



Case Report

Usefulness of Fluorescence Vascular Imaging for Preserving the Remnant Stomach After Distal Pancreatosplenectomy: A Case Report

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Due to recent developments in medical treatment, the number of patients that undergo multiple surgical procedures for secondary metachronous cancer is increasing. In cases in which patients undergo distal pancreatectomy after distal gastrectomy, surgeons might have concerns about whether they are able to preserve the remnant proximal stomach because the main feeding vessels will have been divided in the previous procedure. Herein, we report a case in which a patient underwent distal pancreatectomy 20 years after undergoing distal gastrectomy, and the remnant proximal stomach was successfully preserved with the help of intraoperative fluorescence vascular imaging using indocyanine green (FVI-ICG). A 65-year-old female was referred to our hospital due to upper gastric pain and was diagnosed with cancer of the pancreatic body. She had undergone distal gastrectomy 20 years earlier for early stage gastric cancer. Therefore, the blood supply to the remnant stomach left after the distal pancreatectomy procedure might have been insufficient. To determine the adequacy of the blood supply to the remnant proximal stomach after distal pancreatectomy, we conducted intraoperative FVI-ICG. Because strong fluorescence was detected, we were able to safely preserve the remnant stomach. At 4 and 8 months after surgery, computed tomography showed good blood flow through the remnant stomach. FVI-ICG is useful for evaluating the blood supply to tissues, and hence, can be used to predict the blood supply of residual organs.

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Key words: Fluorescence vascular imaging – Distal pancreatectomy – Distal gastrectomy

Recent developments in medical treatment have improved the outcomes of patients with various types of cancer. Therefore, the number of patients that undergo multiple surgical procedures due to secondary metachronous cancer is increasing. In such cases, it is necessary for surgeons to try to preserve organ function in order to offer a good postoperative quality of life.

The blood supply to the proximal stomach is considered to be mainly derived from the left gastric artery (LGA), splenic artery (SA), and the compensatory left inferior phrenic artery (LIPA).^{1,2} When distal pancreatectomy is performed for a left-sided pancreatic tumor in patients who have already undergone distal gastrectomy, the adequacy of the blood supply to the remnant proximal stomach is an important issue. As the stomach is only supplied with blood by the LIPA in such cases, severe postoperative complications can occur due to ischemia in the preserved organ.

Ordinarily, surgeons estimate the degree of blood perfusion in tissues using visual examinations, palpation, and or laser Doppler flowmetry.^{3–5} However, postoperative tissue ischemia cannot be accurately evaluated using such methods.⁵

Recently, there have been many reports regarding the usefulness of intraoperative fluorescence vas-

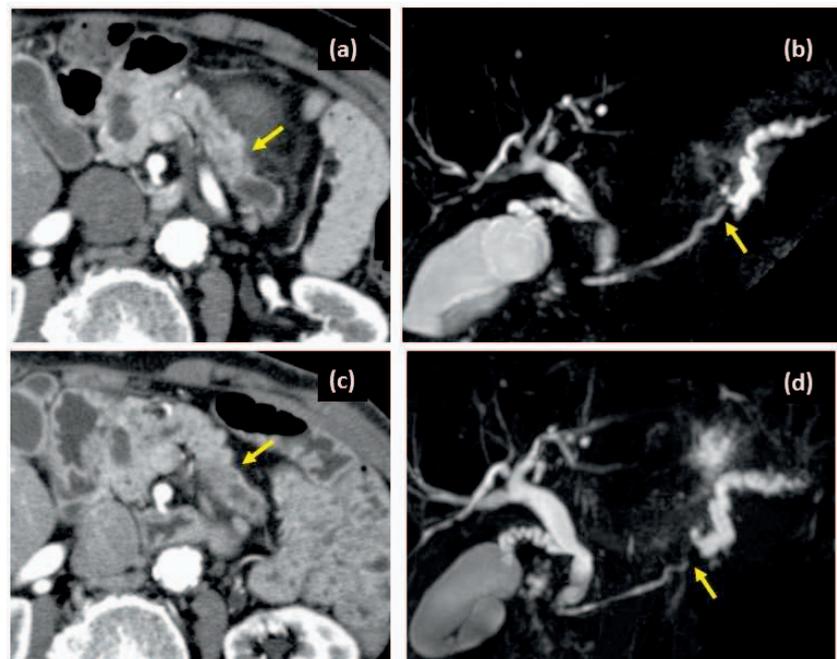
lar imaging performed using indocyanine green (FVI-ICG) for assessing blood perfusion within tissues. This technique facilitates the real-time visualization of the hemodynamics of various tissues.

Herein, we report a case in which a distal pancreatectomy procedure involving the preservation of the remnant proximal stomach was performed 20 years after distal gastrectomy. To the best of our knowledge, this is the first case to report the usefulness of FVI-ICG for assessing the blood perfusion of the remnant proximal stomach after the loss of the main feeding artery due to repeated surgery.

Case presentation

A 65-year-old female was referred to our hospital due to upper gastric pain and the subsequent detection of a tumor in the body of the pancreas and dilation of the distal main pancreatic duct on ultrasonography (US). She had been smoking for more than 40 years. She had an upper middle incisional wound, which had been caused by a previous distal gastrectomy combined with lymph node dissection. The latter procedure had been performed for early stage gastric cancer 20 years

Fig. 1 Pre- and postneoadjuvant chemotherapy (NAC) images. (a) (b) Pre-NAC images. Computed tomography (CT) showed a 13×10 mm mass in the body of the pancreas together with distal dilation of the main pancreatic duct (MPD). Magnetic resonance cholangiopancreatography (MRCP) showed an MPD defect measuring 10 mm in length in the body of the pancreas together with distal dilation of the MPD. (c) (d) Post-NAC images. Neither CT nor MRCP showed any marked changes compared with the pre-NAC images.



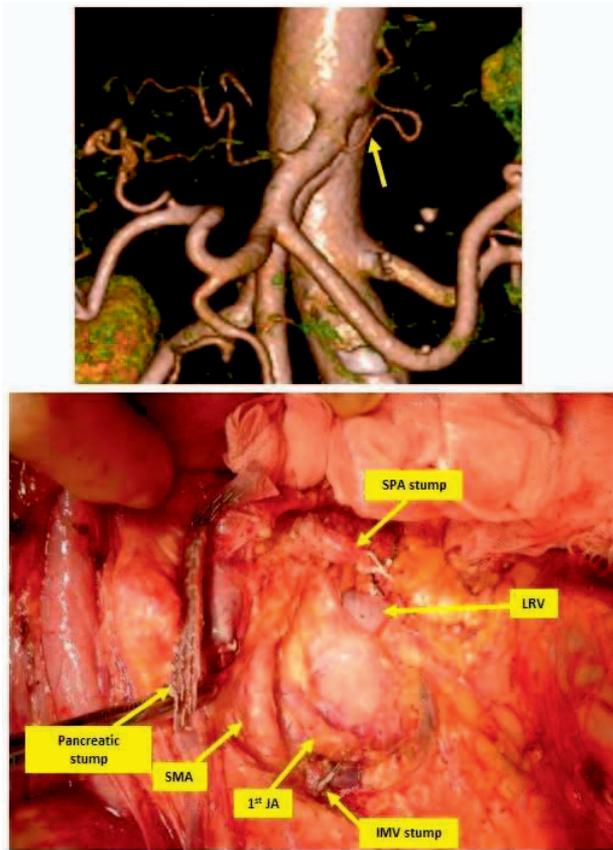


Fig. 2 Preoperative 3D-CT images and the surgical view after RAMPS. (a) 3D-CT clearly showed that the LIPA branched from the celiac artery. The LGA was not observed, as it had been divided during the previous distal gastrectomy procedure. (b) The distal pancreas, spleen, regional lymph nodes, and Gerota's fascia were resected simultaneously using the RAMPS maneuver. IMV, inferior mesenteric vein; JA, jejunal artery; LRV, left renal vein; SMA, superior mesenteric artery; SPA, splenic artery.

earlier. The patient's laboratory findings, including her tumor marker levels, such as those of carcinoembryonic antigen and carbohydrate antigen 19–9, were normal. Delayed contrast-enhanced computed tomography (CT) revealed a mass measuring 13×10 mm in the body of the pancreas and a dilated distal main pancreatic duct (8 mm) without regional lymph node metastasis or liver metastasis. Although three-dimensional (3D)-CT showed the LIPA clearly, the epigastric artery, LGA, and right gastric artery were not present due to their division during the previous surgery. Magnetic resonance cholangiopancreatography (MRCP) clearly showed the dilated distal main pancreatic duct. Positron emission tomography (PET) detected an area of hyperintensity in the same region as the pancreatic tumor. To

confirm the precise histology of the pancreatic tumor, we conducted a biopsy examination using endoscopic US, which revealed tubular adenocarcinoma. Before surgery, we clinically diagnosed the tumor as stage III (cT3, cN0, cM0) pancreatic invasive ductal adenocarcinoma based on the 7th edition of the Union for International Cancer Control (UICC) classification.

We planned to perform preoperative chemotherapy followed by radical antegrade modular pancreatectomy (RAMPS) together with lymph node dissection. The preoperative chemotherapy involved 2 anticancer agents: Gemcitabine was administered intravenously, and TS-1 was administered orally. An evaluation of the clinical response to the preoperative chemotherapy, which was based on CT, magnetic resonance imaging, US, and PET, indicated that the patient had stable disease, and so we decided to perform the planned surgery.

Regarding the surgical procedure, we first performed RAMPS together with regional lymph node dissection in the usual manner. Next, using FVI-ICG we tried to evaluate whether the remnant proximal stomach could be preserved without causing ischemia, which can lead to severe complications. Three mL of ICG were administered intravenously, and the fluorescence level of the remnant proximal stomach was examined. At 60 seconds after the injection of ICG, a high level of fluorescence was observed on both the duodenal and esophageal sides of the remnant stomach, and the fluorescent region gradually extended into the remnant stomach. Finally, at 120 seconds after the injection of the ICG, the whole of the remnant stomach exhibited strong fluorescence. As we were able to confirm that the remnant stomach had a good blood supply, we decided to preserve it. The patient's postoperative course was quite good, and she was able to start oral intake at 4 days after surgery and was discharged on the 8th postoperative day. CT scans were obtained at 4 and 8 postoperative months to check for recurrence and examine the blood supply to the remnant stomach. Fortunately, no recurrence was detected, and the stomach wall, including the stomach mucosa, was well enhanced. This indicated that the LIPA was able to provide a normal blood supply to the remnant proximal stomach.

Discussion

Despite the recent rapid development of medical equipment, it is still very difficult to precisely evaluate whether the blood supply to specific

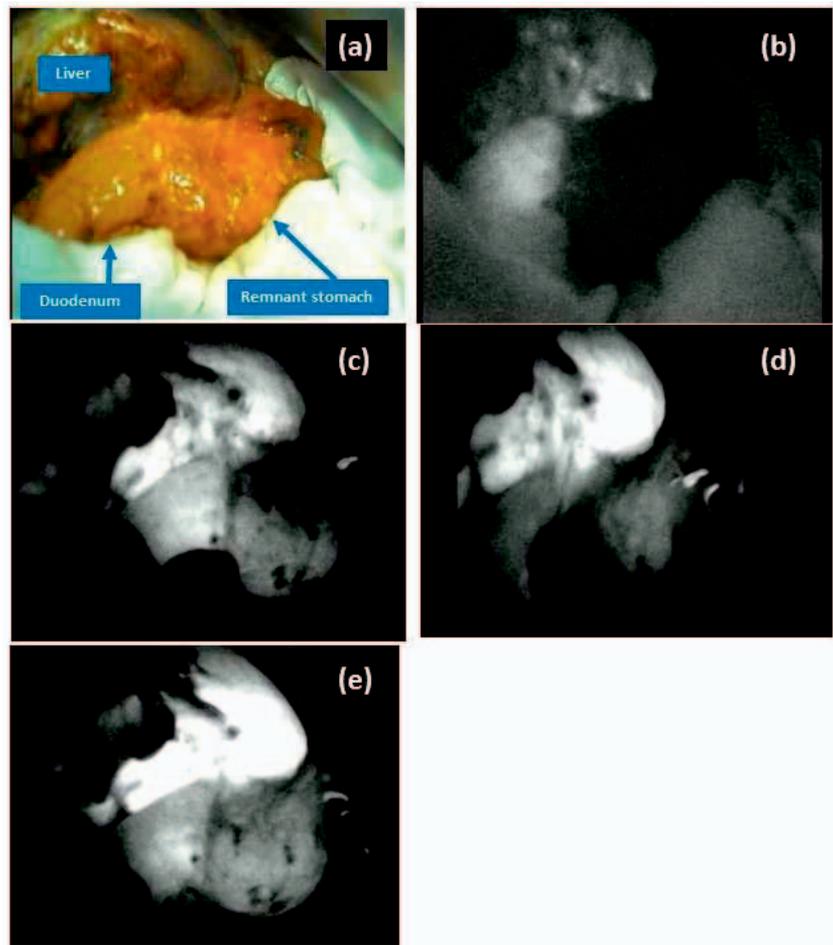


Fig. 3 Evaluation of the post-RAMPS perfusion of the remnant stomach with FVI-ICG. (a) Before the injection of ICG. (b–e) Fluorescence images obtained 30 s, 60 s, 90 s, and 120 s after the injection of ICG, respectively. The remnant stomach started to exhibit strong fluorescence on both the duodenal and esophageal sides at 60 s (c) after the injection of ICG, and the fluorescence gradually spread to the rest of the remnant stomach. At 120 s after the injection of ICG (e), the whole of the remnant stomach displayed strong fluorescence.

tissues is sufficient during surgery. In particular, cases in which the main feeding artery of a target organ has previously been divided due to bowel anastomosis or to aid organ preservation can cause significant concern after surgery because the optical color of a tissue or the pulsation of peripheral feeding vessels cannot provide an accurate measure of the risk of postoperative ischemic changes. Many previous reports have described the benefits of laser Doppler for assessing blood perfusion.^{3,4,6} Certainly,

laser Doppler is useful for evaluating the blood flow of feeding vessels; however, it cannot be used to directly evaluate the blood perfusion of the target tissue itself. On the other hand, FVI-ICG, which has been used for lymphography, angiography, and sentinel lymph node detection, can provide information about real-time blood flow in feeding vessels and the target tissue itself.^{7–14} There have been many reports regarding the usefulness of FVI-ICG, and Boni *et al* reported that FVI-ICG could be used

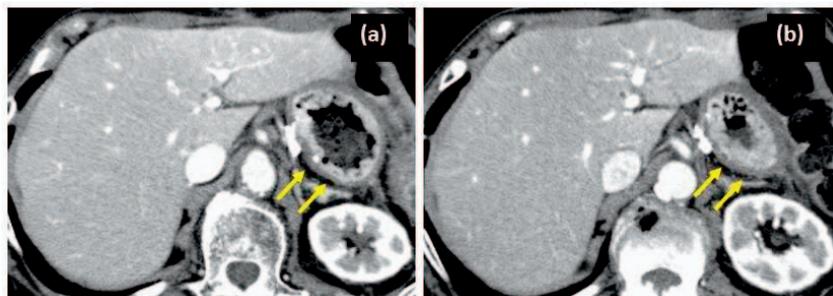


Fig. 4 CT images obtained after surgery. (a) (b) CT images obtained at 4 and 8 months after surgery. Both CT images showed that the remnant proximal stomach was well perfused.

to assess bowel perfusion during surgery and to help prevent anastomotic leakage.^{15,16} Furthermore, Zaidi *et al* reported that FVI-ICG can be used to predict hypoparathyroidism after thyroidectomy, indicating that the fluorescence level of the parathyroid gland is useful for predicting its function.¹⁷ Therefore, FVI-ICG is considered to be a useful tool for aiding decision-making regarding the optimal surgical approach.

Our patient had several risk factors that made it more likely that the blood supply to her remnant stomach would be insufficient. Therefore, it was unclear whether the LIPA could supply sufficient blood to the remnant proximal stomach after distal pancreatectomy, which involves the division of the main feeding vessel (the SA). Furthermore, the fact that the patient had been a heavy smoker for a long time could have had a negative impact on her blood supply. Hanaoka *et al* reported their experience of distal gastrectomy followed by distal pancreatectomy, and it was similar to our case. Although they directly assessed the blood supply by cutting peripheral blood vessels or tissue during surgery, they concluded that careful preoperative CT examinations aimed at detecting collateral vessels or the use of Doppler US during surgery are recommended for ensuring appropriate blood perfusion.¹⁸ However, it was deemed that neither method was able to fully assess the blood perfusion of the target tissue. Therefore, we tried to evaluate the blood perfusion of the remnant stomach after distal pancreatectomy using FVI-ICG. Although it is generally quite difficult to evaluate the blood supply of remnant stomach tissue, the remnant stomach exhibited strong fluorescence during FVI-ICG in the present case. Thus, we were able to preserve the remnant stomach safely. Interestingly, the remnant stomach started to fluoresce on both the esophageal and duodenal sides, the latter of which was used for the previous anastomosis. This indicates that microcollateral pathways had formed during the long period after the ligation of the main feeding vessels around the duodenum and were able to supply adequate blood flow from the duodenal side. Thus, the remnant stomach did not show any ischemic changes after the distal pancreatectomy. In addition to these intraoperative findings, CT scans obtained at 4 and 8 postoperative months demonstrated that the remnant stomach was well perfused, which supported the validity of our surgical approach.

However, there are several drawbacks and questions regarding the application of FVI-ICG.

First, although 3 mL of ICG were intravenously injected in this case the optimal dose of ICG should be evaluated further. Secondly, because the target vessel or organ exhibits high signal intensity for more than 5 minutes, it is difficult to assess venous return or the washout speed. Thirdly, although we evaluated the intensity of the fluorescence subjectively in this study, it should be assessed objectively, and the minimum blood supply required to protect the stomach from ischemic changes should be determined in future studies.

Conclusion

We experienced a case of cancer of the pancreatic body in a patient that had undergone distal gastrectomy involving division of the LGA 20 years earlier due to early stage gastric cancer. FVI-ICG is useful for evaluating the blood supply of residual organs.

Acknowledgments

We declare that none of the authors received any financial or material support.

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