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Case Report

Intraoperative Indocyanine Green Fluorescence Angiography for Diagnosis of Nonocclusive Mesenteric Ischemia: A Case Report

Makoto Takeda[1], Yoshihiro Hiramatsu[1], Naoki Unnno[1], Yoshiaki Takahashi[2], Hirotoshi Kikuchi[1], Naoto Yamamoto[1], Manabu Ohta[1], Kinji Kamiya[1], Takanori Sakaguchi[1], Satoshi Baba[3], Hiroyuki Konno[1]

[1]Second Department of Surgery, [2]Department of Emergency and Disaster, and [3]Department of Pathology, Hamamatsu University School of Medicine, Hamamatsu, Japan

Nonocclusive mesenteric ischemia (NOMI) has a very poor prognosis. It is often difficult to determine the extent to which the necrotic intestine should be resected. We herein report a case in which indocyanine green (ICG) fluorescence angiography was found to be a useful method for diagnosis of NOMI and determination of the extent to which the necrotic intestinal tissue should be resected. A 65-year-old man underwent a second-look operation followed by surgical repair of strangulation of the ileum. A noncontinuous segmental ischemic lesion was detected in the remnant small intestine and cecum. Whether necrotic changes had occurred in the small intestine was difficult to discern. Thus, intraoperative ICG fluorescence angiography was performed with a near-infrared camera system to visualize the blood flow in the intestines and mesentery. ICG fluorescence angiography revealed insufficient blood flow in some parts of the intestine. Based on these findings, ileocecal resection and enterectomy were carried out. Histopathologic examination revealed necrotic changes in all layers of the resected specimens, but no thrombi in the associated blood vessels. The patient received a diagnosis of NOMI based on the findings of intraoperative ICG fluorescence angiography and subsequent histopathologic examination. Intraoperative ICG angiography appears to have the potential to be one of the convenient and useful modalities for the diagnosis and treatment of NOMI.

Key words: Indocyanine green – Fluorescein angiography – Nonocclusive mesenteric ischemia

Corresponding author: Yoshihiro Hiramatsu, MD, PhD, Department of Surgery, Hamamatsu University School of Medicine, 1-20-1 Handayama, Higashi-ku, Hamamatsu, Shizuoka 431-3192, Japan.
Tel.: +81 53 435 2279; Fax: +81 53 435 2273; E-mail: hiramatu@hama-med.ac.jp

Nonocclusive mesenteric ischemia (NOMI) constitutes 10% to 20% of cases of acute mesenteric circulatory disorders and leads to extensive and irreversible intestinal necrosis, which has a very poor prognosis despite the absence of organic obstruction of the principal arteries.[1] Angiography is the gold standard modality for diagnosis of NOMI. However, NOMI occurs in patients with poor or unstable systemic conditions; therefore, angiography might not be possible because of its complexity and invasiveness.[1] During surgical treatment of NOMI, however, it is often difficult to determine the extent to which the necrotic intestine should be resected. We herein report a case in which indocyanine green (ICG) fluorescence angiography was found to be a useful method for diagnosis of NOMI and determination of the extent to which the necrotic intestinal tissue should be resected.

Case Report

A 65-year-old man was admitted to our hospital with the chief complaint of abdominal pain. His medical history included systemic burns and laparoscopic total gastrectomy for gastric cancer. Physical examination revealed a blood pressure of 161/128 mmHg, rhythmic pulse of 56 beats per minute, body temperature of 35.6°C, and respiratory rate of 22 breaths per minute. His whole abdomen exhibited tenderness, rebound tenderness, and muscle rigidity. Electrocardiography revealed a regular sinus rhythm and pulse rate of 103 beats per minute. The patient's blood examination and arterial blood gas analysis results are shown in Table 1. Contrast-enhanced computed tomography of the abdomen revealed ascites (Fig. 1A), dilation of the whole intestine, and the whirl sign around the superior mesenteric artery without thrombosis (Fig. 1B and 1C). However, no gas was present in the hepatic portal vein (Fig. 1A).

An emergency operation was performed under a diagnosis of strangulation of the ileum. During surgery, we found that the greater omentum had adhered to the left abdominal wall, forming a hernia gate, and the incarcerated intestine was strangulated. Therefore, we separated the greater omentum from the resected necrotic intestine. Because the remnant intestine was very edematous and ischemic change was observed in some parts, a second-look operation was considered necessary. Therefore, the first operation was finished by covering the abdomen with drapes and wet towels instead of closing the abdominal wall, and the intestines were not anastomosed.

In the second-look operation performed 36 hours after the first operation, a noncontinuous segmental ischemic lesion was observed in some parts of the remnant intestine (Fig. 2). Intraoperative ICG angiography was performed for accurate evaluation of the ischemic lesions. One milliliter of ICG (1 mg/mL; Diagnogreen, Daiichi Pharmaceutical, Tokyo, Japan) was intravenously injected, and fluorescent images of the blood flow in the intestine and mesentery were obtained using a camera system for fluorescence angiography (Photodynamic Eye, Hamamatsu Photonics, Hamamatsu, Japan) as previously described.[2] ICG angiography revealed blood flow in the mesentery, but not in the cecum or some parts of the remnant intestine that exhibited weak tonus (Fig. 3). Based on these findings, ileocecal resection and enterectomy were performed, and the intact intestine was anastomosed.

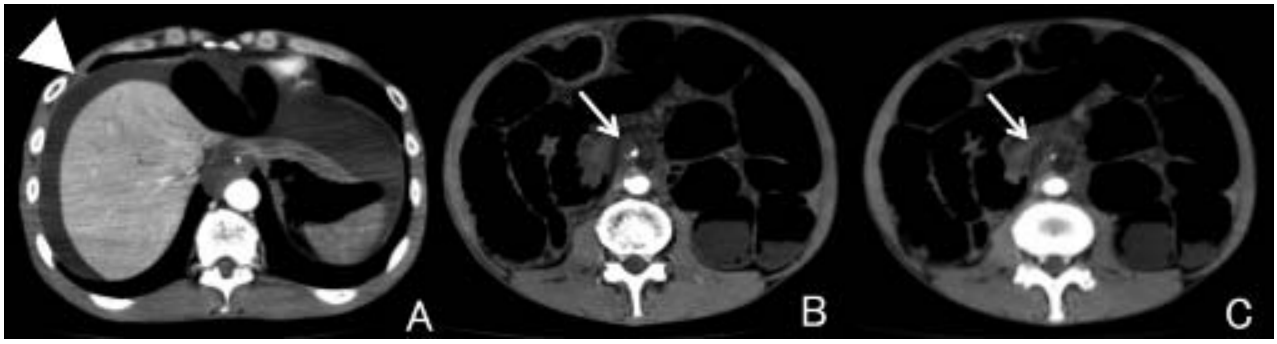

Fig. 1 Enhanced abdominal computed tomography. (A) Ascites was mainly found around the liver (white arrowhead). (B and C) The small intestine was dilated. The superior mesenteric artery displayed sufficient enhancement and the whirl sign (white arrow).

Table 1 Results of blood examination and arterial blood gas on room air

Parameter	Value
WBC, μ/mL	7810
RBC, μ/mL	419×10^4
Hb, g/dL	14.3
Ht, %	44.5
Plt, μ/mL	23.9×10^4
BUN, mg/dL	16.5
Cre, mg/dL	0.84
Na, mEq/L	141
K, mEq/L	4.0
Cl, mEq/L	106
T. bil, mg/dL	1.1
LDH, IU/L	325
AST, IU/L	37
ALT, IU/L	18
AMY, IU/L	189
CPK, IU/L	497
TP, mg/dL	7.9
Alb, mg/dL	4.5
CRP, mg/dL	0.58
FBS, mg/dL	191
PT, s	12.4
PT, %	89
APTT, s	26.6
APTT, %	126
Fibrinogen, mg/dL	351
FDP-DD, μg/mL	2.9
pH	7.363
$PaCO_2$, mmHg	34.8
PaO_2, mmHg	101.5
HCO_3^-, mEq/L	19.4
BE, nmol/L	5.1

Alb, albumin; ALT, alanine transaminase; AMY, amylase; APTT, activated partial prothrombin time; AST, aspartate aminotransferase; BE, base excess; BUN, blood urea nitrogen; Cl, chloride; CPK, creatine phosphokinase; Cre, creatinine; CRP, C-reactive protein; FBS, fasting blood sugar; FDP-DD, fibrinogen degradation products-D dimer; Hb, hemoglobin; HCO_3^-, bicarbonate; Ht, hematocrit; LDH, lactate dehydrogenase; K, potassium; Na, sodium; $PaCO_2$, partial pressure of carbon dioxide in arterial blood; PaO_2, partial pressure of oxygen in arterial blood; Plt, platelets; PT, prothrombin time; RBC, red blood cells; T. Bil, total bilirubin; TP, total protein; WBC, white blood cells.

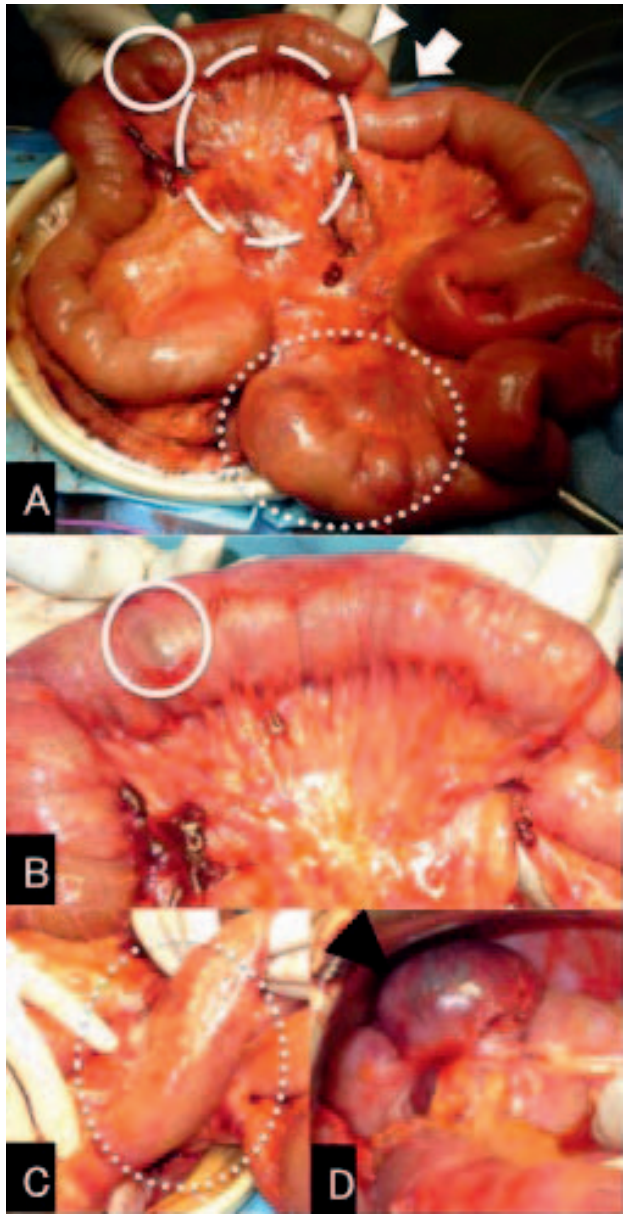

Fig. 2 Images obtained during the second-look operation. (A) Intraoperative findings obtained during laparotomy. The oral side (white arrow) and the anal side (white arrowhead) of the small intestine were not anastomosed. The intestinal mesentery, which is surrounded by a broken line, displayed a good color. The continuous and dotted lines correspond to those in (B) and (C), respectively. (B) The portion of the intestine surrounded by the continuous line was suspected of being necrotic. (C) The tonus of the portion of the intestine within the dotted line was weak. (D) Necrotic changes were detected in the cecum (black arrowhead).

Histopathologic examination revealed necrotic changes in all layers of the resected specimen (Figs. 4 and 5), but no thrombosis or fibrin in the associated blood vessels (Fig. 5D). The final diagnosis was NOMI.

Postoperatively, the patient developed candidemia and pneumonia, which may have occurred in part because of pulmonary emphysema. After undergoing tracheotomy and medical treatment, the patient recovered and was discharged on postoperative day 51.

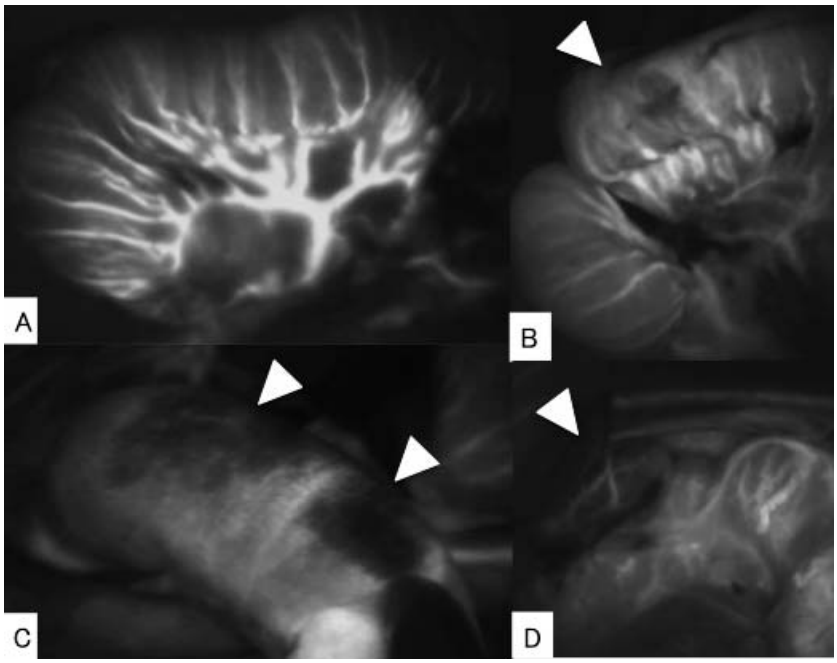

Fig. 3 ICG angiography findings. (A) Good blood flow was detected in the mesentery. (B–D) Intestinal regions that displayed weak fluorescence (white arrowheads) were suspected to have undergone necrotic changes. (B), (C), and (D) correspond to the regions in (B), (C), and (D), respectively, in Fig. 2.

Discussion

NOMI was first reported in 1958 by Ende,[3] who described 3 patients with heart failure. Many cases of NOMI have since been reported, mainly in Europe and North America. NOMI is considered to be difficult to diagnose and treat. Its mortality rate ranges from 70% to 90% and has not been improving.[1,4]

Most patients with NOMI are elderly, and NOMI tends to occur in patients in the intensive care unit and coronary care unit after cardiovascular surgery or dialysis.[1] Our patient developed severe septic shock–induced NOMI after a surgical operation to treat strangulation of the ileum.

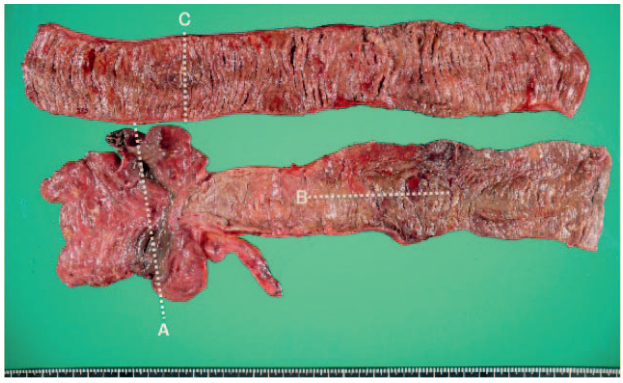

Fig. 4 Gross findings of resected specimens. The resected intestine and cecum were necrotic. Lines A, B, and C correspond to the regions shown in (B), (C), and (D), respectively, in Fig. 3.

The laparotomy finding of NOMI is that the mesenteric blood flow can be maintained, even in marginal arteries that extend to the lesions, despite extensive necrosis throughout the intestine (non-continuous segmental necrosis). This is a characteristic feature of NOMI and can be used to distinguish it from mesenteric thrombosis, in which the mesentery and intestine are necrotized from the site of the thrombus, forming a continuous necrotic area in the region of the occluded artery. The following findings are required for a definitive diagnosis of NOMI: absence of organic obstruction of the blood vessels in the necrotic intestinal region, segmental discontinuous intestinal ischemic changes and necrosis identified during laparotomy, and histopathologic detection of hemorrhagic and necrotic changes.[1] However, early diagnosis is difficult, and the disease can slowly advance to an irreversible state and cause extensive intestinal necrosis during the diagnostic process. It is difficult to detect the subjective symptoms of NOMI when the condition develops after surgery because the effects of general and epidural anesthesia can persist, masking the emerging disease and allowing its progression to go unnoticed.

Angiography is generally considered to be the gold standard modality for diagnosis of NOMI.[1,5] Some reports have suggested that multidetector computed tomography is an effective modality for

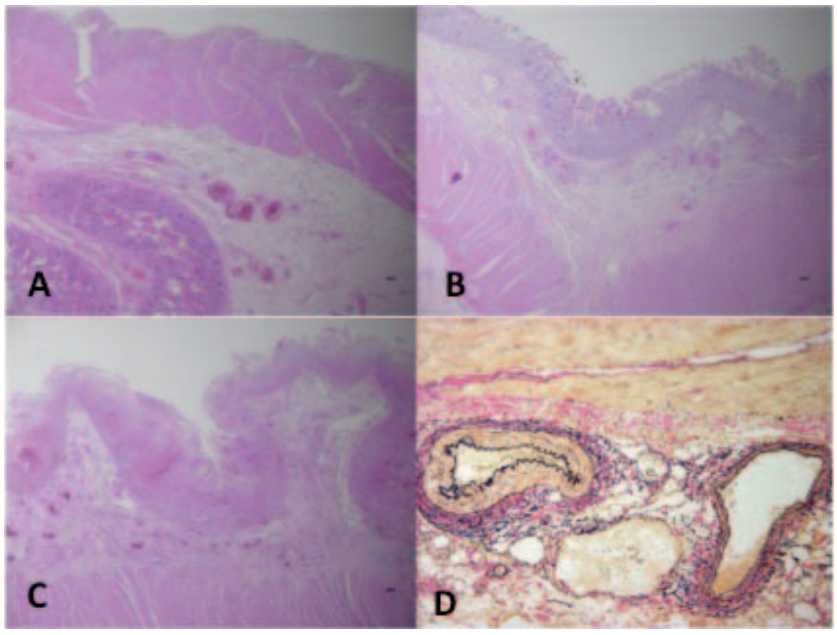

Fig. 5 Microscopic findings of resected specimens. (A–C) Hematoxylin-eosin. Panels show the regions indicated by lines A, B, and C, respectively, in Fig. 4. Each specimen exhibited necrosis without vessel thrombosis in all layers of the intestine. (D) Elastica–van Gieson (×10). No vessel thrombosis was detected in the subserosa in the region shown in (B).

early diagnosis of NOMI.[6] However, both of these methods are difficult to use in patients with a poor general condition.

Determination of which parts of the intestine to resect may be difficult because the necrotic changes are often unclear. Excessive or insufficient resection should be avoided in order to reduce the risk of short bowel syndrome or a second operation. In the present case, we evaluated the patient's blood flow and extent of intestinal necrosis using a combination of ICG and the Photodynamic Eye camera system, which contributed significantly to our decisions regarding surgical management.

ICG has been widely and safely used to examine liver function, perform retinal angiography, and assess bypass patency.[7–9] Moreover, we have reported that ICG angiography and lymphography are effective tools for intraoperative assessment of blood flow, detection of lymphatic leakage after esophagectomy or bile leakage after hepatectomy, and diagnosis of secondary lymphedema.[2,10–15] In the present case, evaluation of intestinal blood flow with ICG fluorescence angiography during the surgical procedure was useful for intraoperative diagnosis of NOMI, which was consistent with the diagnosis made by the final postoperative histopathologic examination. ICG angiography allowed for the evaluation of blood flow through both the principal and peripheral blood vessels. Therefore, we consider it to be an effective intraoperative method for determining which parts of the intestine are irreversibly ischemic or necrotic and should thus be resected.

In conclusion, we reported a case in which intraoperative ICG angiography was convenient and useful. It should be assessed, in future clinical experiments, whether ICG angiography is a reliable and effective modality for diagnosis and treatment of NOMI.

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