Single Case

Ischemic Necrosis of the Gastric Remnant Treated Successfully Using Total Remnant Gastrectomy

Tetsuhiro Hara, Noriaki Tokumoto, Kensuke Shimbara, Tomohiro Adachi, Hideaki Hanaki, Manabu Shimomura, Yoshiro Aoki, Mikihiro Kano, Toshihiko Kohashi, Jun Hihara, Mahito Funakoshi, Mayumi Kaneko, Hidenori Mukaida

Keywords
Distal gastrectomy · Gastric cancer · Gastric remnant · Ischemic necrosis

Abstract
Distal gastrectomy (DG) with lymph node dissection is considered as the standard treatment for gastric cancer. Ischemic necrosis of the gastric remnant is a rare but serious complication of DG that requires careful consideration for early diagnosis and treatment to lower the associated mortality rate. A 71-year-old male presented to our hospital with hyperglycemia and was evaluated for suspected diabetes. The patient's medical history was otherwise unremarkable. Computed tomography (CT) revealed a thickening of the stomach wall, with follow-up esophagogastroduodenoscopy revealing type 3 gastric cancer in the greater curvature of the antrum. Biopsy specimen confirmed a pathological diagnosis of mucinous adenocarcinoma, with a clinical diagnosis of cT3N0M0, cStageIIB. An open DG with Billroth I reconstruction was performed, without incident. On postoperative day 1, the patient developed a high fever, abdominal pain, and elevated white blood cell count (12,200/μL). On postoperative day 2, his C-reactive protein level increased to >30 mg/dL. CT revealed an edematous thickening of the stomach wall, with poor mucosal enhancement of the remnant stomach and thinning of the anastomosis wall, with air nearby. Emergency surgery was performed for suspected leakage. Intraoperative findings showed no evidence of leakage. Intraoperative endoscopy revealed a necrotic gastric remnant, and we performed a total remnant gastrectomy with Roux-en Y reconstruction. The patient was discharged in a stable condition, 25 days after the first surgery. Although ischemic necrosis of the gastric remnant is a rare complication, its possibility should be carefully considered after DG, for early diagnosis and treatment.
Introduction

Distal gastrectomy (DG) with D2 lymph node dissection is considered to be the standard treatment for gastric cancer. Gastrectomy can be safely performed owing to the anatomical distribution of the vascular supply to the stomach and the collateral vessels which make this organ exceptionally rich in blood supply [1, 2]. As such, gastric remnant necrosis is a rare postoperative complication of gastrectomy. Gastric remnant necrosis was first reported in the literature in 1953 [3], with a subsequent study reporting survival in only 3 of 12 patients with gastric remnant necrosis [4]. However, in our review of the literature in Japan, we identified only 7 reports of gastric remnant necrosis between 1991 and 2020, with 5 of these patients surviving; these case reports are summarized in Table 1 [5–11]. This rate of survival in Japan is better than the historic rate reported. In this case report, we present a rare case of extensive gastric remnant necrosis after DG and describe the diagnosis, treatment, and survival of the patient.

Case Report/Case Presentation

A 71-year-old male presented to our department of endocrinology for assessment of possible diabetes due to a finding of hyperglycemia. He had no history of smoking or alcohol consumption. With exception of the hyperglycemia, his medical history was unremarkable. Initial blood test revealed an elevated HbA1c (HbA1c 16.7%). As part of a close examination, abdominal computed tomography (CT) revealed a thickening of the antrum wall of the stomach, with subsequent esophagogastroduodenoscopy (EGD) revealing irregularly shaped deep ulcer located in the greater curvature of the antrum. The pathological diagnosis of the biopsy specimen obtained was mucinous adenocarcinoma, with a clinical diagnosis of cT3, cN0, cM0, cStageIIB, according to the Japanese Classification of Gastric Carcinoma (15th edition). After achieving glycemic control, endoscopic mucosal resection (EMR) of a polyp in the descending colon was performed, with the histological examination revealing a tubular adenoma. With patient’s consent, we proceeded with surgical treatment of gastric cancer 13 days after EMR.

At the time of surgery, his HbA1c level had improved to 9.3%, and his carcinoembryonic antigen and carbohydrate antigen 19-9 levels were normal (carcinoembryonic antigen, 1.5 ng/mL and carbohydrate antigen 19-9, 34.7 U/mL). DG, with D2 lymph node dissection and Billroth I reconstruction, was performed with preservation of the short and the posterior gastric vessels. The pathological diagnosis of the surgical specimen was poorly differentiated adenocarcinoma, including signet ring cells (41 × 41 mm), pT3 (SS), Ly1a, V0, PM0 (64 mm), DM0 (36 mm), pN1 (2/29), pM0, and pStageIIIB.

On postoperative day (POD) 1, the patient developed a high fever and abdominal pain. A blood test revealed a white blood cell count of 12,200/μL. The level of amylase in the drained abdominal fluid was normal (174 U/L). On POD 2, serial blood test showed a steep increase in C-reactive protein (CRP; 33.9 mg/dL) with sustained leukocytosis, high fever, and an increase in level of amylase in the drained abdominal fluid (2,514 U/L). We were concerned about serious postoperative complications and proceeded with an abdominal CT. CT imaging revealed an edematous thickening of the wall of the stomach, with poor mucosal enhancement of the remnant stomach and thinning of the wall at the level of the anastomosis, with presence of air nearby (shown in Fig. 1). These findings were suggestive of a possible leakage, and we proceeded with emergency surgery.

Intraoperative findings indicated that the anastomosis was intact, with no evidence of a pancreatic fistula, but the remnant stomach was discolored and thinned (shown in Fig. 2a).
| Author                | Year | Age | Sex | Medical history               | Reconstruction | PostOpeCRPmax | Re-ope day | Pre-ope diagnosis               | Treatment | Prognosis |
|-----------------------|------|-----|-----|-------------------------------|----------------|---------------|------------|--------------------------------|-----------|-----------|
| Fujiwara et al. [5]   | 1995 | 61  | F   | None                          | B-I            | 36.4          | POD7       | Leakage, peritonitis           | TG        | Survival  |
| Morita et al. [6]     | 2004 | 72  | M   | Angina                        | R-Y            | 27            | POD15      | Leakage, peritonitis           | TG        | Survival  |
| Takahashi et al. [7]  | 2011 | 62  | M   | None                          | B-I            | -             | POD3       | Leakage                        | TG        | Survival  |
| Nonaka et al. [8]     | 2011 | 64  | M   | HT                            | R-Y            | 32.9          | POD21      | Gastric remnant necrosis       | TG        | Survival  |
| Shirai et al. [9]     | 2019 | 70  | F   | HT, DM, dialysis, angina      | B-I            | -             | POD13      | Gastric remnant necrosis, peritonitis | TG        | Death     |
| Kumano et al. [10]    | 2019 | 83  | F   | HT                            | B-I            | 27            | -          | Gastric remnant necrosis       | conservative | Survival |
| Wada et al. [11]      | 2020 | 82  | F   | HT, HL, arteriosclerosis      | R-Y            | -             | POD17      | Peritonitis                    | TG        | Death     |
| Our case              | 2020 | 71  | M   | DM                            | B-I            | 33.9          | POD2       | Leakage                        | TG        | Survival  |

HT, hypertension; HL, hyperlipidemia; DM, diabetes mellitus; AAA, abdominal aortic aneurysm; B-I, Billroth I; R-Y, Roux-en Y; POD, on postoperative day; TG, total gastrectomy.
Intraoperative endoscopy revealed extensive dark blue coloring of the gastric mucosa with edema throughout the gastric remnant (shown in Fig. 2b, c). As the splenic artery was intact, we proceeded with total remnant gastrectomy and Roux-en-Y reconstruction.
without splenectomy. During operation, an incidental perforation was found at the EMR site of the descending colon, and we performed a partial descending colectomy and construction of a stoma on the transverse colon. Macroscopically, mucosal necrosis was observed in the distal portion of the remnant stomach at the site of the anastomosis (shown in Fig. 3a). Histopathological findings revealed erosion and mucosal necrosis. The silk sutures (bule arrow; magnification, ×100) in the muscularis propria were infected with Gram-positive cocci (yellow arrow) (c, magnification, ×4). The lumen of the artery is filled with thrombus containing many inflammatory cells and their degenerates. The wall of the vein is also involved with suppurative inflammation (d, magnification, ×100). Immunothrombosis entrapped Gram-positive cocci (yellow arrow), and Gram-negative rods are observable (yellow arrow head).

**Fig. 3.** Macroscopic findings of resected specimen. a Distal portion of the remnant stomach with observable mucosal necrosis along the suture line. b–d Low power-view of the anastomosis site (b, magnification, ×1.25). Evidence of erosion and mucosal necrosis. The silk sutures (bule arrow; magnification, ×100) in the muscularis propria were infected with Gram-positive cocci (yellow arrow) (c, magnification, ×4). The lumen of the artery is filled with thrombus containing many inflammatory cells and their degenerates. The wall of the vein is also involved with suppurative inflammation (d, magnification, ×100). Immunothrombosis entrapped Gram-positive cocci (yellow arrow), and Gram-negative rods are observable (yellow arrow head).
the patient had recovered well, with no evidence of recurrence on CT imaging performed on an outpatient basis.

**Discussion/Conclusion**

The stomach has five major supplying blood vessels, in combination with a rich vascular supply through a complex and extensive collateral plexus [1]. In animal models, ligation of up to 95% of the arterial supply to the stomach does not negatively affect the gastric mucosa [2]. Therefore, ischemic necrosis of the gastric remnant after DG is very rare, but it is potentially fatal, with a mortality rate of 40–70% [8, 12] and, thus, requires careful consideration. An interruption of the blood flow to the remnant stomach has been suggested as the root cause of necrosis of the remnant stomach. The etiology of such an interruption in gastric blood flow is associated with a number of risk factors, including arteriosclerosis, atrial fibrillation, sepsis, and venous thrombosis [13]. Smoking, diabetes mellitus (DM), hypertension, and hyperlipidemia are also known risk factors for blood flow interruption. In several case reports, ischemic necrosis of the gastric remnant developed secondary to splenic infarction. In our case, the splenic artery and short gastric vessels were intact; however, this is not sufficient to confirm that adequate blood flow was sufficiently maintained to the organ. In fact, considering that untreated DM was the presenting medical issue, significant vasculopathy due to DM may have been an important predisposing factor for rapid tissue injury in our patient.

At the time of the first surgical procedure, we had been concerned with the slight change to a poor color of the remnant stomach, a possible indicator of the risk for postoperative ischemic necrosis of the gastric remnant. The usefulness of indocyanine green fluorescence angiography for intraoperative assessment of the status of a gastrointestinal anastomosis has previously been reported [14]. In high-risk cases, like ours, indocyanine green fluorescence angiography could provide a good option to assess the status of the gastric remnant. In addition, the possible effect of perforation at the site of EMR in our case also needs to be considered. The pathological findings at the site of necrosis of anastomosis included acute suppurative peritonitis, infected sutures, and immunothrombosis in arteries, with Gram-positive cocci and rods identified at all sites (shown in Fig. 3b, d). The perforation site of the descending colon also showed suppurative inflammation with many kinds of Gram-positive and -negative rods and cocci. Taken together, the findings indicate that the anastomosis infection likely spread from the perforation in the descending colon, and DM may have further promoted the development of the infection. The resulting immunothrombosis of arteries in the gastric mucosa likely resulted in mucosal necrosis.

Early diagnosis and treatment of necrosis of the gastric remnant are important to improve outcomes. The most common presenting symptom of necrosis of the gastric remnant is abdominal pain that develops in the early postoperative period. It is important to note that many patients do not present clinical signs of peritonitis before leakage or perforation. As such, diagnosis requires astute follow-up, with the possibility of necrosis of the gastric remnant being carefully considered. According to the summary of cases presented in Table 1, a steep increase in CRP over 25 mg/dL may be an early clinical sign. Timely CT and EGD may assist in the detection of ischemia, leakage, or perforation, although CT sometimes cannot rule out the early signs of ischemia in the early postoperative period [15]. In retrospect, in our case, CT images obtained in the early postoperative phase revealed did reveal edematous thickening of the gastric wall with poor mucosal enhancement of the remnant stomach, but necrosis could not be diagnosed from these images. Therefore, EGD should be considered as the cornerstone for identifying early signs of gastric remnant ischemia, especially in the early postoperative period. In our case, intraoperative endoscopy provided the final basis for diagnosis.
Park et al. [16] reported a mortality rate of 64% among patients who develop gastric remnant necrosis after DG. Among these, 80% of patients had undergone jejunostomy. Moreover, while 67% of patients with gastric remnant necrosis treated conservatively died, 69% of patients treated with total gastrectomy (TG) survived. Similarly, the data summarized in Table 1 indicate that 83% of patients with gastric remnant necrosis treatment with TG survived. Therefore, based on available evidence, TG and drainage may be a required surgical treatment for gastric remnant necrosis diagnosed early.

In summary, ischemic necrosis of the gastric remnant is a rare but serious complication of DG. Careful observation of the postoperative course, particularly in the early postoperative phase, is essential for early identification and treatment of this complication. In this regard, EGD can be useful for an early diagnosis of ischemic necrosis of the gastric remnant.

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Statement of Ethics

Written informed consent was obtained from the patient for publication of the details of their medical case and any accompanying images. This study protocol was reviewed, and the need for approval was waived by the Ethics Committee of Asa Citizen Hospital.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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Author Contributions

Tetsuhiro Hara organized the case study, evaluated the information, and drafted the manuscript. Noriaki Tokumoto, Mikihiro Kano, and Jun Hihara participated in the organization of the case study and contributed to drafting of the manuscript. Mayumi Kaneko diagnosed the case pathologically. Kensuke Shimbara, Tomohiro Adachi, Hideyuki Hanaki, Mayabu Shimomura, Yoshiro Aoki, Toshihiko Kohashi, Mahito Funakoshi, and Hidenori Mukaida supervised this case report.

Data Availability Statement

All data analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.
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