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Current Trends in Gastric Cancer Surgery and Postoperative Care

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The surgical management of gastric cancer has evolved rapidly, with minimally invasive, function-preserving, and fluorescence-guided techniques increasingly adopted as standard practice. Laparoscopic and robotic gastrectomies have shown comparable long-term oncologic outcomes while providing improved perioperative recovery, and individualized reconstruction methods further enhance postoperative quality of life. Recent trials support the use of neoadjuvant chemotherapy for locally advanced disease, demonstrating improved recurrence-free survival. Postoperative management has shifted its focus from early complication prevention to long-term care, addressing nutritional deficiencies and functional syndromes such as anemia, osteoporosis, dumping syndrome, and gastrointestinal dysfunction. Close coordination between surgeons and multidisciplinary care teams is crucial to ensure the prompt management of postoperative complications, including bleeding, leakage, and abscess formation. The implementation of structured protocols for nutritional assessment, micronutrient supplementation, and comprehensive long-term surveillance is strongly advocated to optimize patient survival and preserve postoperative quality of life. This review summarizes the latest evidence and trends in surgical and postoperative care for gastric cancer, highlighting the importance of standardized, evidence-based protocols and individualized patient care strategies.

Keywords Stomach neoplasm; Gastrectomy; Postoperative complications; Nutritional support; Quality of life.

INTRODUCTION

In recent years, remarkable progress has been made in the surgical management of gastric cancer, propelled by high-quality clinical trials and technological innovation.[1-5] Minimally invasive modalities, ranging from laparoscopic to robotic gastrectomy, are increasingly replacing open techniques, achieving comparable oncologic outcomes while providing superior perioperative recovery and enhanced quality of life (QOL).[6] Efforts to minimize surgical morbidity have led to the adoption of function-preserving procedures, as well as the integration of sentinel node navigation and fluorescence-guided surgery, which enable more personalized and targeted approaches.[7,8] In parallel, the implementation of tailored perioperative chemotherapy and a focus on structured, multidisciplinary postoperative management reflect a paradigm shift from simply achieving survival to optimizing functional and metabolic outcomes among long-term survivors.[9] This review provides an up-to-date synthesis of these advances, emphasizing evidence-based surgical strategies and comprehensive postoperative care for contemporary gastric cancer treatment.

SURGICAL TREATMENT OF GASTRIC CANCER

Minimal invasive surgery

Minimally invasive surgery has become increasingly important in gastric cancer management. In early gastric cancer (EGC), laparoscopic distal gastrectomy (LDG) has demonstrated not only safety but also non-inferiority of survival compared with open surgery.[1,3]

In addition, two randomized phase III clinical trials reported favorable survival outcomes with LDG in patients with locally advanced gastric cancer.[2,4,5,10] These results have led to the widespread application of laparoscopic gastrectomy, as evidenced by the increase in laparoscopic approaches to 70.8% in nationwide survey data.[11]

However, the efficacy of laparoscopic total gastrectomy (TG) remains unclear. Several clinical trials have shown similar morbidity and mortality rates between open and laparoscopic TG performed by experienced surgeons.[12-14] Furthermore, a multicenter randomized controlled trial (KLASS-06) is ongoing to verify the technical and oncologic safety of laparoscopic surgery compared with open surgery (NCT03385018). However, the long-term outcomes of laparoscopic TG have yet to be fully established.

Robotic systems have been developed to overcome the technical limitations of laparoscopic surgery. Robotic gastrectomies have shown advantages over the laparoscopic approach in terms of reduced blood loss and increased lymph node harvest.[15-17] Several studies have demonstrated a reduction in severe postoperative complications after robotic gastrectomies.[15,16] However, robotic approaches did not lead to improved long-term survival compared with laparoscopic gastrectomy. In a retrospective study that matched robotic and laparoscopic gastrectomy groups, the 5-year overall survival (OS) and recurrence-free survival (RFS) were statistically comparable between the groups (5-year OS, 93.2% vs. 94.2%; 5-year RFS, 90.7% vs. 92.6%, respectively).[18] One randomized controlled trial showed no difference in 3-year RFS between the two groups (84.5% vs. 80.2%, p=0.17).[16] As a result, current evidence highlights the benefits of robotic gastrectomy in high-risk surgeries (e.g., complex lymphadenectomy or cases with a high risk of complications), although further studies on cost-effectiveness and expanded indications are needed.

Function-preserving surgery

As there is a practical need to focus on the QOL of patients with EGC, function-preserving surgery has been introduced to reduce postoperative morbidity and improve long-term QOL by minimizing the extent of resection and preserving the physiological function of the stomach.

Proximal gastrectomy

Proximal gastrectomy (PG) has the potential advantages of improved postoperative nutritional outcomes[19-25] and QOL[24,25], and prevention of anemia[19,21,22,26,27] because the gastric volume is retained (Fig. 1A).

Several retrospective analyses have demonstrated that EGC located in the proximal stomach has a negligible rate of peripyloric lymph node (LN stations 4d, 5, and 6) metastasis,[28-31] and survival rates are comparable between the TG and PG

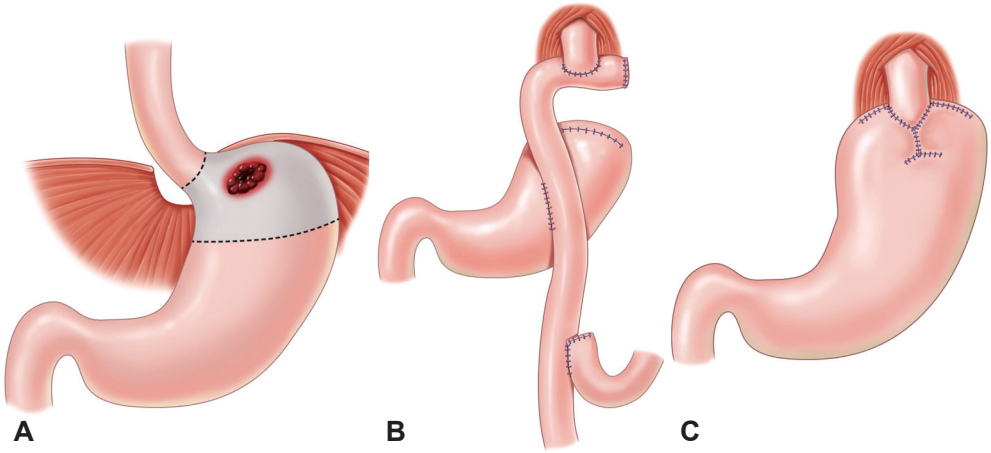

Fig. 1. Illustration of proximal gastrectomy procedures. A: In proximal gastrectomy, the esophagus and stomach are separated by resecting the upper portion of the stomach. B: Double tract reconstruction involves three distinct anastomoses: an esophagojejunostomy connecting the esophagus to a jejunal Roux limb; a gastrojejunostomy linking the residual gastric antrum to the same jejunal limb; and a jejunostomy that reestablishes intestinal continuity. These connections create two separate pathways for food, mitigating bile reflux and improving digestive function. C: The double-flap technique is an esophagogastrostomy procedure that creates two seromuscular flaps from the anterior wall of the gastric remnant. The posterior esophageal wall is anastomosed to the deep layer of the gastric remnant, and the flaps are subsequently used to cover the anastomosis, creating a valve-like mechanism that prevents reflux.

groups.[19,26,32] Accordingly, PG is recommended when more than half of the remnant stomach can be preserved in cT1N0 upper-third gastric cancer according to Korean and Japanese guidelines.[9,33] Patients with upper-third gastric cancer (cardia, fundus, or high body) and a tumor size of less than 4.0 cm are candidates for PG.

In many cases, the most important issue after PG is gastroesophageal reflux. Esophagogastrostomy is a simple and physiological reconstruction method that requires only one anastomosis but is likely to cause reflux (12.0%–37.4%) and anastomotic stricture (6.6%–35.1%).[19,22,26,34] To resolve these concerns, double tract reconstruction (Fig. 1B), double-flap technique (Fig. 1C), and jejunal interposition have also been devised. The reconstruction method should be determined by considering technical difficulties, complications, and surveillance of the remnant stomach following PG.

Currently, a multicenter, prospective, randomized controlled trial has reported the results of nutritional outcomes, QOL, reflux esophagitis, and 2-year survival between laparoscopic PG with double tract reconstruction and laparoscopic TG patients.[35] This study provides evidence of the efficacy of laparoscopic PG with double tract reconstruction for proximal EGC with lower vitamin B12 supplementation (14.7% vs. 58%), better QOL subscales, similar reflux esophagitis, and 2-year survival outcomes compared with TG.

The double-flap technique, an alternative reconstruction method for PG, was introduced and has shown favorable outcomes in terms of postoperative complications, reflux esophagitis, and postoperative nutritional parameters.[36,37]

According to the 2023 national data survey in Korea, the proportion of PG was only 3.4%, of which double tract reconstruction accounted for 51.9% and the double-flap technique accounted for 18.1%, with various anastomosis methods being implemented.[11] Therefore, multicenter prospective studies to determine the optimal anastomotic method for PG and enhance clinical outcomes are required.

Pylorus preserving gastrectomy

Pylorus preserving gastrectomy (PPG) was developed as a surgical procedure for EGC in the middle third of the stomach, designed to preserve pyloric function and maintain a better postoperative QOL (Fig. 2).

Several reports have found very low incidences of supra- and infra-pyloric lymph node metastases (LN stations 5 and 6) in EGC of the middle third of the stomach,[38-40] and PPG shows similar 5-year OS and RFS rates to those of conventional distal gastrectomy (DG).[41] Accordingly, PPG is recommended as a surgical option for cT1N0 tumors located in the middle portion of the stomach with a distal tumor border at least 4 cm proximal to the pylorus.[33]

A Korean multicenter randomized controlled trial (KLASS-04) compared laparoscopic pylorus preserving gastrectomy and LDG and found that the PPG group showed a lower rate of bile reflux (13.2% vs. 24.4%, respectively) and gallstone formation (2.3% vs. 8.7%).[42] However, there was a higher incidence of reflux esophagitis (17.8% vs. 6.3%) and delayed gastric emptying (16.3% vs. 4.0%), and similar body weight changes and QOL in the PPG group.

PPG has advantages over DG in reducing gallstone formation, bile reflux, and nutritional deficiencies, while maintaining similar survival rates, complication rates, and QOL. PPG may be a good option for EGC located at least 5 cm from the pylorus, although the risk of delayed gastric emptying should be considered.

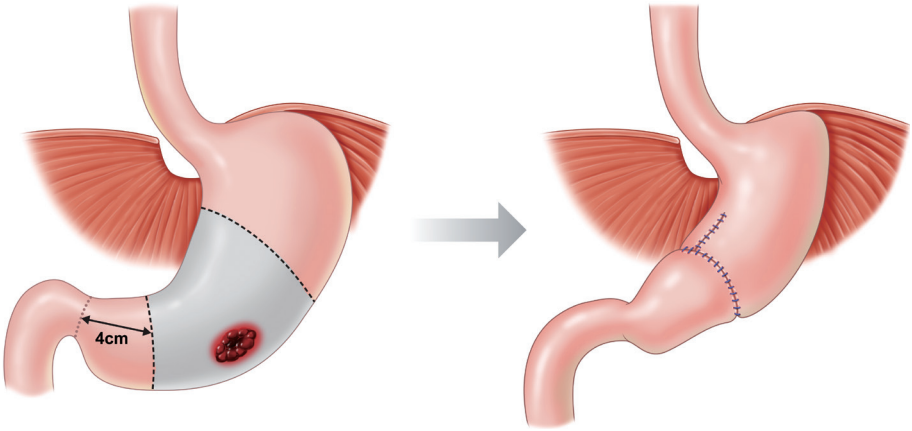

Fig. 2. Pylorus preserving gastrectomy. The middle portion of the stomach containing the tumor is resected, while the pylorus and a portion of the antrum are preserved. The antral cuff should remain at least 4.0 cm from the pylorus. The remaining upper and lower portions of the stomach are then anastomosed (gastro-gastric anastomosis).

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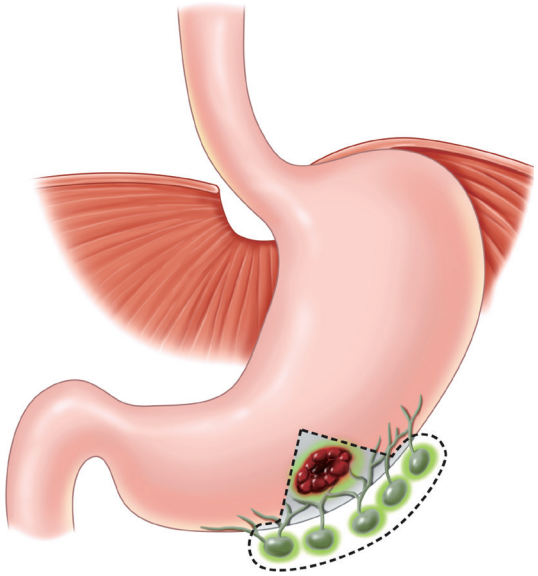

Fig. 3. Sentinel node navigation surgery. After endoscopic injection of a dual tracer into the submucosal layer of the gastric tumor, sentinel basins containing sentinel nodes are detected visually and using specialized detectors. All harvested sentinel nodes are sent for intraoperative frozen-section analysis by a pathologist. Subsequently, stomach-preserving surgery is performed in patients without metastasis in the sentinel basin lymph nodes. These procedures include endoscopic submucosal dissection, endoscopic full-thickness resection, laparoscopic wedge resection, or segmental resection.

Sentinel node navigation surgery

Laparoscopic sentinel node navigation surgery (LSNNS) (Fig. 3) is a promising technique for reducing the extent of lymphadenectomy in EGC patients.[43] Although a prospective multicenter phase III trial (SENORITA) failed to show noninferiority of LSNNS (91.8%) relative to standard laparoscopic gastrectomy (95.5%) for 3-year disease-free survival (DFS) with a 5% margin, 3-year disease-specific survival (DSS) and OS rates were not significantly different between the LSNNS (99.1% and 97.6%, respectively) and standard gastrectomy groups (99.5% and 99.2%, respectively) for stage IA gastric cancer.[7] In addition, the 5-year DFS, DSS, and OS rates did not differ significantly between the two groups.[44] Long-term nutritional and physical parameters and QOL were superior in the LSNNS group.[45] Nonetheless, LSNNS has several issues in terms of standardization of procedures and oncological safety, including the false-negative rate of sentinel node biopsy and the survival rate.[46] Therefore, issues regarding the establishment of standardized techniques for sentinel node mapping and detection, as well as oncologic safety, must be resolved.

Fluorescence imaging-guided surgery

A novel surgical navigation technique, the fluorescence imaging system for intraoperative image-guided surgery, was developed to enable intraoperative staging, detect tumor and lymph node metastases, and identify critical normal tissues.[47]

This fluorescent imaging system enables real-time visualization of indocyanine green (ICG) during surgery, which helps surgeons perform effective and safe sentinel lymph node biopsies and lymphadenectomies. To date, many studies have shown the feasibility and safety of ICG fluorescence imaging for sentinel node detection.[48,49] ICG fluorescence imaging is expected to be applied widely and replace the sentinel node mapping method using radioisotopes in gastric cancer.

Several studies have reported favorable results with the use of ICG in effective lymphadenectomy.[8,50,51] However, clinical evidence confirming whether ICG fluorescence imaging-guided surgery reduces recurrence and improves survival remains limited.[8,52]

In addition, the limited penetration of fluorescence imaging is a major issue. The development of fluorescent imaging techniques and probes, along with the accumulation of experimental data and clinical applications of imaging technology, is required to realize truly targeted surgery in cancer treatment.

NON-SURGICAL TREATMENT OF GASTRIC CANCER

Neoadjuvant chemotherapy

Recent evidence from Asia has supported the use of neoadjuvant chemotherapy (NAC) for advanced gastric cancer. Notably, the Korean PRODIGY trial demonstrated superior outcomes with NAC (docetaxel, oxaliplatin, and S-1 [DOS]) compared with adjuvant therapy alone, particularly in terms of complete resection rates and progression-free survival.[53,54] Similarly, the RESOLVE trial showed that perioperative chemotherapy with S-1 and oxaliplatin (SOX) significantly improved DFS compared with adjuvant capecitabine and oxaliplatin.[55,56] Long-term analyses from both trials confirmed a significant OS benefit with perioperative chemotherapy.

Based on these findings, the Korean Gastric Cancer Treatment Guidelines recommend the use of NAC (DOS and SOX regimens) for patients with locally resectable advanced gastric cancer.[9]

In the FLOT4 trial conducted in Western countries, fluorouracil, leucovorin, oxaliplatin, and docetaxel (FLOT) demonstrated superior OS compared with the epirubicin, cisplatin, and fluorouracil regimen (median OS, 50 months vs. 35 months; 5-year OS, 45% vs. 36%, respectively).[57]

However, the FLOT regimen has not yet been extensively studied or widely adopted in Asian populations owing to limited evidence.

Given its OS benefit, NAC as part of perioperative chemotherapy is considered a viable therapeutic option for patients

with resectable, locally advanced gastric cancer in Korea. Clinical decisions to proceed with NAC should be made after careful multidisciplinary discussion of various factors, including clinical stage, and a balanced consideration of its potential advantages and limitations compared with upfront surgery.

POST-GASTRECTOMY MANAGEMENT

Recent advances in EGC detection and surgical techniques have improved postoperative survival rates. Consequently, the focus has shifted from survival to QOL and nutritional status after gastrectomy. Postoperative management can be categorized into immediate postoperative care during hospitalization and long-term continuous care after discharge. This section addresses patient management from several perspectives.

Immediate postoperative care

Patient management immediately after gastrectomy involves monitoring for complications and implementing gradual dietary progression. The risk of postoperative complications varies according to the extent of gastric resection and the type of anastomosis performed. Recent studies have indicated a declining trend in complication rates compared to historical data. Nevertheless, serious complications persist, necessitating diligent monitoring and appropriate intervention.

Bleeding

Postoperative bleeding occurs in approximately 1% of gastric cancer surgeries.[58,59] Bleeding may occur immediately after surgery or develop later. Postoperative bleeding can be classified as intra-abdominal or gastrointestinal bleeding. Immediate postoperative bleeding often results from incomplete hemostasis or diffuse capillary oozing. Bleeding that manifests within one to two weeks after surgery may result from vascular erosion secondary to anastomotic leakage, intra-abdominal abscess formation, or a delayed pseudoaneurysm due to vascular injury. In cases of minimal intra-abdominal bleeding, conservative management with close observation for spontaneous hemostasis is possible. However, surgical re-exploration for vessel ligation or angiographic embolization is required if arterial bleeding is confirmed on computed tomography (CT).[60]

Intraluminal bleeding occurs primarily at the gastrectomy site or anastomosis. Most bleeding episodes arise from microvascular sources and can be managed endoscopically with epinephrine injection or clipping. Surgical intervention may be required in cases of significant bleeding with obscured visualization due to intraluminal hematoma. Recent studies have shown promising outcomes using immediate intraoperative endoscopy to identify and manage bleeding sites, thereby reducing anastomotic complications.[61]

Anastomosis leakage

Anastomotic leakage is defined as the breakdown of the anastomotic connection and subsequent leakage of effluent from the digestive tract following gastric surgery. Gastric juice and biliopancreatic fluid are the main components in gastric cancer surgery. Various types of anastomotic leakage can occur after gastric cancer surgery, depending on the type of anastomosis performed. Gastroenterologists play an important role in the diagnosis and management of anastomotic leakages.[62,63]

Type of anastomosis leakage

- Distal gastrectomy

Duodenal stump leakage, Gastro-duodenostomy, Gastro-jejunostomy, Jejuno-jejunostomy

- Total gastrectomy

Duodenal stump, Esophago-jejunostomy, Jejuno-jejunostomy

- Proximal gastrectomy

Esophagogastrostomy and Esophagojejunostomy (double tract anastomosis)

Diagnosis for anastomosis leakage

Sequels after anastomosis leakage cause progressive spillage of enteric contents (containing digestive enzymes and air), bacterial contamination, intra-abdominal abscesses, wound infections, and enterocutaneous (E-C) fistulas. Prolonged sepsis and mortality may occur if appropriate treatment is not administered. Symptoms or signs suggestive of anastomotic leakage include abrupt abdominal pain with muscle guarding, dyspnea, diaphoresis, ambiguous abdominal pain with fever, color or odor changes in the drainage contents, and wound erythema or abscess. In this situation, anastomotic leakage should be considered a possible cause.

To make an accurate diagnosis of anastomotic leakage, confirming the communication between the abdominal cavity and the intraluminal space is essential. CT or fluoroscopy using oral water-soluble dyes are helpful in identifying anastomotic leakage. When a surgical drain is already in place, fistulography through the drain may assist diagnosis if contrast medium enters the intraluminal space. Endoscopic evaluation is sometimes needed, especially in esophagojejunostomies, when these studies are not helpful in making a definite diagnosis. Using a direct endoscopic view, we can define a wall defect at the anastomosis line.[63]

Management for anastomosis leakage

Management of anastomotic leakage consists of two com-

ponents: general management, and the conversion of intra-abdominal contamination into a well-controlled E-C fistula.

General management of anastomotic leakage begins with acute resuscitation with adequate fluid and electrolyte replacement and stable vital signs. Oral intake should be stopped and proper central nutritional support should be substituted. Pain control is fully adopted when it does not interfere with decision-making for reoperation. Nasogastric or nasoenteric tubes should be placed to relieve obstructive symptoms. Nutritional support is one of the most important therapies because healing at the leakage site depends largely on the patient's intrinsic wound-healing capacity.

Several processes are involved in the management of anastomotic leakage. Among these procedures, endoscopy plays a role in minimizing the output control of luminal contents.[64] In general, a high-output fistula is known to be a negative factor for early closure of an E-C fistula. Therefore, coverage of the luminal side of the leakage site is important for preventing high-output fistulas and delayed leakage management. This approach includes Foley catheter duodenostomy for duodenal stump leakage[65] and covered stenting for esophagojejunostomy leakage or endoscopic vacuum-assisted closure (EVAC) using a polyurethane foam sponge.[64] EVAC is an endoscopic procedure used to manage leakage sites by promoting granulation tissue formation and facilitating defect closure. A polyurethane sponge was positioned at the leakage site, attached to the end of a Levine tube, and placed endoscopically. By applying continuous negative pressure, dirty fluid can be suctioned out, and tissue growth through tiny holes in the sponge can be induced. Choi et al.[66] reported successful EVAC procedures with substantially larger leakage sites and failed cases with self-expandable metallic stents (SEMS). Moreover, patients who healed with EVAC had a lower incidence of anastomotic stricture formation. When this management is successfully performed, the abscess cavities quickly shrink and become complete, creating a controlled E-C fistula. All these processes need to be harmonized between surgeons and gastroenterologists because the timing of intervention and understanding of anastomosis and anatomic status are important for safe and effective management. It is clinically useful to classify nonsurgical treatment options according to the type of anastomotic leakage.

- Esophagojejunostomy: conservative care, pigtail drainage, SEMS, EVAC
- Duodenal stump: conservative care, pigtail drainage, foley duodenostomy, percutaneous transhepatic biliary drainage
- Gastroduodenostomy: conservative care, pigtail drainage, SEMS, EVAC
- Gastrojejunostomy: conservative care, pigtail drainage

Intra-abdominal abscess

Intra-abdominal abscesses are a common infectious complication of gastrectomy for gastric cancer.[11,67] The mechanisms underlying abscess formation typically include the following: first, gastrointestinal contents that leak into the abdominal cavity during surgery may remain unaspirated and subsequently form an abscess. Second, fluid leakage from dissected surfaces after lymph node dissection may fail to drain properly, resulting in secondary infection. Finally, pancreatic fluid leakage during lymph node dissection can injure surrounding tissues, leading to secondary infections.[68]

Diagnosis is typically confirmed by abdominal CT, and treatment can be effectively achieved by percutaneous drainage.[69] It is important to note that even when postoperative drainage tubes are in place and the drainage fluid appears clear, adhesions surrounding the catheter may impede adequate drainage, potentially masking nearby abscess formation. The role of surgical drainage in the early detection of postsurgical abscess formation remains controversial.[70] Therefore, if an intra-abdominal abscess is clinically suspected, abdominal CT should be performed before discharge to confirm or rule out complications.

Long-term complications

Gastrectomy for gastric cancer induces various physiological and anatomical alterations that significantly affect patients' QOL and necessitate continuous management because of the potential for multiple chronic complications.

Partial gastrectomy results in a marked reduction in gastric volume, whereas TG involves the complete removal of the stomach, severely limiting the volume of food intake per meal. Consequently, gastrectomy patients experience a decline in QOL and are advised to modify their dietary habits by consuming smaller, more frequent meals. Fortunately, the remnant stomach and small intestine possess adaptive elasticity, allowing patients to gradually increase their food intake over the adaptation period. In general, dietary QOL recovers within 6 to 12 months after surgery.[71]

Substantial hormonal changes occur after gastrectomy. Gastrectomy considerably reduces the number of parietal cells predominantly located in the gastric body, resulting in decreased gastric acid secretion. Furthermore, the removal or reduction of G cells located primarily in the gastric antrum decreases gastrin secretion, thereby further reducing gastric acidity. These reductions negatively affect digestion and the bactericidal capacity of the stomach, thereby increasing the risk of digestive dysfunction and intestinal bacterial overgrowth. Long-term consequences include chronic diarrhea, malabsorption, and small intestinal bacterial overgrowth.

Finally, vagotomy performed during gastrectomy is associated with various physiological changes. The vagus nerve plays a critical role in the regulation of gastrointestinal motility and gastric acid secretion. Therefore, vagotomy can lead to impaired gastric motility, decreased gastric acid secretion, dumping syndrome, impaired gallbladder function, and increased risk of gallstone formation.

Dumping syndrome

One of the primary physiological functions of the stomach is to store ingested food temporarily and gradually release it into the small intestine. However, following gastrectomy, storage function is impaired or lost. Additionally, associated procedures such as vagotomy and pyloric dysfunction further accelerate the rapid transit of food into the small intestine, causing various uncomfortable symptoms, collectively known as dumping syndrome.[72]

Clinically, dumping syndrome can be classified into two types based on timing and symptoms.

Early dumping syndrome typically occurs within 10 to 30 min after a meal. This occurs when food enters the small intestine rapidly, causing rapid distension and stimulating neural and hormonal responses. Common symptoms include abdominal fullness, pain, diarrhea, nausea, vomiting, flushing, dizziness, and a rapid heartbeat.[72]

Late dumping syndrome usually occurs 1 to 3 hours after a meal and is primarily associated with rapid glucose absorption leading to reactive hypoglycemia. The rapid absorption of food, particularly simple carbohydrates, initially elevates blood glucose levels, triggering excessive insulin secretion, and subsequently causing hypoglycemia. Symptoms include fatigue, cold sweats, tremors, dizziness, reduced concentration, hunger, and palpitations.[72,73]

While most patients primarily experience symptoms of early dumping syndrome shortly after meals, some may exhibit both early and late symptoms simultaneously.

Dietary modifications are essential for preventing or alleviating dumping syndrome. Patients should consume small, frequent meals and limit the intake of high-sugar foods such as simple sugars, refined carbohydrates, sweeteners, and fruit juices. Patient education regarding diet composition and meal size adjustments is crucial for symptom management.[74]

In most cases, dietary adjustments alone can significantly improve symptoms, which often resolve naturally. However, patients with severe symptoms or poor response to dietary modification may require pharmacologic intervention (e.g., somatostatin analogs). Surgical revision is rarely considered if symptoms remain unmanageable despite medical therapy.[74]

The diagnosis of dumping syndrome is primarily based on clinical presentation. This can be further supported by a gastric emptying test that objectively measures how rapidly food passes from the stomach into the small intestine. Additionally, for patients with suspected late dumping syndrome, blood glucose monitoring and oral glucose tolerance tests should be performed to confirm reactive hypoglycemia.[74]

Anemia after gastrectomy

Anemia is a common and multifactorial complication of gastrectomy, with an incidence that tends to increase progressively over time. Iron deficiency anemia (IDA) and vitamin B12 deficiency are the two most clinically significant causes of anemia after gastrectomy. Among these, IDA is the most common, followed by vitamin B12 deficiency.

IDA occurs because iron absorption predominantly takes place in the duodenum and proximal jejunum and is facilitated by gastric acid, which converts dietary ferric iron (Fe^{3+}) into the absorbable ferrous form (Fe^{2+}).[75] Reduced gastric acid secretion and altered anatomy involving duodenal bypass further contribute to iron deficiency.[75]

Vitamin B12 deficiency arises primarily from a lack of intrinsic factor secretion by parietal cells in the gastric body, which is essential for its absorption in the terminal ileum. Patients who undergo TG are at a higher risk of developing IDA and vitamin B12 deficiency than those who undergo partial gastrectomy, primarily because of the complete absence of intrinsic factor secretion resulting from the removal of gastric parietal cells.[76] Vitamin B12 deficiency typically becomes evident within two years of TG. Routine surveillance and regular vitamin B12 supplementation are essential for long-term management.[77]

To minimize complications and ensure a satisfactory QOL following gastrectomy, lifelong monitoring and appropriate supplementation with iron and vitamin B12 are recommended as standard management practices.

Other long-term complications

Post-gastrectomy, impaired fat absorption frequently leads to decreased uptake of fat-soluble vitamins, notably vitamin D. Additionally, diminished gastric acidity and accelerated intestinal transit further compromise calcium absorption, predominantly in the duodenum.[78] These physiological alterations frequently disrupt calcium–phosphorus homeostasis, triggering secondary hyperparathyroidism and progressive loss of bone mineral density, thereby increasing the risk of osteomalacia or osteoporosis.[79] Approximately 53.5% of patients develop osteoporosis within 10 years after gastrectomy for gastric cancer. Specifically, the risk of osteoporosis was approximately 8.69-fold higher in patients who underwent TG and 5.46-fold

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higher in those who underwent subtotal gastrectomy than in healthy controls.[80] Therefore, proactive strategies for the prevention and early detection of osteoporosis are essential for post-gastrectomy management. Patients at high-risk—particularly women, older adults, and postmenopausal women—should undergo regular pre- and postoperative bone mineral density monitoring, and early supplementation with vitamin D and calcium is strongly recommended to prevent the development and progression of osteoporosis.

Following gastric cancer surgery involving gastric and lymph node dissection, anti-reflux mechanisms at the gastroesophageal junction may become compromised, leading to reflux of gastric contents. Bile reflux rather than acid reflux frequently occurs in such patients.[81] The incidence of bile reflux is relatively low in patients who undergo Roux-en-Y reconstruction after surgery. Conversely, gastroduodenal or gastrojejunal anastomoses often result in bile reflux, which contributes to gastritis and esophagitis. These symptoms can worsen notably following late night overeating, indicating the necessity for dietary habit assessment.[82] Gastritis and related symptoms caused by bile reflux can be alleviated by medications that alter the bile acid composition of the refluxed bile in distal gastrectomy patients (e.g., ursodeoxycholic acid, trypsin inhibitors).[83] In contrast, pylorus-preserving or PG primarily involves acid reflux, necessitating pharmacological treatments targeted at gastric acid reduction (e.g., proton pump inhibitors or histamine H2 receptor antagonists).[84] Therefore, lifestyle modification combined with pharmacological intervention is the primary therapeutic strategy. In severe and refractory cases, surgical treatments aimed at altering anatomical structures may become necessary.

Resection of the anterior vagal trunk during gastrectomy can cause gallbladder dysmotility and increase the risk of gallstone formation. Recent studies have reported a gallstone incidence rate of approximately 20% after anterior vagus nerve resection.[85] Specifically, PPG, which preserves the hepatic branch of the anterior vagus nerve, is associated with a significantly lower gallstone incidence rate than standard distal gastrectomy.[86] Furthermore, recent randomized controlled trials have indicated that prophylactic administration of ursodeoxycholic acid after gastrectomy can significantly reduce gallstone formation.[87]

In addition, gastrectomy can alter the anatomical structure and functional integrity of the gastrointestinal tract, leading to increased intestinal motility. This often results in rapid transit of incompletely digested food into the small intestine, causing diarrhea.[88] The mechanisms underlying post-gastrectomy diarrhea are multifactorial; however, osmotic diarrhea due to lactose intolerance is recognized as one of the major contributors. Following surgery, lactose-containing foods pass through the gastrointestinal tract more rapidly than normal, exceeding the body's lactose-hydrolyzing capacity, thereby triggering osmotic diarrhea.[88] For patients typically experience worsening diarrhea symptoms after overeating or consuming dairy products, dietary modifications can effectively control these symptoms. Anti-diarrheal medications may be prescribed for more severe cases. Moreover, diarrhea following gastrectomy can be associated with multifactorial malabsorption syndromes, such as small intestinal bacterial overgrowth and bile acid malabsorption.[89] Recent studies indicate that probiotic supplementation can help restore gut microbiota balance and effectively alleviate diarrhea symptoms.[90,91] Therefore, probiotic administration is a beneficial strategy for managing intestinal function after gastrectomy.

CONCLUSION

Contemporary gastric cancer surgery has evolved to emphasize minimally invasive techniques, functional preservation, and optimal perioperative as well as long-term patient management. Advances in robotic and fluorescence-guided procedures have enabled safer, more precise oncologic resections and improved postoperative recovery. Postoperative care extends beyond complication management to encompass improvements in nutrition and QOL, addressing challenges such as anemia, osteoporosis, dumping syndrome, and altered gastrointestinal function. Lifelong surveillance and individualized supplementation protocols are essential for long-term patient survival and well-being. Continued research and multidisciplinary collaboration are imperative to further improve patient outcomes, establish patient-centered protocols, and strengthen the clinical evidence base.

Authors' Contribution

Conceptualization: Sin Hye Park, Dong Jin Kim. Data curation: all authors. Investigation: all authors. Project administration: Dong Jin Kim. Supervision: Dong Jin Kim. Writing—original draft: Sin Hye Park, Ara Cho. Writing—review and editing: Sin Hye Park, Dong Jin Kim. Approval of final manuscript: all authors.

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