—Case Reports—

Laparoscopic Repeat Hepatectomy with Indocyanine Green Fluorescence Navigation: A Case Report

Masato Yoshioka[1], Nobuhiko Taniai[2], Youichi Kawano[3], Tetsuya Shimizu[1], Ryota Kondo[1], Yohei Kaneya[1], Yuto Aoki[1] and Hiroshi Yoshida[1]

[1]Department of Gastrointestinal and Hepato-Biliary-Pancreatic Surgery, Nippon Medical School Hospital
[2]Department of Gastroenterological Surgery, Nippon Medical School Musashi Kosugi Hospital, Kanagawa, Japan
[3]Department of Gastroenterological Surgery, Nippon Medical School Chiba Hokusoh Hospital, Chiba, Japan

The indocyanine green (ICG) fluorescence method is reportedly useful for intraoperative visualization of hepatocellular carcinoma and metastatic liver cancer. Herein, we report the use of an ICG fluorescence navigation system for laparoscopic hepatectomy. The patient was a 73-year-old man with a surgical history of two laparotomies for hepatocellular carcinoma resection. During follow-up at our hospital, abdominal computed tomography revealed recurrence of hepatocellular carcinoma in the lateral area of the liver, after which the patient was hospitalized for surgery. His surgical history indicated that adhesions in the abdominal cavity were likely. We scheduled laparoscopic repeat hepatectomy (LRH) with an ICG fluorescence method in which ICG dye was injected intravenously 2 days before surgery. ICG fluorescence was easily detected intraoperatively. The advantages of the present approach are that it induces pneumoperitoneum and, with laparoscopic magnification, enables good visualization of the surgical field for LRH and clear intraoperative identification of the tumor, thus facilitating LRH. Laparoscopic partial resection of the liver (S3) was successfully performed; the operation time was 197 minutes and bleeding volume was 30 mL. Postoperative course was uneventful and he was discharged on postoperative day 10. (J Nippon Med Sch 2019; 86: 291–295)

Key words: laparoscopic repeat hepatectomy, indocyanine green (ICG), fluorescence navigation

Introduction

Laparoscopic liver resection (LLR) is now performed much more frequently, with several modifications. Furthermore, we routinely perform laparoscopic repeat hepatectomy (LRH) procedures for patients who have previously undergone upper abdominal laparotomy procedures, including hepatectomy. Safe completion of LRH requires that the surgeon recognize post-resection liver deformities and accurately locate the tumor. In addition, the surgical difficulty of LRH can be high because of the limited utility of intraoperative ultrasound and the presence of adhesions around the liver.

An indocyanine green (ICG) fluorescence navigation system combined with preoperative three-dimensional simulation has been introduced for LRH. Recently, the intraoperative usefulness of injecting intravenous ICG 2 days before surgery has been reported in various fields, including liver surgery[1,2]. The specific distribution of ICG over time shows blood flow, hepatic parenchyma, and biliary tract. In patients with liver cirrhosis and those who have previously undergone transcatheter arterial chemoembolization or surgery (especially hepatectomy), the boundary between the tumor and non-tumorous parenchyma can be unclear, making it difficult to determine the required range of resection. ICG fluorescence technique might enable clear identification of tumor tissue in such cases.

Herein, we report the successful performance of LRH for a patient who had undergone two previous hepatectomies.

Correspondence to Masato Yoshioka, MD, PhD, Department of Gastrointestinal and Hepato-Biliary-Pancreatic Surgery, Nippon Medical School Hospital, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8603, Japan
E-mail: y-masato@nms.ac.jp
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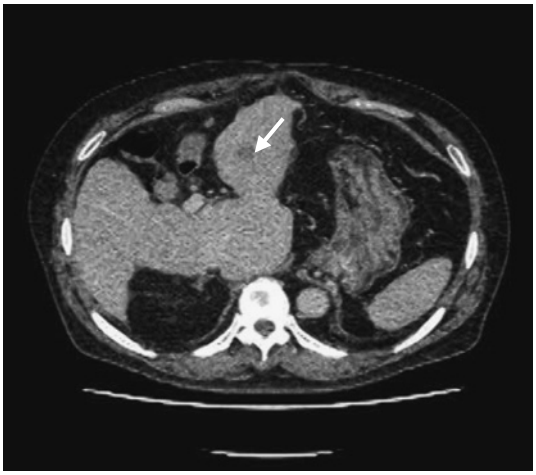

Fig. 1 Computed tomography image showing a 1.5-cm tumor in liver S3 (white arrow), with wash-out in the late contrast phase, indicating hepatocellular carcinoma.

Case Report

A 73-year-old man with nonalcoholic steatohepatitis (results of testing for hepatitis B surface antigen and hepatitis C virus antibody were negative) and diabetic nephropathy was followed-up at our outpatient clinic. The patient had undergone anterior segmentectomy of the liver for hepatocellular carcinoma (HCC) at age 65 years and hepatic caudate partial resection for HCC recurrence at age 68 years. Follow-up abdominal computed tomography (CT) detected suspected recurrent liver cancer in the lateral area of the liver. The patient was admitted to our hospital for further investigation and treatment.

His physical status on admission was unremarkable. Preoperative hematologic and blood biochemical tests, including testing of tumor markers α-fetoprotein and PIVKA II, showed only hyperglycemia and mild renal dysfunction. Abdominal ultrasonography revealed a hypoechoic mass lesion in segment 3 (S3) of the liver. Abdominal contrast CT indicated that the tumor was a recurrent HCC with a diameter of 1.5 cm. The tumor was intensively stained with a contrast agent early in the arterial phase and washed out in the venous phase (**Fig. 1**). On the basis of these findings, single recurrence of HCC in liver S3 was diagnosed, and partial laparoscopic resection of the segment was scheduled. As the patient had previously undergone two open hepatectomies, we predicted that adhesions in the abdominal cavity were likely and that accurate identification of the tumor location would be difficult. Nevertheless, we elected to perform a laparoscopic operation because of its minimal invasiveness and the magnification provided by the laparoscope. Use of ICG fluorescence navigation was also planned, to enable easier identification of the tumor. ICG reagent (0.5 mg/kg) was injected intravenously 2 days before surgery.

Surgical Procedure

Use of intravenous ICG injection for intraoperative navigation was approved by the ethics committee of our institute. Although our patient had previously undergone upper abdominal laparotomy and had a surgical scar at the umbilicus, a 3-cm incision was created at the umbilicus, and a Lap Protector™ (Hakko, Nagano, Japan) was attached. A 12-mm port for a camera and two 5-mm ports for the multiaccess port system (EZ Access®; Hakko, Nagano, Japan) were also constructed (**Fig. 2**). In LRH, the location and number of additional ports are decided in accordance with patient factors such as presence of adhesions in the abdominal cavity. In the present case, an additional 12-mm port was inserted in the right upper abdominal quadrant, and a 5-mm port was inserted in the right lower and left upper quadrants (**Fig. 3**). In LRH cases, previous upper abdominal surgery often results in strong adhesions followed by shortening deformities of the hepatic duodenal ligament, which prevents use of the Pringle method[3].

Preoperative three-dimensional CT imaging indicated that the tumor was located on the dorsal side of the liver (**Fig. 4a, 4b**). Therefore, adhesions were detached or divided, as necessary, to create the surgical field for the planned hepatectomy. Adhesions from the abdominal wall, transverse colon, omentum, lateral extrahepatic area, and stomach were sufficiently detached to enable partial resection of liver segment S3, while adhesions not in the required surgical field were left intact (**Fig. 5a, 5b, 5c**). Because the tumor was located on the dorsal side of the liver, adhesions that could be used to lift the liver were left *in situ*. When the liver surface on which the tumor was predicted was exposed, the camera was switched to ICG fluorescence mode, enabling visualization of the tumor as a clearly demarcated region of green fluorescence (**Fig. 6a, 6b**). An ultrasonically activated scalpel was used to dissect the superficial layer, while the deep layer was dissected with a Cavitron ultrasonic surgical aspirator (Valley Lab; Medtronic, Minneapolis, MN, USA). The appropriate vessels in the liver were clipped and dissected, and partial resection of liver segment S3 was performed in accordance with the preoperative simulation (**Fig. 6c, 6d**). The operative time was 197 minutes, and bleeding volume was 30 mL. The postoperative

Fig. 2 A 3-cm incision was made at the umbilicus, and adhesions under the umbilicus and in surrounding tissue were identified. A multiaccess port system (EZ access; Hakko Medical, Nagano, Japan) with one 12-mm and two 5-mm ports was used.

Fig. 3 Postoperative photograph showing the surgical wound sites. A 12-mm port was inserted in the right upper abdominal quadrant, and 5-mm ports were inserted in the right lower and left upper quadrants (arrow).

course was uneventful, and the patient was discharged 10 days postoperatively.

Discussion

Outcomes for treatment of HCC and liver metastases from colorectal cancer have improved, and repeat hepatectomy is now more frequently indicated. Additionally, development and refinement of surgical instruments, as well as improvements in the reliability and safety of surgical techniques, have enabled safe and effective implementation of minimally invasive LLR.

In LRH, there are limitations on securing an adequate visual field, because of adhesions, liver displacement, and deformation from previous surgery. Adequate resection is sometimes difficult to achieve in LRH; thus, no conclusive indications for LRH have been established. However, laparoscopic surgery has been reported to be a feasible and effective option for repeat hepatectomy[4,5]. In our institute, we have performed LRH in 24 patients, and our experience confirms its safety and feasibility. The adhesions encountered during LRH can be managed with the aid of the good visual field provided by the induction of pneumoperitoneum, while the magnification provided by the laparoscopic approach facilitates surgical success in a small operative field.

Access to the lesion and excision is often possible with minimal management of adhesions in LRH, which results in less bleeding and short operation times, as in the present patient. In contrast, conventional re-operative laparotomy requires creation of a surgical field that is similar in size to that of the previous laparotomy, thus necessitating a wider range of adhesion detachment. In conventional LLR, intraoperative ultrasonic assessment is indispensable for confirming tumor location and extent. However, in patients undergoing LRH, movement of the ultrasound probe may be limited by adhesions. In addition, residual liver displacement and deformation can complicate visualization of the tumor, and it is often hard to distinguish the borderline between normal liver and tumor in a patient with an impaired liver.

ICG fluorescence techniques are used in various fields for intraoperative identification of lymph nodes, vessels, and tumors. ICG has a molecular weight of 77.460 Da, is water-soluble, and rapidly binds with plasma lipoproteins, most of which are taken up by liver parenchymal cells and excreted in bile without being metabolized[6]. ICG is thus widely used for preliminary evaluation of the liver. ICG fluorescence techniques have also been used to identify target areas of the liver during anatomical hepatic resection[7] and for detection of bile leakage, to reduce the incidence of postoperative biliary fistula formation after hepatectomy[8]. A camera with a charge-coupled device can be used to observe the near-infrared wavelength of ICG fluorescence to a depth of 10 mm from the body surface[9,10]. ICG emits a fluorescent color upon binding with α-1 lipoprotein[11]. HCC exhibits fluorescence because well-differentiated HCC produces bile; however, bile excretion is delayed. Some evidence indicates that bile excretion is impaired in normal liver parenchyma surrounding HCC[10].

As mentioned above, it can be difficult to locate tumors by ultrasound examination of patients undergoing

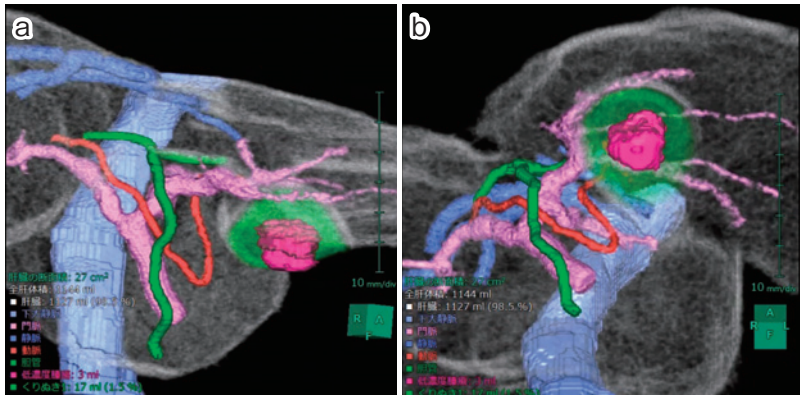

Fig. 4 (a, b) Three-dimensional computed tomography simulation showing the tumor on the dorsal side of liver segment S3.

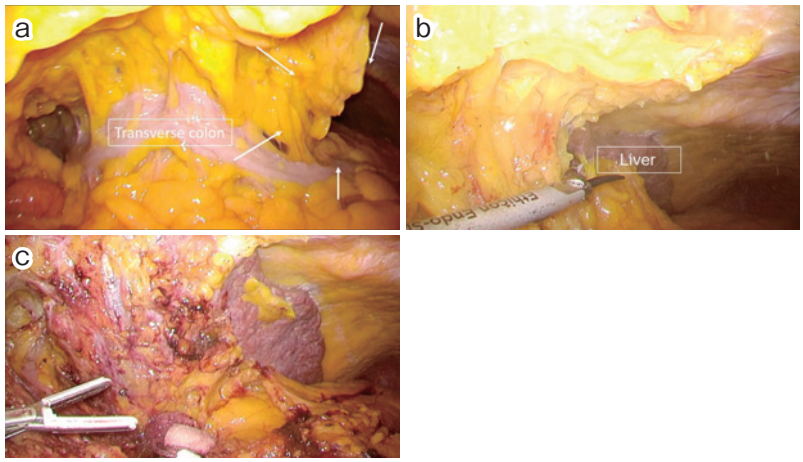

Fig. 5 (a) Intraoperative photographs. Consistent with the previous laparotomies, the transverse colon and omentum adhere to the peritoneum, which restricts the visual field of the upper abdomen. (b) An adhesion in the left upper abdominal cavity. (c) The outer lateral area of the liver adheres to the abdominal wall. This ensured a good field of view from the dorsal side, which was required for tumor resection.

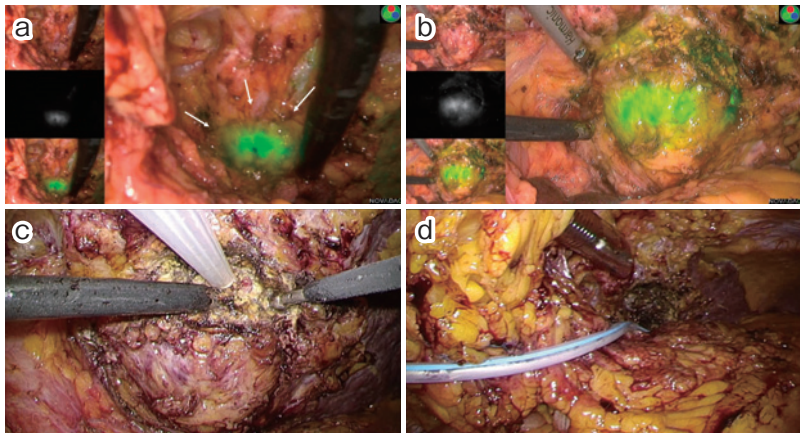

Fig. 6 Intraoperative photographs. (a) After switching to an indocyanine green (ICG) fluorescence camera, the tumor area is visualized by the emission of fluorescent green light (White arrow). (b) With the aid of an ICG fluorescence camera, the liver surface is marked to indicate the area of the tumor resection. (c) The required liver resection can be performed in a limited space but with a good field of view. (d) Hepatic resection in the left upper abdomen is successful, and a drain has been left in place.

repeat hepatectomy. However, identification of tumor tissue is easier with the ICG fluorescence navigation method. ICG fluorescence navigation enables identification of approximately 100% of gross HCC and 40% of microscopic lesions that were not detected preoperatively[4]. For these reasons, we use an ICG fluorescence navigation system when performing LRH.

A limitation of the ICG fluorescence technique is that it sometimes yields false positives, because precancerous lesions and regenerative nodules also reportedly fluoresce in patients with liver cirrhosis. Therefore, combined use of ultrasound examination using Sonazoid[12] (Daiichi-Sankyo, Tokyo, Japan) and ICG fluorescence technique might provide superior results, particularly when identifying tumors during LRH for which the operative field for liver resection is narrow.

In the present patient, LRH with ICG fluorescence navigation resulted in satisfactory operation time, bleeding volume, and duration of hospital stay. Overall, we believe that implementing ICG fluorescence navigation when performing LRH is feasible and useful in improving safety and convenience.

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Conflict of Interest: The authors declare that they have no conflict of interest.

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