation of the conduit [3]. When the whole stomach is used, we prefer to maintain prophylactic NGT placement to prevent the development of thoracic stomach syndrome. However, conventional NGT use in esophagectomy is still a matter of debate. Weijs et al. [51] reported that early removal of the NGT had no inferiority in terms of pulmonary complications, anastomotic leakage, and mortality compared to routine NGT use in their meta-analysis.

Pyloric drainage procedure

Pyloric interventions have been thought of as the major form of prophylaxis against DGE. There are 5 pyloric management strategies at the time of esophagectomy: no intervention [52,53], botulinum toxin injection [37], finger fracture [15], pyloroplasty [54], and pyloromyotomy [7,39]. Each method has its advantages and disadvantages, so we cannot say with certainty which one is the best. However, advocates for the no-intervention strategy have been gradually reporting convincing results [40,55,56].

Conclusion

The optimal strategy for preventing DGE is still a matter of debate among surgeons. However, there is no doubt that a straight, narrow, and mediastinalized conduit without redundancy is beneficial for gastric emptying. We are now facing the need to consistently modify esophageal surgery techniques to be suitable for the changing environment of minimally invasive surgery.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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