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Anatomical Alterations and Endoscopic Strategies After Upper Gastrointestinal Surgery

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With the increasing number of upper gastrointestinal (GI) surgeries, the anatomical changes resulting from these procedures have become diverse and complex, presenting significant challenges for endoscopic evaluation and intervention. This review systematically analyzes the representative anatomical alterations following upper GI surgeries, including esophageal, gastric, and bariatric surgeries, and proposes effective endoscopic approaches tailored to each surgical type. In esophageal surgery, strategies for evaluating structural changes, such as conduit reconstruction, anastomotic strictures, and delayed gastric emptying, are reviewed. Anatomical alterations associated with various reconstruction methods (Billroth I, Billroth II, Roux-en-Y, and double-tract reconstruction), including anastomotic strictures, bile reflux, and remnant gastric dilatation, are discussed, along with detailed approaches for endoscopic access and assessment. Additionally, we address the significant increase in bariatric surgeries (sleeve gastrectomy and Roux-en-Y gastric bypass) in South Korea and discuss the endoscopic management of related complications, such as marginal ulcers, strictures, and gastrogastric fistulae. Through this review, we emphasize that a thorough understanding of surgery-specific anatomical characteristics, meticulous pre- and post-operative reviews of medical records and imaging, and adherence to the recently highlighted "3C principles" (confirm anatomy, check perfusion, and control complications) are essential for enhancing the accuracy and safety of endoscopic diagnoses and interventions in patients with surgically altered anatomy.

Keywords   Surgically altered anatomy; Upper gastrointestinal surgery; Gastric surgery; Bariatric surgery; Endoscopic approach.

INTRODUCTION

Over the past few decades, the number of upper gastrointestinal (UGI) surgeries has steadily increased worldwide, driven by improvements in early cancer detection, advances in function-preserving surgical techniques, and the growing adoption of bariatric metabolic procedures.[1,2] In South Korea, the implementation of a national cancer screening program has significantly improved the early detection rate of gastric cancer, leading to an increase in the number of curative operations, such as distal and total gastrectomies. In parallel, function-preserving procedures such as pylorus-preserving gastrectomies have also gained traction.[3] The introduction of diverse reconstruction methods, including Roux-en-Y and double-tract reconstruction, has further increased the complexity of the post-operative anatomy, posing notable challenges for endoscopic evaluation and intervention in clinical practice.[4]

Transthoracic and cervical esophagectomies remain the primary surgical options for esophageal diseases. Reconstruction is typically achieved via a gastric pull-up or interposition of the jejunum or colon, depending on patient-specific anatomical or vascular factors. These procedures frequently result in

significant anatomical alterations, including anastomotic strictures (reported in approximately 12%–33% of cases), fistulas, and delayed gastric emptying, all of which complicate endoscopic navigation and assessment.[1,5] Moreover, in patients who have undergone surgical treatment for gastroesophageal reflux disease (GERD), such as fundoplication, endoscopic evaluation of the fundic wrap position and integrity (e.g., wrap dehiscence) is essential.[6]

Simultaneously, bariatric surgery's prevalence has rapidly increased in South Korea following its inclusion in the national health insurance system. Sleeve gastrectomies and Roux-en-Y gastric bypasses (RYGBs) are the most commonly performed procedures.[7] These surgeries induce distinct alterations in the gastrointestinal anatomy and are frequently associated with complications requiring endoscopic evaluation, such as gastric pouch dilatation, marginal ulcers, and gastrogastric fistulas.[8,9] Importantly, endoscopic access to the distal limb in RYGBs using conventional scopes is technically challenging, necessitating balloon-assisted enteroscopy or other advanced techniques.[10] Depending on the reconstruction method, the failure rate of access to the papilla of Vater may reach 30%, underscoring the critical need for careful preprocedural planning.[2,11]

These anatomical complexities highlight the need for a systematic understanding of postsurgical anatomy and tailored endoscopic strategies, which are essential for accurate diagnosis, therapeutic intervention, and patient safety.

POSTOPERATIVE ANATOMICAL ALTERATIONS AND ENDOSCOPIC STRATEGIES

Surgical anatomy and endoscopic considerations after esophageal surgery

Surgical treatment for esophageal diseases is performed either with curative intent for malignancy or high-grade dysplasia or for functional improvement in cases such as benign strictures. Primary surgical approaches include transthoracic and cervical esophagectomies.[1,12] During transthoracic esophagectomy, a gastric conduit is created and pulled up through the posterior mediastinum to the chest for intrathoracic anastomosis. In cervical esophagectomy, the esophagus is mobilized from the abdominal side, and anastomosis is performed in the cervical region, bypassing the thoracic cavity (Figs. 1 and 2).[2,13] Reconstruction is most commonly performed using a gastric pull-up technique. When the gastric conduit is inadequate owing to insufficient blood supply or conduit length, jejunal or colonic interposition may be selected.[3,14] With the recent expansion of minimally invasive surgery using laparoscopy and thoracoscopy, the variety and complexity of postoperative anato-

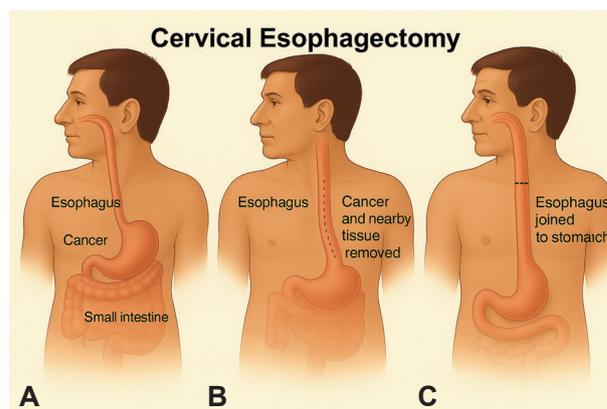**Fig. 1.** Endoscopic view of the esophagogastric anastomosis after esophagectomy.

Fig. 2. Illustration of cervical esophagectomy showing sequential surgical steps (ChatGPT; Version 5, OpenAI (2025), https://openai.com). A: Esophageal tumor identification. B: Resection of the tumor along with adjacent tissues. C: Reconstruction using a gastric conduit pulled up to the cervical region with a cervical esophagogastric anastomosis.

mies have increased.[5,8]

The major anatomical changes after esophagectomy include gastric conduit deformity, anastomotic strictures, delayed gastric emptying, and complicated endoscopic routes in patients undergoing intestinal interposition. The tubularized gastric conduit created by resecting the greater curvature of the stomach has a limited blood supply at the distal end, with a reported necrosis rate of approximately 5%–10%, particularly in patients with diabetes mellitus or a history of smoking.[15] Anastomotic strictures occur in approximately 10% of patients after transthoracic esophagectomies and 12%–33% after cervical esophagectomies, with a 2-fold increased risk in those with prior radiation therapy.[16] Delayed gastric emptying caused by impaired motility of the conduit is observed in approximately 15%–20% of cases and often results in poor endoscopic visualization due to food residue (Fig. 3).[17] In intestinal interpo-
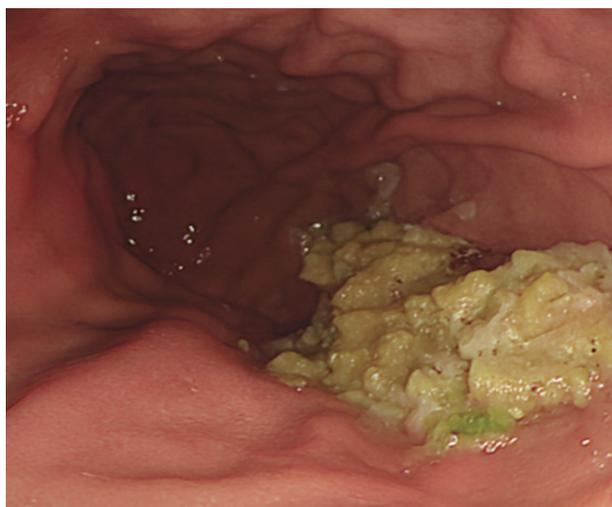
Fig. 3. Endoscopic image demonstrating food retention within the gastric conduit after esophagectomy.

sition, double anastomoses and variable conduit orientation lead to unpredictable luminal direction and length, often compounded by excessive loop distention that limits visualization.[18]

Endoscopy after esophagectomy requires a strategic approach based on a detailed understanding of the altered anatomy. A pediatric endoscope with an outer diameter of approximately 5.9 mm is often necessary for cervical anastomoses or suspected strictures. Before advancing to the anastomotic site, careful assessment of the stricture length and curvature is essential to guide the direction.[19] In cases of delayed gastric emptying, retroflexion is critical for evaluating retained food and mucosal integrity at the conduit base.[10] For patients with intestinal interposition, owing to the high likelihood of twisted lumens or excessive distention, insufflation should be minimized using CO_2. If needed, extended examination via single-balloon enteroscopy may be warranted.[11]

Cervical anastomoses often form at steep angles exceeding 45°, limiting maneuverability and requiring enhanced torque and tip-deflection control. Thus, selecting an endoscope with superior angulation capabilities is critical, and combined techniques including rotation, controlled advancement, and retroflexion must be used to secure an adequate field of view.[12] These strategies are essential not only for lesion detection but also for procedural safety and diagnostic precision.

The "3C principle" (confirm anatomy, check perfusion, and control complications) has been emphasized in the endoscopic evaluation of patients with surgically altered anatomy.[1] Preprocedural review of surgical records and cross-sectional imaging is essential to reduce the risk of misdirection, poor visualization, or procedural failure.[1,13]

For example, when applying "confirm anatomy," meticulous review of imaging and operative records is crucial in intestinal interpositions, where luminal direction is often unpredictable. The "check perfusion" step should be performed by assessing mucosal color and vascularity at the distal gastric conduit; evidence of poor perfusion warrants particular caution, as aggressive dilation or thermal therapy may markedly increase perforation risk. The "control complications" principle is most relevant in anastomotic strictures, where gradual balloon dilatation with CO_2 insufflation is recommended to reduce perforation risk.

In conclusion, endoscopic examination after esophageal surgery requires greater technical proficiency. Strategic planning based on a thorough understanding of the surgically altered anatomy is required. Accurate identification of the insertion angles, luminal configurations, and anastomotic sites is vital for minimizing endoscopic failure and maximizing diagnostic accuracy.

Surgical anatomy and endoscopic considerations after gastric surgery

The frequency of gastrectomies continues to increase in South Korea, paralleling advances in early gastric cancer detection and function-preserving surgical techniques.[8] Common procedures include distal, total, and pylorus-preserving gastrectomies, each followed by distinct reconstruction methods such as Billroth I, Billroth II, and Roux-en-Y anastomoses.[4,5] More recently, double-tract reconstruction has been selectively adopted to reduce bile reflux and postprandial symptoms, particularly in patients requiring functional preservation.[19]

Postoperative anatomical alterations vary depending on the type of reconstruction and commonly include anastomotic strictures, remnant stomach dilatation, bile reflux, and anastomotic ulcers.[4] These changes can complicate endoscopic access and visualization. For example, Billroth I reconstruction maintains physiological continuity between the remnant stomach and duodenum, thereby facilitating standard endoscopic insertion (Fig. 4). In contrast, Billroth II reconstructions create a loop configuration involving afferent and efferent limbs, which may lead to difficulty in identifying the gastrojejunostomy site or proper insertion route.[20] When accessing the afferent limb, careful angulation and discrimination between limb directions are essential (Fig. 5).

In this setting, a pediatric colonoscope or forward-viewing endoscope is often selected for initial intubation. Stepwise advancement with torque and careful rotation is recommended, using bile-stained fluid as a marker of the afferent loop. When conventional insertion fails, balloon-assisted enteroscopy can serve as a reliable second-line option.

The Roux-en-Y reconstruction presents further challenges. Exclusion of the duodenum prevents standard access to the

ampulla of Vater, necessitating balloon-assisted enteroscopy if a biliary or pancreatic evaluation is required.[18] In this setting, recognition of the Roux limb and navigation to the gastrojejunostomy site require meticulous orientation (Fig. 6).

Balloon-assisted enteroscopy is considered the first-line method for accessing the papilla in RYGB anatomy, while endoscopic ultrasound (EUS)-guided approaches or surgical interventions may be required as second-line strategies when enteroscopy is unsuccessful. However, the use of these advanced techniques may be limited by device availability and operator expertise, and referral to specialized centers should be considered in technically demanding cases.
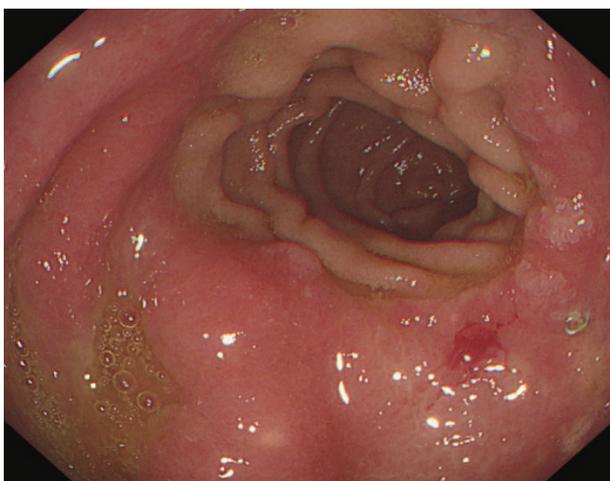

Fig. 4. Endoscopic appearance after Billroth I gastrectomy. Gastroduodenal anastomosis preserves physiological continuity, generally allowing straightforward passage; however, careful inspection is essential to detect strictures or ulcerations.

Anastomotic strictures develop in approximately 5%–15% of patients who undergo total gastrectomies and may require therapeutic endoscopic interventions such as balloon dilation or placement of self-expandable metal stents (SEMS) in symptomatic individuals.[21] Roux-en-Y reconstruction is often associated with bile stasis and marginal ulcers at the anastomotic site, which can manifest clinically as anemia or epigastric discomfort. Retroflexed endoscopic inspection of the remnant stomach and anastomotic mucosa is crucial in such cases.[22]

In pylorus-preserving gastrectomies, delayed gastric emptying occurs in approximately 15%–20% of patients. During endoscopy, food stasis in the proximal antrum and pyloric sphincter function must be assessed. A pediatric endoscope may be useful for evaluating pyloric passage, and targeted biopsies are recommended for mucosal evaluation when indicated.[23,24]

The "3C principle" can be directly applied in these settings. For the "confirm anatomy" principle, careful differentiation of afferent and efferent limbs in Billroth II reconstructions and precise recognition of the Roux limb in Roux-en-Y reconstructions are critical for avoiding misdirection. The "check perfusion" principle is particularly relevant when evaluating marginal ulcers at the anastomotic site; endoscopic findings such as mucosal pallor or friability may indicate impaired vascularity, warranting cautious biopsy or avoidance of thermal coagulation. "Control complications" is especially important during balloon dilation of anastomotic strictures, where stepwise expansion under CO_2 insufflation reduces perforation risk. Such examples highlight the practical relevance of the 3C framework to endoscopic strategies after gastric surgery.
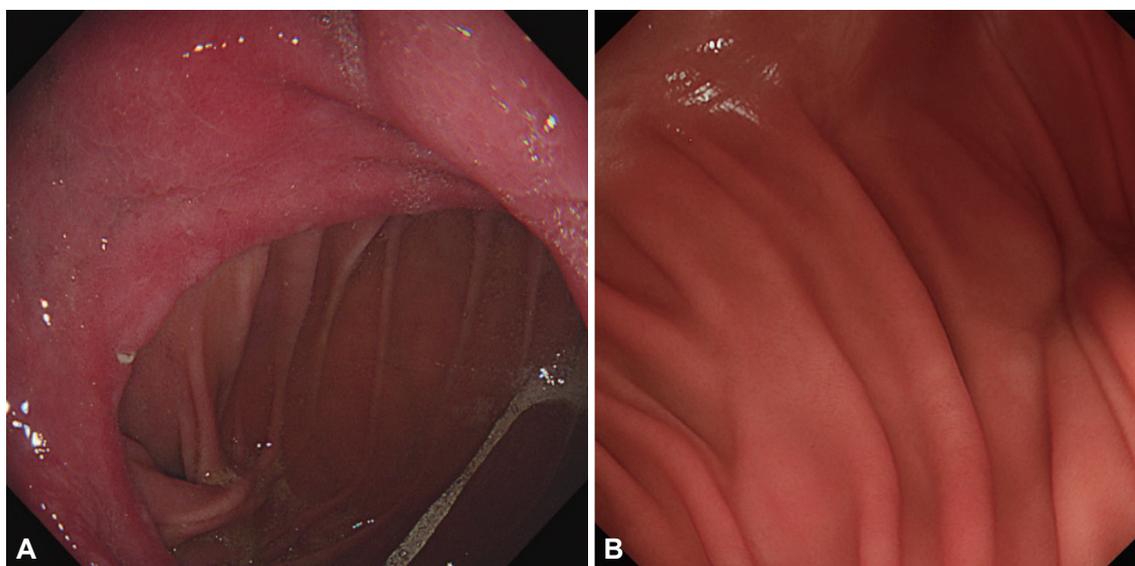

Fig. 5. Endoscopic findings after Billroth II reconstruction. A: Endoscopic view of the gastrojejunostomy site. The orifice often appears narrowed and angled, making identification and entry challenging. B: Internal view of the anastomosis with bifurcation into afferent and efferent loops. Differentiating the correct route is a major challenge, as misdirection into the afferent limb can prolong procedures or lead to failure.
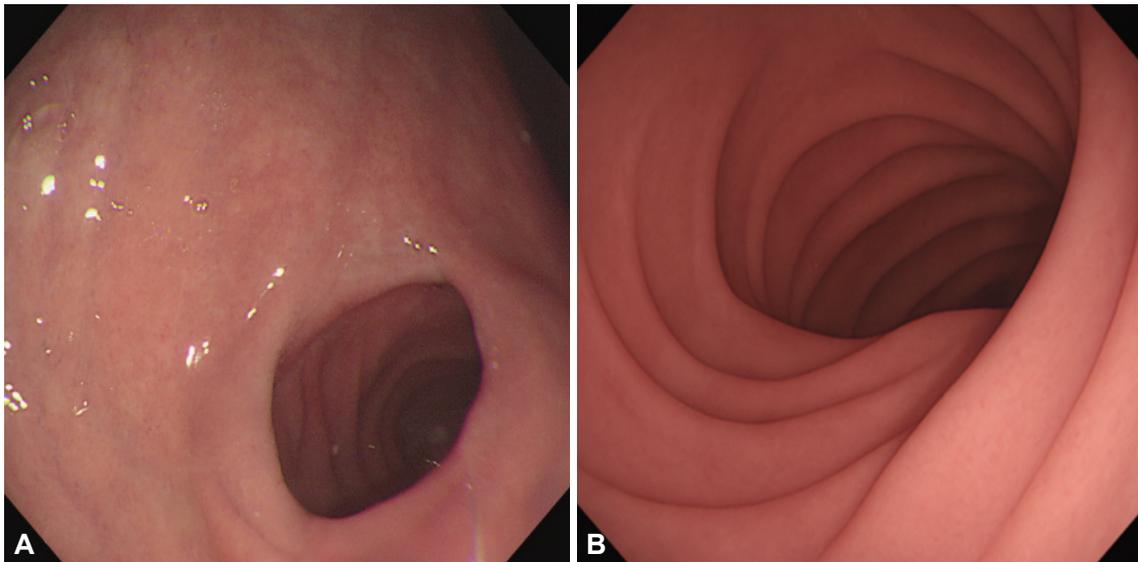
Fig. 6. Endoscopic views after Roux-en-Y reconstruction. A: Endoscopic appearance of the gastrojejunostomy site. Orientation requires precise recognition of the anastomotic lumen to avoid misentry. B: Roux limb with characteristic mucosal folds. Exclusion of the duodenum prevents standard access to the papilla of Vater, and biliary or pancreatic interventions often require balloon-assisted enteroscopy or endoscopic ultrasound-guided approaches.

Surgical anatomy and endoscopic considerations after bariatric/metabolic surgery

Bariatric surgery has evolved beyond its original role in weight reduction and is now widely recognized as a metabolic intervention for managing type 2 diabetes mellitus, dyslipidemia, and hypertension.[25] In South Korea, the number of bariatric surgeries surged following the inclusion of these procedures under the national health insurance coverage in 2022, with sleeve gastrectomy and RYGB being the most commonly performed operations.[26]

Sleeve gastrectomy involves vertical resection along the greater curvature of the stomach and the removal of the body and fundus to create a tubular remnant.[27] This results in a 70%–80% reduction in gastric volume and a decrease in the secretion of ghrelin, a hormone associated with appetite regulation.[28,29] In the early post-operative period, the remnant stomach appears as a straight and narrow tube, but long-term follow-up frequently reveals sleeve dilation, anastomotic stricture, and worsening of GERD due to increased intragastric pressure.[30-32] If stricture is suspected, evaluation using a pediatric endoscope can aid in assessing luminal patency and enable therapeutic interventions such as balloon dilation. Retroflexion is essential for evaluating sleeve configuration and narrowing (Fig. 7).[31]

Stepwise management is recommended in sleeve strictures: balloon dilation under CO_2 insufflation is the first-line therapy, while placement of a fully covered SEMS may be considered in refractory cases.

RYGB involves the creation of a small gastric pouch anastomosed to the jejunum, thereby bypassing the stomach, duode-

Fig. 7. Representative endoscopic image after sleeve gastrectomy.

num, and proximal small bowel.[33] This reconstruction resulted in three distinct limbs: the Roux (alimentary) limb, the biliary limb, and the common channel. This altered anatomy significantly limits conventional endoscopic access, especially to the papilla of Vater, rendering standard endoscopic retrograde cholangiopancreatography (ERCP) technically unfeasible in most cases.[34] In such scenarios, alternative approaches, such as balloon-assisted enteroscopy, EUS-guided access, and surgical biliary drainage, may be necessary.[34,35]

Balloon-assisted enteroscopy is generally the first-line method for accessing the biliary limb and papilla in patients with RYGBs. When unsuccessful, EUS-guided rendezvous or laparoscopy-assisted ERCP can serve as second-line options depending on device availability and local expertise. Because these advanced procedures often require specialized equipment and considerable technical expertise, timely referral to high-volume or specialized centers should be considered when local resources are limited.

Common post-operative complications of RYGB include anastomotic ulcers, anastomotic strictures, gastrogastric fistulas, and internal hernias, all of which require endoscopic diagnosis and management.[6,36,37] Anastomotic ulcers can lead to clinical symptoms such as abdominal pain, poor appetite, and iron deficiency anemia (Fig. 8). Therefore, careful inspection of the anastomotic mucosa during endoscopy for inflammation, erosion, or ulcers is essential.[2,6] When a gastrogastric fistula is suspected, chromoendoscopy or contrast-enhanced endoscopy may aid in confirming communication between the pouch and excluded stomach.[38]

The "3C principle" also provides practical guidance after bariatric surgery. For the "confirm anatomy" principle, accurate identification of the Roux, biliary, and common limbs is essential to prevent misdirection during scope advancement, particularly in patients with RYGBs. The "check perfusion" principle should be emphasized when evaluating anastomotic ulcers; endoscopic findings such as mucosal pallor or friability
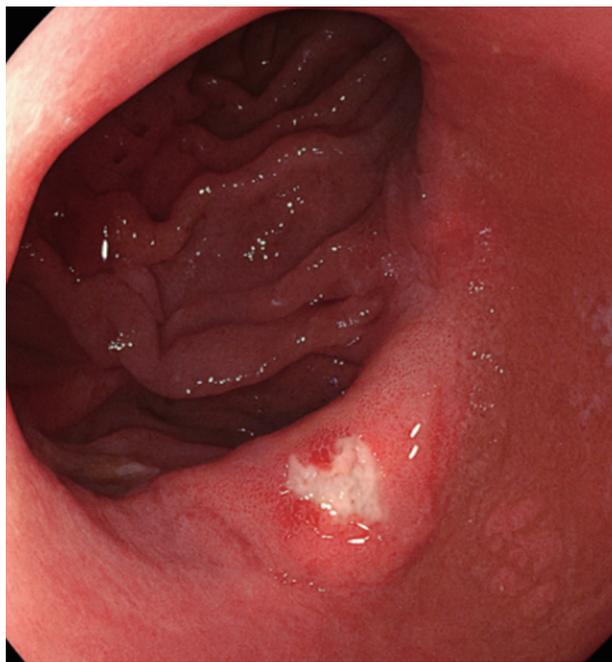

Fig. 8. Anastomotic ulcer after Roux-en-Y gastric bypass observed by endoscopy.

Table 1. Postoperative anatomical alterations and endoscopic strategies by surgical type

Surgery type	Anatomical alterations	Endoscopic challenges	Common complications	Endoscopic strategies
Esophagectomy (transthoracic, cervical)	Gastric conduit or intestinal interposition; cervical/intrathoracic anastomosis	Angulated anastomosis; limited perfusion at distal conduit; tortuous segments	Anastomotic stricture, delayed emptying, conduit necrosis	Pediatric scope for narrow anastomosis; retroflexion for stasis; CO_2 insufflation; balloon dilation; balloon enteroscopy if interposition
Gastrectomy – Billroth I	Gastroduodenal continuity preserved	Generally straightforward passage	Stricture, bile reflux	Standard gastroscope; careful anastomotic inspection
Gastrectomy – Billroth II	Gastrojejunostomy with afferent/efferent limbs	Orientation difficult; risk of afferent misentry	Marginal ulcer, afferent loop syndrome	Pediatric colonoscope or forward-viewing scope; stepwise torque/rotation; bile-stained fluid as marker; balloon enteroscopy if needed
Gastrectomy – Roux-en-Y	Duodenum excluded; Roux limb created	Ampulla inaccessible; long limb navigation	Marginal ulcer, bile stasis, stricture	Balloon-assisted enteroscopy (1st line); EUS-guided or laparoscopy-assisted ERCP (2nd line)
Gastrectomy – pylorus-preserving	Pylorus preserved; reduced emptying	Food stasis at pylorus	Delayed emptying, remnant gastritis	Pediatric scope for pyloric passage; targeted biopsies
Bariatric – sleeve	Tubular stomach; ↑ intragastric pressure	Difficult retroflexion; reflux	Stricture, dilation, GERD	Balloon dilation (1st line); SEMS if refractory
Bariatric – Roux-en-Y gastric bypass	Gastric pouch, Roux/biliary/common limbs	Papilla inaccessible	Ulcer, stricture, fistula, hernia	Balloon enteroscopy (1st line); EUS-guided rendezvous or laparoscopy-assisted ERCP (2nd line); chromoendoscopy for fistula

CO_2, carbon dioxide; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound; GERD, gastroesophageal reflux disease; SEMS, self-expandable metal stent.

may indicate ischemia and should guide decisions to avoid aggressive interventions. The "control complications" principle is particularly relevant in managing sleeve strictures or anastomotic narrowing, where incremental balloon dilation under CO_2 insufflation is preferred to minimize perforation risk. Collectively, these examples demonstrate how the 3C framework can be translated into practical endoscopic guidance after bariatric procedures. To provide a concise comparison across surgical types, we have added a summary table that outlines key anatomical alterations, common complications, and corresponding endoscopic strategies (Table 1).

In conclusion, endoscopic evaluation after bariatric surgery requires high technical proficiency. A detailed understanding of specific anatomical alterations associated with each surgical procedure is critical for effective and safe endoscopic access. Preprocedural review of surgical records, cross-sectional imaging, and contrast studies is recommended to minimize navigation failures and missed diagnoses. When appropriate, the use of specialized endoscopes and a multidisciplinary approach should be considered to optimize outcomes.

CONCLUSIONS

Anatomical alterations following UGI surgery vary depending on the type of operation (esophageal, gastric, or bariatric) and present significant challenges for both diagnostic and therapeutic endoscopy. Esophageal surgeries, including gastric pull-up and intestinal interposition techniques, often lead to anastomotic strictures and delayed gastric emptying, requiring precise endoscopic insertion planning and careful visualization. Common post-operative changes include anastomotic stenosis, bile reflux, and remnant gastric dilation. In such cases, strategic endoscopic access, which accounts for altered loop configurations, is essential. Moreover, the recent surge in bariatric/metabolic procedures in South Korea, particularly sleeve gastrectomy and RYGB, has introduced unique anatomical challenges and a wide range of endoscopy-relevant complications, such as anastomotic ulcers and gastrogastric fistulas.

To effectively manage these complexities, endoscopists must have a thorough understanding of the anatomical characteristics of each surgical procedure. A structured and strategic approach based on operative reports and cross-sectional imaging is critical to ensure safe and accurate endoscopic evaluations and interventions. Adherence to fundamental principles such as "confirming anatomy, checking perfusion, and controlling complications" can further enhance procedural safety and diagnostic precision. Ongoing research and the accumulation of clinical experience are essential for deepening our understanding of postsurgical anatomy and for the continued development and standardization of endoscopic strategies tailored to surgically altered anatomy.

Authors' Contribution

Conceptualization: Byung Chul Jin, Seung Young Seo. Data curation: Byung Chul Jin, Seung Young Seo. Formal analysis: Byung Chul Jin, Seung Young Seo. Investigation: Byung Chul Jin, Seung Young Seo. Methodology: Byung Chul Jin, Seung Young Seo. Project administration: Byung Chul Jin, Seung Young Seo. Resources: Byung Chul Jin, Seung Young Seo. Supervision: Seung Young Seo. Validation: Byung Chul Jin, Seung Young Seo. Visualization: Byung Chul Jin, Seung Young Seo. Writing—original draft: Byung Chul Jin, Seung Young Seo. Writing—review & editing: Byung Chul Jin, Seung Young Seo. Approval of final manuscript: Byung Chul Jin, Seung Young Seo.

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