



Ileal long-segment ischemia after the unintended ligation of variant ileal branch during laparoscopic right hemicolectomy

Gyung Mo Son^{1,5}, Tae Un Kim², Dong-Hoon Shin³, Joo-Young Na⁴, In Young Lee⁵, Shin Hoo Park⁶

¹Department of Surgery, Pusan National University Yangsan Hospital, Yangsan, Korea

²Department of Radiology, Pusan National University Yangsan Hospital, Yangsan, Korea

³Department of Pathology, Pusan National University Yangsan Hospital, Yangsan, Korea

⁴Department of Forensic Medicine, Pusan National University Yangsan Hospital, Yangsan, Korea

⁵Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital, Yangsan, Korea

⁶Department of Medicine, Pusan National University School of Medicine, Yangsan, Korea

The variant terminal trunk of the superior mesenteric artery (SMA) could be confused with the ileocolic artery (ICA) as it runs on the right side of the superior mesenteric vein. If the variant ileal branch of SMA is mistaken for the ICA, unintentional ligation could cause long-segment ischemia in the ileum. We encountered a rare case of ileal ischemia caused by unintentional ligation of the variant ileal branch of the SMA during laparoscopic right hemicolectomy, which was confirmed by indocyanine green (ICG) angiography and hyperspectral imaging (HSI). Intraoperative real-time perfusion monitoring using ICG angiography and tissue oxygen saturation monitoring using HSI could help detect segments of hypoperfusion and prevent hypoperfusion-related anastomotic complications.

Keywords: Mesenteric ischemia, Superior mesenteric artery, Colectomy, Indocyanine green, Hyperspectral imaging

Received May 18, 2022

Revised June 24, 2022

Accepted July 2, 2022

Corresponding author

Gyung Mo Son

Department of Surgery, Pusan National University Yangsan Hospital, 20 Geumo-ro, Mulgeum-eup, Yangsan 50612, Korea

Tel: +82-55-360-212

Fax: +82-55-360-2154

E-mail: skm1711@pusan.ac.kr

ORCID:

<https://orcid.org/0000-0002-8861-6293>

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Copyright © The Korean Society of Endo-Laparoscopic & Robotic Surgery.

INTRODUCTION

When performing hemicolectomy for right-sided colon cancer, complete mesocolic excision and central vascular ligation are recommended as the standard procedures for radical lymph node dissection [1,2]. Surgical effort is usually made to ligate the vascular root of the feeding artery at the branching point of the superior mesenteric artery (SMA). When the ileocolic artery (ICA) root is retrieved while dissecting the anterior chamber of the superior mesenteric vein (SMV), the ICA is easily found on the right side of the SMV [3]. Rarely, the ileal branch of the SMA might travel across the behind of the SMV to the right colon and could be confused with the ICA. If the ileal branch of the SMA

is mistaken for the ICA, unintentional ligation could cause long-segment ischemia in the ileum. We encountered a rare case of ileal ischemia which was caused by unintentional ligation of the ileal branch of the SMA during laparoscopic right hemicolectomy and confirmed by indocyanine green (ICG) angiography and hyperspectral imaging (HSI).

MATERIALS AND METHODS

A 72-year-old woman was diagnosed with a hepatic flexure cancer. Preoperative computed tomography (CT) revealed an ulceroinfiltrating mass at the hepatic flexure of the right colon and enlarged pericolic lymph nodes (cT3N1M0). On the serial

coronal reformatted CT images during portal venous phase, the ileal branch of the SMA (red arrows in Fig. 1) runs across the SMV forward to the cecum. And then, that ileal branch travels downward into the distal ileum (Fig. 1). One day before surgery, diluted ICG (Diagnogreen Inj. 25 mg; Daiichi Sankyo, Tokyo, Japan) solution (0.5 mg/mL) was injected into the submucosal layer for tumor localization and fluorescent lymph node mapping [4,5]. The patient underwent a laparoscopic right hemicolectomy on May 13, 2021. Tumor location was identified by fluorescence

using a near-infrared (NIR) camera system (1588 AIM camera system; Stryker, Kalamazoo, MI, USA). Fluorescent lymph nodes which were directly connected to the primary tumor were observed around the middle colic artery (MCA). The mesentery was incised along the anterior surface of the SMV while pulling the transverse colon and cecum upward laterally. One mesenteric arterial branch passed across the behind of the SMV toward the cecum; therefore, this artery was considered the ICA. The artery directing to the ascending colon was assumed to be the

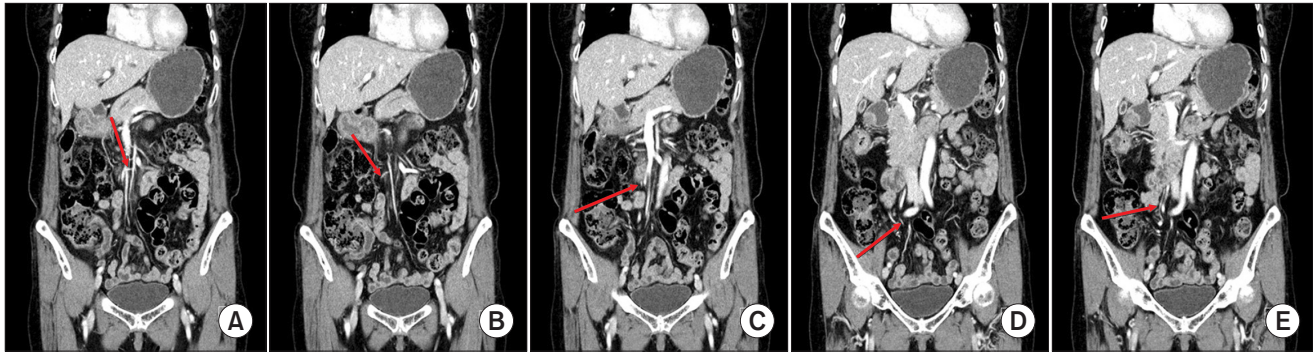


Fig. 1. Preoperative computed tomography (CT) for mesenteric vascular branching. The ileal branch of the superior mesenteric artery (SMA) is indicated by red arrows. Serial coronal reformatted CT images during the portal venous phase show that the ileal branch of SMA runs across the superior mesenteric vein (SMV) forward to the right side of SMV. And then, that ileal branch of SMA travels downward into the distal ileum.

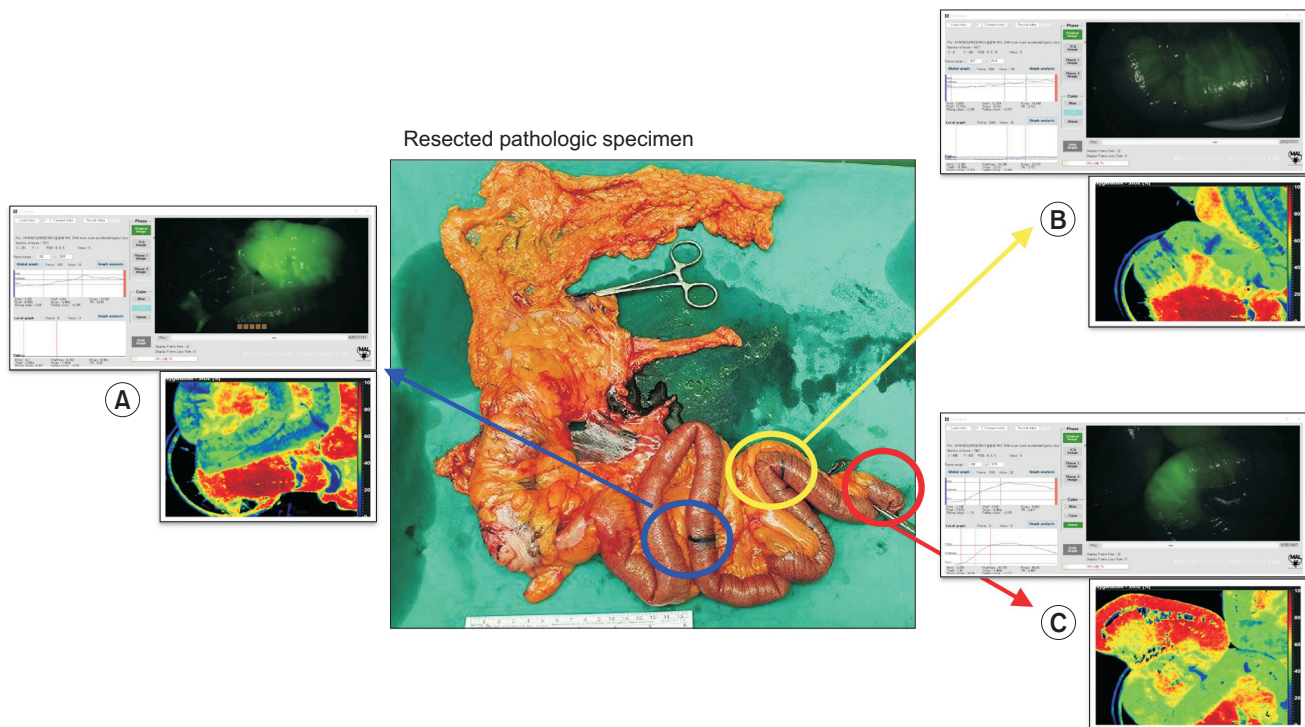


Fig. 2. The resected specimen with the quantitative perfusion analysis by indocyanine green angiography (above boxes of A–C) and tissue oxygen saturation by hyperspectral imaging (below boxes of A–C). Blue circle (A) is represented as poor perfusion status on the distal ileum. Yellow circle (B) is also not enough perfusion status. Red circle (C) is represented as good perfusion status on the proximal ileum.

right colic artery (RCA). However, these vascular diameters were larger than usual, leading to suspicion of an abnormal mesenteric vascular structure. Fluorescent lymph nodes were safely removed using MCA root ligation. After ligation of ICA and RCA following complete mobilization of the right colon, a pale color change in the ileal segment was identified as a warning of ileal ischemia under white light view of conventional laparoscopic camera. For real-time assessment of bowel perfusion status, we performed additional ICG angiography and HSI. On the planned transection line in the transverse colon, favorable perfusion status was identified through ICG angiography. However, the ileal segment had unfavorable perfusion without fluorescence enhancement on ICG angiography and poor oxygen saturation ranging from 20.0% to 22.9% through HSI (TIVITA Tissue System; Diaspective Vision GmbH, Am Salzhaff, Germany) (Fig. 2). With the second ICG angiography and HSI performed on the more proximal ileum, fluorescence enhancement was still slow, and tissue oxygen saturation remained at 33.0% to 35.9%. Adequate arterial flow could maintain tissue oxygen saturation at 85.4% in the proximal ileum 60 cm from the ileocolic valve. Therefore, the third point was determined to be the modified transection line for anastomosis (Supplementary Video 1).

RESULTS

The total operation time was 150 minutes with an estimated blood loss of 15 mL. The resected right colon was 30.5 cm in length, and the ileum was 63.5 cm. No metastatic lymph node was found, and the pathologic tumor stage was pT3N0M0. A liquid diet was started on the second postoperative day, and the patient was discharged on the fifth day. No postoperative complications occurred.

DISCUSSION

When performing a right hemicolectomy, preservation of the main trunk of the SMA is important to preserve blood flow to the small intestine. Since the mesenteric artery to the small intestine is also considered to have sufficient collateral circulation, the perfusion status of the ileum has not been a serious concern for surgeons during right hemicolectomy. Unusually, the ileal branch of the SMA might pass behind the SMV and travel to the cecum; therefore, it could be confused with the ICA. If the collateral circulation of the jejunal and ileal artery systems is not sufficiently formed in these cases, unintended ligation of the ileal branch of the SMA can lead to catastrophic long-segment ischemia of the ileum.

In this case, the ileal branch of the SMA ran to the right side across the SMV leading to the ileum, which could be traced on the portal venous phase of the preoperative CT. It is not easy to

routinely evaluate arterial branching patterns of the SMA using conventional CT in all patients. In addition, when the mesentery is pulled in the operating field, the distorted orientation of the mesenteric vasculature could increase the risk of mistaking the variant ileal branch of the SMA for the colonic artery. Therefore, if the vascular diameter is larger than that of the usual colic artery, it is necessary to make a more careful decision on vascular ligation by suspecting a variant ileal branch of the SMA. If the bowel color is pale or hypoperfusion is suspected during surgery, objective perfusion status can be evaluated using ICG angiography and HSI [6,7]. ICG angiography can visualize the dynamic perfusion status in real time, and repetitive angiography with low-dose ICG (0.02 mg/kg) allows multiple sites to be explored in the case of hypoperfusion. However, repeated intravenous injections of ICG may accumulate in the intestine prior to washing out and be mistaken for fluorescence enhancement. To compensate for these shortcomings of repetitive ICG angiography, quantitative analysis based on the dynamic fluorescence intensity-time curve can be helpful in determining perfusion status [7,8]. Currently, real-time tissue oxygen saturation levels can be easily measured using HSI in the surgical field. A tissue oxygen saturation maintained at 80% to 90% or more can be interpreted as reflecting a safe perfusion state. The development of intraoperative image analysis is expected to reduce complications that may occur due to unintentional errors made by inexperienced surgeons. In our previous study with laparoscopic low anterior resection, there was no anastomotic leak in patients with favorable perfusion segments, but the anastomotic leak rates were 11.1% to 71.4% in patients using moderate to poor perfusion segments [9]. Changing the primary planned transection line was required on 18.6% after detecting a hypoperfusion segment by the quantitative perfusion analysis of ICG angiography [10]. The drug price of ICG is only \$25, and the fluorescence image is installed as an essential function on the laparoscopic NIR camera system. So, ICG angiography is expected to become a promising method for real-time perfusion assessment method that can improve patient safety to prevent the hypoperfusion-related anastomotic complication. In this case, the variant ileal branch of the SMA was mistaken for the ICA and ligated unintentionally. However, long-segment ischemia was confirmed using ICG angiography and HSI in the ileum, and the bowel segment with good perfusion was anastomosed. The patient recovered safely without complications.

In conclusion, intraoperative real-time perfusion monitoring using ICG angiography and tissue oxygen saturation monitoring using HSI may be helpful in detecting segments of hypoperfusion to prevent anastomotic complications.

NOTES

Ethical statements

This study was conducted after receiving the approval of the Institutional Review Board of the Pusan National University Yangsan Hospital (No. 05-2022-127). Written informed consent was obtained from a patient.

Authors' contributions

Conceptualization: GMS

Writing—original draft: GMS

Writing—review & editing: All authors

All authors read and approved the final manuscript.

Conflict of interest

All authors have no conflicts of interest to declare.

Funding/support

This study was supported by a 2022 research grant from Pusan National University Yangsan Hospital.

Acknowledgments

The authors would like to thank Kyung Hee Kim, RN; Hyun Seok Jung, RN; and Sung Mi Yoon, RN for technical assistance with fluorescence image-guided surgery in the surgical field of Pusan National University Yangsan Hospital.

ORCID

Gyung Mo Son, <https://orcid.org/0000-0002-8861-6293>

Tae Un Kim, <https://orcid.org/0000-0003-1017-6926>

Dong-Hoon Shin, <https://orcid.org/0000-0002-4980-9295>

Joo-Young Na, <https://orcid.org/0000-0003-1138-433X>

In Young Lee, <https://orcid.org/0000-0001-5954-6188>

Shin Hoo Park, <https://orcid.org/0000-0003-0801-6691>

Supplementary materials

Supplementary materials can be found via <https://doi.org/10.7602/jmis.2022.25.3.116>.

REFERENCES

1. Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation--technical notes and outcome. *Colorectal Dis* 2009;11:354-365.
2. Shah MF, Naeem A, Haq IU, et al. Laparoscopy offers better clinical outcomes and long-term survival in patients with right colon cancer: experience from national cancer center. *Ann Coloproctol* 2022;38:223-229.
3. Son GM, Lee IY, Lee YS, et al. Is laparoscopic complete mesocolic excision and central vascular ligation really necessary for all patients with right-sided colon cancer? *Ann Coloproctol* 2021;37:434-444.
4. Son GM, Ahn HM, Lee IY, Ha GW. Multifunctional indocyanine green applications for fluorescence-guided laparoscopic colorectal surgery. *Ann Coloproctol* 2021;37:133-140.
5. Ahn HM, Son GM, Lee IY, et al. Optimal ICG dosage of preoperative colonoscopic tattooing for fluorescence-guided laparoscopic colorectal surgery. *Surg Endosc* 2022;36:1152-1163.
6. Mehdorn M, Köhler H, Rabe SM, et al. Hyperspectral imaging (HSI) in acute mesenteric ischemia to detect intestinal perfusion deficits. *J Surg Res* 2020;254:7-15.
7. Son GM, Kwon MS, Kim Y, Kim J, Kim SH, Lee JW. Quantitative analysis of colon perfusion pattern using indocyanine green (ICG) angiography in laparoscopic colorectal surgery. *Surg Endosc* 2019;33:1640-1649.
8. Ahn HM, Son GM, Lee IY, Park SH, Kim NS, Baek KR. Optimization of indocyanine green angiography for colon perfusion during laparoscopic colorectal surgery. *Colorectal Dis* 2021;23:1848-1859.
9. Son GM, Ahn HM, Lee IY, Lee SM, Park SH, Baek KR. Clinical effect and standardization of indocyanine green angiography in the laparoscopic colorectal surgery. *J Minim Invasive Surg* 2021;24:113-122.
10. Kim D, Son GM, Kwon MS, Baek S, Park BS, Kim H. Educational benefits of intraoperative indocyanine green angiography for surgical beginners during laparoscopic colorectal surgery. *J Minim Invasive Surg* 2018;21:25-30.