Delayed Gastric Emptying after Esophagectomy: Management and Prevention

Hee Chul Yang, M.D., Ph.D., Jin Ho Choi, M.D., Moon Soo Kim, M.D., Jong Mog Lee, M.D.

Center for Lung Cancer, Research Institute and Hospital, National Cancer Center, Goyang, Korea

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Corresponding author
Hee Chul Yang
Tel 82-31-920-1705
Fax 82-31-920-2798
E-mail yang@ncc.re.kr
ORCID https://orcid.org/0000-0003-2605-5985

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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-
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 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 (SmartPill 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].

**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  |

**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.
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 gastrointestinal 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 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].

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]. Hadzijusufovic 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 postoperative 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 endoscopy 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
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.

ORCID

Hee Chul Yang: https://orcid.org/0000-0003-2605-5985
Jin Ho Choi: https://orcid.org/0000-0001-5098-4544
Moon Soo Kim: https://orcid.org/0000-0001-8228-9036
Jong Mog Lee: https://orcid.org/0000-0001-7691-6072

References

1. Van Hagen P, Hulshof MC, van Lanschot JJ, et al. Preoperative chemoradiotherapy for esophageal or junctional cancer. N Engl J Med 2012;366:2074-84.
2. Elliott JA, Docherty NG, Eckhardt HG, et al. Weight loss, satiety, and the postprandial gut hormone response after esophagectomy: a prospective study. Ann Surg 2017;266:82-90.
3. Donington JS. Functional conduit disorders after esophagectomy. Thorac Surg Clin 2006;16:53-62.
4. Li B, Zhang JH, Wang C, et al. Delayed gastric emptying after esophagectomy for malignancy. J Laparoendosc Adv Surg Tech A 2014;24:306-11.
5. Benedix F, Willems T, Kropf S, Schubert D, Stubs P, Wolff S. Risk factors for delayed gastric emptying after esophagectomy. Langenbecks Arch Surg 2017;402:547-54.
6. Zhang L, Hou SC, Miao JB, Lee H. Risk factors for delayed gastric emptying in patients undergoing esophagectomy without pyloric drainage. J Surg Res 2017;213:46-50.
7. Arya S, Markar SR, Karkhesalingam A, Hanna GB. The impact of pyloric drainage on clinical outcome following esophagectomy: a systematic review. Dis Esophagus 2015;28:326-35.
8. Sutcliffe RP, Fordshaw MJ, Tandon R, et al. Anastomotic strictures and delayed gastric emptying after esophagectomy: incidence, risk factors and management. Dis Esophagus 2008;21:712-7.
9. Bolton JS, Conway WC, Abbas AE. Planned delay of oral intake after esophagectomy reduces the cervical anastomotic leak rate and hospital length of stay. J Gastrointest Surg 2014;18:304-9.
10. McLarty AJ, Deschamps C, Trastek VF, Allen MS, Pairolero PC, Harmsen WS. Esophageal resection for cancer of the esophagus: long-term function and quality of life. Ann Thorac Surg 1997;63:1568-72.
11. Gockel I, Gomez U, Domeyer M, Lang H, Junginger T. Long-term survivors of esophageal cancer: disease-specific quality of life, general health and complications. J Surg Oncol 2010;102:516-22.
12. Deldycke A, van Daele E, Ceelen W, van Nieuwenhove Y, Pattyn P. Functional outcome after Ivor Lewis esophagectomy for cancer. J Surg Oncol 2016;113:24-8.
13. Anandavadivelan P, Wikman A, Johar A, Lagergren P. Impact of weight loss and eating difficulties on health-related quality of life up to 10 years after oesophagectomy for cancer. Br J Surg 2018;105:410-8.
14. Finley FJ, Lamy A, Clifton J, Evans KG, Fradet G, Nelems B. Gastrointestinal function following esophagectomy for malignancy. Am J Surg 1995;169:471-5.
15. Lee HS, Kim MS, Lee JM, Kim SK, Kang KW, Zo JI. Intrathoracic gastric emptying of solid food after esophagectomy for esophageal cancer. Ann Thorac Surg 2005;80:443-7.
16. Konradsson M, Nilsson M. Delayed emptying of the gastric conduit remnant in patients receiving high-dosage preoperative chemoradiotherapy for esophageal cancer. Ann Thorac Surg 2007;83:1391-7.
after esophagectomy. J Thorac Dis 2019;11(Suppl 5):S835-44.
17. Bagheri R, Fattahi SH, Haghif SZ, et al. Botulinum toxin for prevention of delayed gastric emptying after esophagectomy. Asian Cardiovasc Thorac Ann 2013;21:689-92.
18. Burrows WM. Gastrointestinal function and related problems following esophagectomy. Semin Thorac Cardiovasc Surg 2004;16:142-51.
19. Kent MS, Luketich JD, Tsiwai W, et al. Revisional surgery after esophagectomy: an analysis of 43 patients. Ann Thorac Surg 2008;86:975-83.
20. Collard JM, Tinton N, Malaise J, Romagnoli R, Otte JB, Kestens PJ. Esophageal replacement: gastric tube or whole stomach? Ann Thorac Surg 1995;60:261-6.
21. Burt M, Scott A, Williard WC, et al. Erythromycin stimulates gastric emptying after esophagectomy with gastric replacement: a randomized clinical trial. J Thorac Cardiovasc Surg 1996;111:649-54.
22. Nishikawa M, Murakami T, Tangoku A, Hayashi H, Adachi J, Suzuki T. Functioning of the intrathoracic stomach after esophagectomy. Arch Surg 1994;129:837-41.
23. Cassilly D, Kantor S, Knight LC, et al. Gastric emptying of a non-digestible solid: assessment with simultaneous SmartPill pH and pressure capsule, antroduodenal manometry, gastric emptying scintigraphy. Neurogastroenterol Motil 2008;20:311-9.
24. Maqbool S, Parkman HP, Friedenberg FK. Wireless capsule motility: comparison of the SmartPill GI monitoring system with scintigraphy for measuring whole gut transit. Dig Dis Sci 2009;54:2167-74.
25. Nakabayashi T, Mochiki E, Garcia M, et al. Gastropyloric motor activity and the effects of erythromycin given orally after esophagectomy. Am J Surg 2002;183:317-23.
26. Collard JM, Romagnoli R, Otte JB, Kestens PJ. The denervated stomach as an esophageal substitute is a contractile organ. Ann Surg 1998;227:33-9.
27. Rove JY, Krupnick AS, Baciewicz FA, Meyers BF. Gastric conduit revision postesophagectomy: management for a rare complication. J Thorac Cardiovasc Surg 2017;154:1450-8.
28. Schaheen LW, Joubert KD, Luketich JD. Revising a gastric conduit after esophagectomy: how do we get it right? J Thorac Cardiovasc Surg 2017;154:1461-2.
29. Tang DM, Friedenberg FK. Gastropareasis: approach, diagnostic evaluation, and management. Dis Mon 2011;57:74-101.
30. Parkman HP, Hasler WL, Fisher RS; American Gastroenterological Association. American Gastroenterological Association medical position statement: diagnosis and treatment of gastroparesis. Gastroenterology 2004;127:1589-91.
31. Dhir R, Richter JE. Erythromycin in the short- and long-term control of dyspepsia symptoms in patients with gastroparesis. J Clin Gastroenterol 2004;38:237-42.
32. Weber FH Jr, Richards RD, McCallum RW. Erythromycin: a motilin agonist and gastrointestinal prokinetic agent. Am J Gastroenterol 1993;88:485-90.
emptying. Zentralbl Chir 1994;119:240-4.
49. Lee JI, Choi S, Sung J. A flow visualization model of gastric emptying in the intrathoracic stomach after esophagectomy. Ann Thorac Surg 2011;91:1039-45.
50. Bemelman WA, Verburg J, Brummelkamp WH, Klopper PJ. A physical model of the intrathoracic stomach. Am J Physiol 1988;254(2 Pt 1): G168-75.
51. Weijs TJ, Kumagai K, Berkelmans GH, Nieuwenhuijen GA, Nilsson M, Luyer MD. Nasogastric decompression following esophagectomy: a systematic literature review and meta-analysis. Dis Esophagus 2017;30:1-8.
52. Fritz S, Feilhauer K, Schaudt A, et al. Pylorus drainage procedures in thoracoabdominal esophagectomy: a single-center experience and review of the literature. BMC Surg 2018;18:13.
53. Lanuti M, de Delva PE, Wright CD, et al. Post-esophagectomy gastric outlet obstruction: role of pyloromyotomy and management with endoscopic pyloric dilatation. Eur J Cardiothorac Surg 2007;31:149-53.
54. Murphy TJ, Levy RM, Crist LR, Luketich JD. Minimally invasive pyloroplasty. Semin Thorac Cardiovasc Surg 2010;22:338-40.
55. Palmes D, Weilinghoff M, Colombo-Benkmann M, Senninger N, Bruewer M. Effect of pyloric drainage procedures on gastric passage and bile reflux after esophagectomy with gastric conduit reconstruction. Langenbecks Arch Surg 2007;392:135-41.
56. Nguyen NT, Dholakia C, Nguyen XM, Reavis K. Outcomes of minimally invasive esophagectomy without pyloroplasty: analysis of 109 cases. Am Surg 2010;76:1135-8.