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Case Report

Usefulness of Indocyanine Green Angiography for Evaluation of Blood Supply in a Reconstructed Gastric Tube During Esophagectomy

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We report a case of necrosis of a reconstructed gastric tube in a 77-year-old male patient who had undergone esophagectomy. At the time of admission, the patient had active gastric ulcers, but these were resolved by treatment with a proton pump inhibitor. Subtotal esophagectomy with gastric tube reconstruction was performed. Visually, the reconstructed gastric tube appeared to be well perfused with blood. Using indocyanine green (ICG) fluorescence imaging the gastroepiploic vessels were well enhanced and no enhancement was visable 3 to 4 cm from the tip of the gastric tube. Four days after esophagectomy, gastric tube necrosis was confirmed, necessitating a second operation. The necrosis of the gastric tube matched the area that had been shown to lack blood perfusion by ICG angiography imaging. It seems that ICG angiography is useful for the evaluation of perfusion in a reconstructed gastric tube.

Key words: Ischemia – Necrosis – ICG angiography – Esophageal cancer – Gastric tube – Esophagectomy

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Gastric tube necrosis is one of the most serious complications of surgery for esophageal cancer involving reconstruction using the stomach, with a reported incidence of between 0.5% and 10.4%, which includes various degrees of ischemia.[1–6] The blood supply to the gastric tube is the most important factor affecting outcome, and surgeons have usually evaluated this on the basis of visual appearance, especially coloration. Recently, the fluorescence of intravenously injected indocyanine green (ICG) has been used to enhance visualization of tissue microvasculature and blood supply,[7–9] and has also been adopted for assessment of blood flow in the esophageal conduit.[10]

Here we document a case of ischemic gastric tube necrosis that illustrates the usefulness of ICG angiography in comparison with conventional macroscopic observation for evaluation of blood flow in a reconstructed gastric tube.

Case Report

A 77-year-old male patient presented with a chief complaint of dysphagia and fever. Computed tomography (CT) at another hospital had revealed bilateral pneumonia and an esophageal tumor with lymph node swelling. After improvement of the pneumonia using antibiotics, the patient was referred to our hospital, and admitted for treatment of the esophageal tumor. His medical history included cerebral infarction at the age of 62 years.

Blood biochemistry at the time of admission showed slight anemia (blood hemoglobin, 11.1 g/dL) and hyponatremia (119 mEq/L).

Double-contrast esophagography and upper gastrointestinal endoscopy demonstrated a 7-cm type 3 tumor in the middle thoracic esophagus. Endoscopy also showed two active peptic ulcers in the anterior and posterior walls of the lower gastric body (Fig. 1A). The pathologic diagnosis based on the histology of the biopsy material was esophageal squamous cell carcinoma. During the clinical course, no malignant pathology was obtained from the gastric ulcers. Medical treatment using a proton pump inhibitor and NaCl infusion was performed, and healing of the gastric ulcer was confirmed 2 weeks after admission (Fig. 1B).

The esophageal squamous cell carcinoma was in clinical stage III (T3N1M0 UICC, TNM classification), and subtotal esophagectomy using a right thoracotomy with three-field lymph node dissection was performed. The operation time was 6 hours, 50 minutes, and the bleeding volume was 625 mL. For reconstruction after esophagectomy, we made a gastric tube using the standard method (*i.e.*, by dividing the omentum 2 cm from the right gastroepiploic artery and preserving this vessel). In addition, we ligated and cut the root of the left gastroepiploic artery, preserving the entire length of the vessel arcade of the major cuvature. Visually, good connection of the right and left gastroepiploic vessels was confirmed. Finally, we constructed the gastric tube using a linear

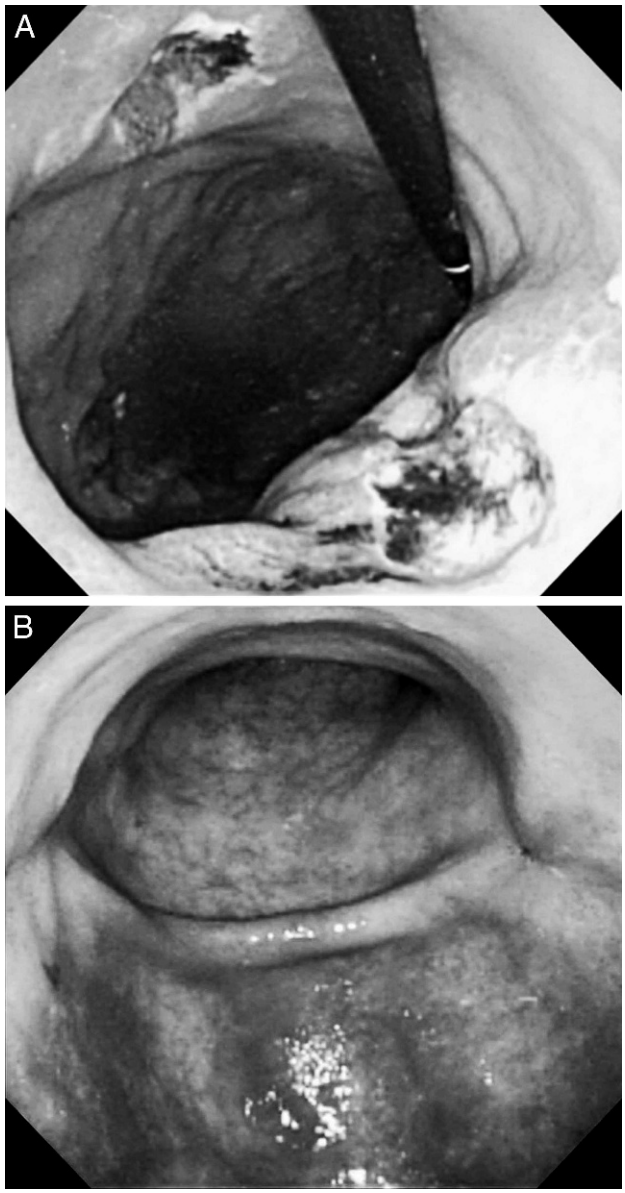

Fig. 1 (A) Endoscopic observation of the upper digestive tract at the time of admission to our hospital. Active gastric ulcers at the anterior and posterior wall of the gastric body were detected. (B) Two weeks after proton pump inhibitor medication, the ulcers were healed and scars remained.

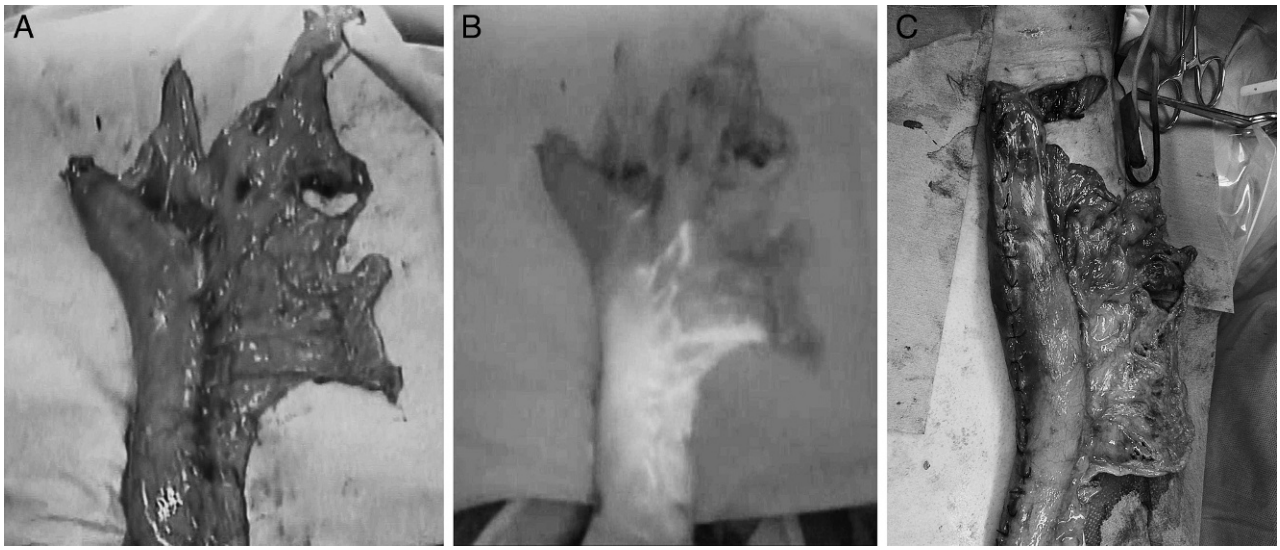

Fig. 2 (A) Macroscopic appearance of the gastric tube before anastomosis (white right mode: Photodynamic Eye; Hamamatsu Photonics K.K, Hamamatsu, Japan). The gastric tube was pinkish in color, and therefore considered to be well perfused with blood. (B) ICG angiography image of the gastric tube. A portion of the gastric tube 3 to 4 cm from the tip was not enhanced with ICG, and an apparent demarcation line was visualized. (C) The gastric tube during the second operation. A portion of the gastric tube 5 cm from the tip revealed total layer necrosis. The necrotic area appeared to match the poorly perfused area that had been suggested by ICG fluorescence during the initial operation.

stapler (TLC75, Ethicon Endo Surgery, Inc, Blue Ash, Ohio).

Visually, the gastric tube appeared sound and there were no signs of ischemia or blood congestion. It was pinkish in color and no dilation of the microvessels was evident (Fig. 2A).

Blood flow within the gastric tube was evaluated using ICG fluorescence imaging with a near-infrared camera system (Photodynamic Eye; Hamamatsu Photonics K.K, Hamamatsu, Japan), and the video was recorded. In brief, images were obtained with a charge-coupled device camera, using a light-emitting diode with a wavelength of 760 nm as the light source and a filter to eliminate light of wavelength below 820 nm before detection. The fluorescence signals were sent to a digital video processor to be displayed on a television monitor in real time.

A bolus injection of 2.5 mg of the ICG dye (Diagnogreen; Dai-Ichi Pharm, Tokyo, Japan) was delivered from a peripheral vein. A few minutes after injection of the dye, ICG fluorescence confirmed blood flow through the right gastroepiploic vessels, which were promptly enhanced by the dye. The left gastroepiploic vessels were also enhanced in a direction opposite to that of the physiologic blood flow. However, the gastric tube was not enhanced for a distance of 3 to 4 cm from its tip 150 seconds after initial enhancement of the right gastroepiploic artery, and an apparent demarcation line orad to the site of the gastric ulcer was visualized (Fig. 2B). We decided to perform gastric tube reconstruction using the retrosternal route with esophagogastric anastomosis and layer-to-layer sewing.

In the postoperative period, the patient's water balance and oxygenation were well maintained, and on the first postoperative day, the patient was weaned from the ventilator. On postoperative day 3, a foul-smelling exudate from the neck wound was evident, and on postoperative day 4, we performed upper gastrointestinal endoscopy, which confirmed necrosis of the gastric tube. Reoperation was performed on the same day, and this revealed total layer necrosis extending 5 cm from the tip of the gastric tube (Fig. 2C). The necrotic area appeared to correspond to the nonperfused area that had been suggested by ICG angiography during the initial operation, and included the esophagogastric anastomosis. We then transected the gastric tube in the area where blood perfusion was adequate, and created an esophagostomy at the neck wound. The tip of the gastric tube was closed, and the gastric tube was fixed using the anterior sternal route. The length of the defect in the digestive tract was 6 cm from the esophagostomy to the tip of the gastric tube.

At 60 days after the initial operation, the patient underwent reconstruction of the digestive tract

using free jejunal transfer. His general condition is currently good after the third operation.

Discussion

Reconstruction after esophagectomy is the one of the most important procedures during surgery for esophageal cancer. Anastomotic leakage is still considered the major complication, and can sometimes become life threatening. After esophagectomy, a gastric tube is most frequently used for reconstruction. Blood is supplied to the gastric tube mainly through the right gastroepiploic artery,[11] and the blood supply at the tip of the gastric tube, which is anastomosed with the remnant esophagus, is considered to be unfavorable.[12,13] The color of the gastric tube, bleeding, tension of the gastric wall, and a palpable right epiploic artery are important considerations when evaluating blood flow. In addition to these macroscopic features, ICG fluorescence imaging is very helpful for distinguishing any ischemic and nonischemic areas. ICG fluorescence imaging has been applied for lymphography, angiography, and sentinel node detection.[9,14,15] Recently, this technique has also been adopted for intraoperative assessment of the blood supply to various reconstructed organs.[10]

In the present case, ICG angiography suggested the presence of ischemia at the tip of the reconstructed gastric tube. However, the color of the gastric tube was favorable, and necrosis was not suspected. If ICG angiography had suggested the possibility of necrosis, then we would have had to abandon reconstruction using the gastric tube and instead used free jejunal transfer or colon interposition. At the time of the initial operation, we acted on the basis of the macroscopic appearance of the gastric tube, as we had had little experience with ICG angiography examination. The outcome in this case demonstrated that ICG angiography examination is superior to conventional macroscopic observation to show blood flow. In general, blood congestion within the gastric tube can be easily recognized as poor coloration. However, during surgery, severe ischemia in the reconstructed organ may not be distinguishable from good blood perfusion. Only a minimal change of coloration, with appearance similar to that of a freshly resected specimen, may be evident.

Laser Doppler flowmetry has been used in several studies[16,17] to assess blood supply of the reconstructed gastric tube, which relies on measurement of the Doppler frequency shift of laser light reflected from moving blood cells. The most obvious advantage of the ICG angiography technique over laser Doppler flowmetry is real-time visualization of blood perfusion to tissues and blood flow within the feeding vessels. It allows intraoperative assessment of contrast enhancement of the reconstructed organ without the use of an X-ray examination. However, it does not allow assessment of the speed of venous return or washout from tissues, which is its limitation. Once the vessels and tissues are enhanced, marked enhancement lasts about 5 minutes, until the liver segregate ICG into bile intact.

The presence of gastric ulcer is a significant factor related to anastomotic leakage after reconstruction using a gastric tube.[4] Fujiwara *et al*[18] reported a patient in whom submucosal blood perfusion of the stomach was impaired by an ulcer scar. Microscopic observation of the resected gastric tube revealed congestion and dilation of the submucosal vessels orad to the ulcer scar. In our patient, although the site of the ulcer scar did not match the ischemic border, we believe that it could have disturbed blood flow inside the gastric wall and caused necrosis. A careful preoperative survey for detection of gastric ulcers should therefore be made in patients undergoing gastric tube reconstruction. Intraoperative ICG angiography is useful for evaluation of blood flow in the reconstructed organ.

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