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Indocyanine Green Fluorescence–Guided Avoidance of Bile Duct Injury During Simultaneous Laparoscopic Fenestration and Cholecystectomy

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Abstract: Real-time indocyanine green (ICG) guided surgery has been reported to be safe for cholangiography in laparoscopic cholecystectomy (LC). Laparoscopic fenestration (LF) is a standard and safe procedure for liver cysts. However, no cases had been reported for simultaneous treatment of fenestration and cholecystectomy using ICG guided laparoscopic surgery. In this presented study, a case of successful simultaneous treatment of LF and LC was reported using ICG to prevent biliary injury. A 72-year-old man diagnosed with multiple hepatic cysts and gallstones was given 0.1 mg ICG intravenously 20 min before surgery. ICG cholangiography clearly showed the common bile duct and the liver parenchyma for LC. The cystohepatic triangle was safely dissected without injuring the common bile duct using the merge view mode. ICG fluorescence cholangiography clearly showed the biliary ducts inside the cyst and distinguished the wall of cysts from parenchyma. Only the cyst walls were resected to the greatest extent possible without injuring surrounding bile ducts. With the administration of 0.1 mg ICG intravenously 20 min before surgery, real-time ICG guided surgery is safe for simultaneous LF and LC for avoidance of bile duct injury. In conclusion, administration of 0.1 mg ICG intravenously 20 min before surgery is an applicable dose and timing for ICG guided simultaneous LF and LC and deserves popularization.

Keywords: Indocyanine Green, Laparoscopic Fenestration, Laparoscopic Cholecystectomy, Cholangiography, Hepatic Cysts

1. Introduction

Laparoscopic fenestration (LF) is a standard surgery for nonparasitic liver cysts with a low symptomatic recurrence rate. [1, 2] The guiding principle of LF consists in resecting the wall of cyst to the greatest extent possible at the cyst–liver boundary to prevent recurrence. However, severe complications, such as bleeding and bile leakage, may occur with excessive resection of the wall of cyst. [3] Laparoscopic cholecystectomy (LC) is considered the gold standard for gallstones. [4] The key to safe LC is to dissect the cystohepatic triangle without injuring the common bile duct. However, about 0.2%–1.5% of LC cases are reported to be caused bile duct injury. [5-7] In a previous work, the authors found the real-time indocyanine green (ICG) guided surgery is safe for cholangiography in LC. [8] A more recent study has also reported that ICG is safe and feasible for identifying biliary tracts and evaluating tissue blood flow. [9] However, there are few reports of simultaneous LC and LF using ICG cholangiography.

Here, a case was reported in which LC and LF were safely

and simultaneously performed using real-time intraoperative ICG cholangiography.

2. Case Presentation

A 72-year-old man was referred to our department with multiple asymptomatic liver cysts and gallstones. The cysts in the liver were detected by ultrasonography 10 years ago during a routine physical examination. No family history of liver cysts identified to this patient. He had a history of chronic hepatitis B virus infection lasting several years, treated with oral antiviral drugs. The laboratory tests of liver function were normal (Child-Pugh score, class A) and the levels of tumor markers were within the normal range. Abdominal computed tomography scan showed multiple homogeneous cystic low-density lesions with clear boundaries and thickened walls. The biggest cyst was located in segment 5/8 and it was 10.6 cm in diameter (Figure 1A). Sediment-like stones were visible in the gallbladder cavity, and these had a size range of about 14 mm × 5 mm (Figure 1B). With the high risk of rupture of the giant cyst and sediment-like gallstones, therefore, LF and cholecystectomy were performed for this case.

Twenty minutes before surgery, the patient was intravenously administered 1 mL of ICG (0.1 mg/mL). A 10-mm trocar was placed below the umbilicus for scope entry, and 12-mm at the epigastric area and 5-mm trocar at right upper areas was placed to manipulate the instruments; another 5-mm trocar at right abdominal mid-axillary line served as the auxiliary operation point (Figure 2). A laparoscopic imaging system armed with near-infrared fluorescence (OptoMedic Technologies, Guangzhou, China) was used to detect ICG fluorescence. During the surgery, the merge mode view was used. The merge model includes four images, i.e., the standard fluorescence mode view on the top-left, the grayscale fluorescence mode on the middle-left, the color fluorescence mode on the bottom-left, and the normal white light mode on the right. Firstly, LC was performed. ICG fluorescence was detected in parenchyma and the common bile duct, but not in the surrounding fat tissues (Figure 3), therefore the cystohepatic triangle was safely dissected without injuring the common bile duct. Then LF was performed. ICG fluorescence cholangiography was clearly distinguished the cysts from parenchyma (Figure 4A), therefore only the cyst wall was resected as wide as possible under the guidance of fluorescence imaging (Figure 4B). After fenestration of the giant cysts in segment 8 (Figure 4C), ICG signals was partially visible in the cyst wall inside (Figure 4D), and strong fluorescence signals was observed in bile ducts (Figure 4E-F). Followed, the cyst wall was fenestrated by avoiding the surrounding biliary branches under the guidance of fluorescence imaging. During surgery, a cyst in the hepatic hilum was distinguished (Figure 5A-B), and then fenestration was performed around the line guided by ICG fluorescence signals (Figure 5C-D). The operation was successfully completed without intraoperative complications. The operation lasted 90 min, and blood loss was 50 mL. The patient was discharged uneventfully on the second postoperative day. Histopathological examination revealed that the cyst wall consisted of calcified tissue without any signs of malignancy. No biliary branches were found along the cyst wall.

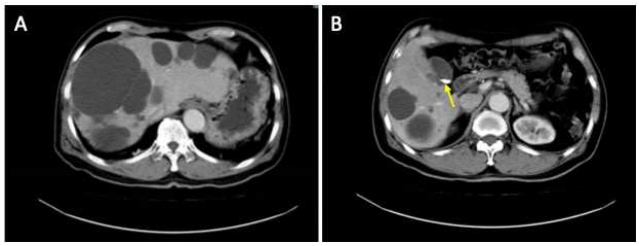

Figure 1. *Computed tomography (CT) scan images. (A) The CT scan shows multiple cystic low-density lesions with clear boundaries, in which the biggest cyst lies in segment 5/8 with a size of 106mm×82mm. (B) Sediment-like stones can be seen in the gallbladder (arrow).*

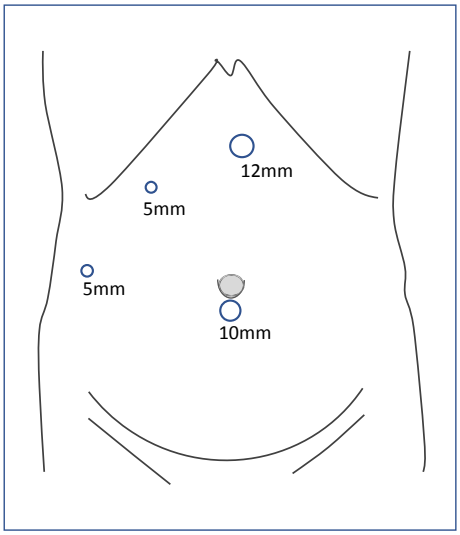

Figure 2. *Diagram of trocar placements. A 10-mm trocar below the umbilicus used for endoscope camera; a 12-mm trocar at the epigastric area and a 5-mm trocar at the right upper areas near to the gallbladder were used as the main operation points; another 5-mm trocar at right abdominal mid-axillary line used as the auxiliary operation point.*

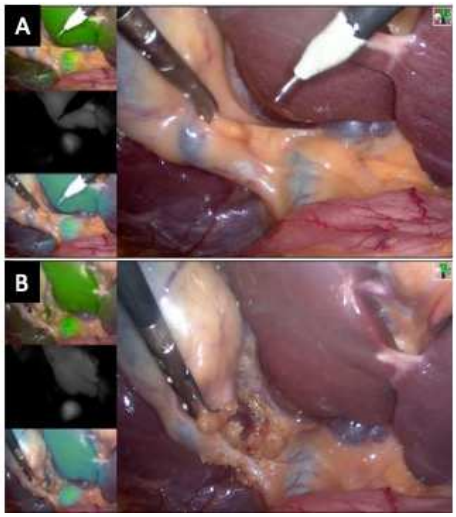

Figure 3. *ICG-guided cholecystectomy with the merge view mode. Images before (A) and after (B) surgical dissection of the cystohepatic triangle; The liver parenchymal and the common bile duct show strong fluorescence.*

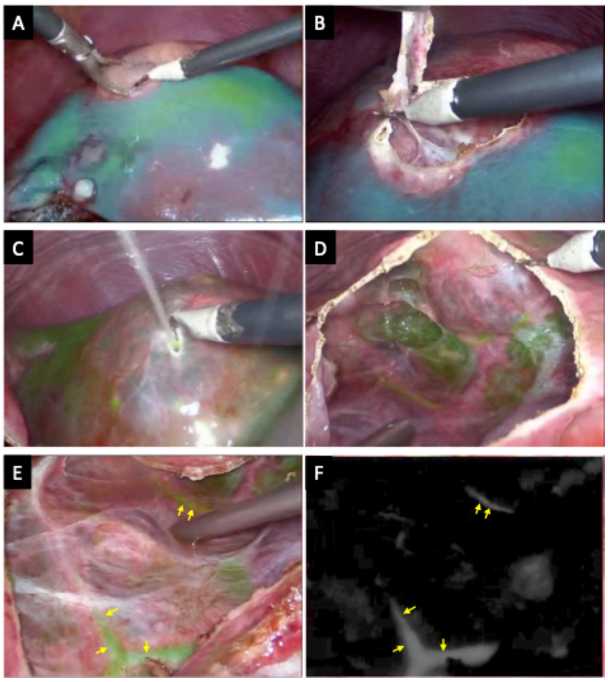

Figure 4. *ICG-guided fenestration for cysts in the right lobe. (A) ICG fluorescence cholangiography clearly showed in liver parenchyma but not in cyst. (B) ICG fluorescence cholangiography guided a clear resection boundary. (C) Fenestration of the giant liver cyst with clear liquid. (D) ICG signals were partially showed in the cysts wall inside. (E) ICG fluorescence cholangiography clearly showed biliary branches (arrows) inside the cyst. (F) Biliary branches presented as high density (arrows) in the grayscale fluorescence mode.*

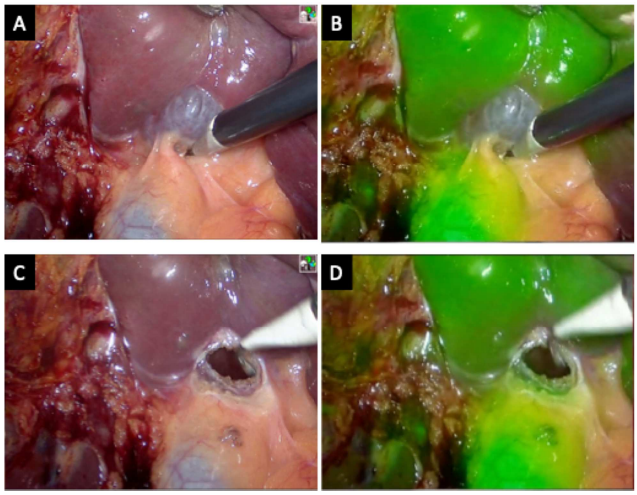

Figure 5. *ICG-guided fenestration for cysts in hepatic hilum. A cyst in hepatic hilum can hardly distinguished in the normal white light mode view (A), while easily be discriminated in the standard fluorescence mode view (B). The fenestrated cyst in hepatic hilum in the normal white light mode view (C) and the standard fluorescence mode view (D).*

3. Discussion

The LF procedure has been the standard method since the first report of the use of LF for liver cysts in 1991. [10, 11] Relative to needle aspiration, LF could decrease the recurrence rate to a profound extent, but there is a reported risk of postoperative bile leakage. Real-time ICG fluorescence–guided surgery was able to identify the biliary tract easily, and has been reported to prevent intraoperative biliary damage and postoperative biliary fistula. [12]

We made a mini literature review of the ICG-guided LF for hepatic cysts by searching the PubMed with the keywords “indocyanine green” and “laparoscopic fenestration” and summarized the previous studies using ICG for LF (Table 1). In 2015, Kitajima et al. [13] reported the first case of a huge liver cyst for which LF was performed using intraoperative fluorescent cholangiography with ICG. They administered 1.25 mg of ICG during surgery through endoscopic nasal biliary drainage (ENBD) tube. [13] In 2021, Umemura et al. [14] reported six cases of LF that used ICG injection from ENBD. They believed that ICG imaging via ENBD during LF of liver cysts could compensate for the weakness of ICG imaging, i.e., infusion ICG imaging involves some time lag after injection due to moving from bloodstream to bile. [14] However, an additional injection ICG may be needed in cases of unclear fluorescent imaging. Besides the ENBD injection route, intravenous injection of ICG before surgery shows another suitable form of ICG administration. In 2016, Tanaka et al. [12] reported the first case of intravenous injection of ICG for LF. Followed, Hanaki et al., [15] Une et al., [16] and Tanioka et al. [17] reported their cases using intravenous injection of ICG during LF. In our present case, ICG was also intravenously administered because ENBD itself may have a risk of causing iatrogenic biliary injury, and ENBD may involve a need for additional staff and equipment. For the timing of ICG administration, ICG was reportedly applied during surgery for the ENBD route and 1 d or 1 h before surgery for the intravenous route. In our case, the ICG was administered just 20 min before surgery at a dose of 0.1 mg, which was a much lower concentration than that reported in previous studies.

Unlike in previously reported studies, [12–17] this presented study simultaneously performed LC and LF guided by real-time ICG fluorescence cholangiography. Our previous report showed real-time ICG fluorescence–guided surgery to be safe for cholangiography in laparoscopic cholecystectomy. [8] Our team also investigated the optimal ICG dose and timing for cholangiography in LC. [8] With the administration of 0.1-mg ICG intravenously 20 min before surgery, ICG cholangiography clearly showed the common bile duct and the liver parenchyma for LC, therefore cystohepatic triangle could be safely dissected without injuring the common bile duct. ICG imaging clearly showed the biliary ducts inside the cyst and distinguished the cyst wall from parenchyma. Only the cyst walls were resected to the greatest extent possible without injuring surrounding bile ducts. Notably, in our case, a cyst near the hepatic hilum was distinguished, which may easily be regarded as the left hepatic duct in the normal white light mode. Fortunately, fenestration was performed around the line guided by ICG fluorescence signals, which was not shown in the cyst (Figure 5).

Table 1. *Summary of previous studies using ICG during laparoscopic fenestration.*

Author	Reported year	Age	Sex	Timing of ICG administration	Administration route	Dose of ICG
Kitajima et al [13]	2015	71	Female	In surgery	Intra-biliary (ENBD)	1.25mg
Tanaka et al [12]	2016	80	Female	1d before surgery	Intravenously	0.5mg/kg
Hanaki et al [15]	2020	67	Male	1h before surgery	Intravenously	0.5mg/kg
Umemura et al [14]	2021	66.5 (60-79)	Six females	In surgery	Intra-biliary (ENBD)	2.5mg/mL
Une et al [16]	2021	74	Female	1h before surgery	Intravenously	2.5mg
Tanioka et al [17]	2021	69	Female	1h before surgery	Intravenously	2.5mg
Huang et al (our case)	2022	72	man	20 min before surgery	Intravenously	0.1mg

Table 1. *Continued.*

Author	ICG-R15 test	Additional bolus ICG	Operation duration (min)	Blood lost (mL)	Postoperative biliary fistula	Discharge day
Kitajima et al [13]	-	Yes (1.25mg/body)	-	-	No	POD6
Tanaka et al [12]	Normal	Yes (5 mg/body)	283	5	No	POD6
Hanaki et al [15]	25%	No	91	2	No	POD5
Umemura et al [14]	-	Yes (2.5mg/mL)	86 (62-120)	8 (3-29)	No	POD4 (3-6)
Une et al [16]	-	No	73	0	No	POD6
Tanioka et al [17]	-	No	81	5	No	POD6
Huang et al (our case)	-	No	90	50	No	POD2

ENBD: endoscopic nasal biliary drainage; ICG: indocyanine green; POD: postoperative day.

4. Conclusion

In summary, this study presented the validity of a theoretical dose and timing (i.e., 0.1 mg, 20 min before surgery) of ICG intravenous injection for simultaneous LF and LC. Considering its efficiency and convenience, this method can be a standard technique for simultaneous LF and LC.

Competing Interests

The authors declare that they have no competing interests.

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