Evaluation of laparoscopic cholecystectomy using indocyanine green cholangiography including cholecystitis

A retrospective study

Kiyokazu Hiwatashi, MD, PhD<sup>a</sup>, Hiroshi Okumura, MD, PhD<sup>b,∗</sup>, Tetsuro Setoyama, MD, PhD<sup>a</sup>, Kei Ando, MD<sup>a</sup>, Yoshito Ogura, MD, PhD<sup>a</sup>, Kuniaki Aridome, MD, PhD<sup>a</sup>, Shigeho Maenohara, MD, PhD<sup>a</sup>, Shoji Natsugoe, MD, PhD<sup>b</sup>

Abbreviations:
ALP = alkaline phosphatase, ALT = alanine aminotransferase, AST = aspartate aminotransferase, CBD = common bile duct, CD = cystic duct, CRP = C-reactive protein, ERCP = endoscopic retrograde cholangiopancreatography, GB = gallbladder, ICG = indocyanine green, LC = laparoscopic cholecystectomy, MRCP = magnetic resonance cholangiopancreatography.

Abstract
Intraoperative cholangiography involving the excretion of fluorescent indocyanine green (ICG) into the bile is used to determine biliary anatomy in laparoscopic cholecystectomy (LC). This study aimed to evaluate the features of intraoperative ICG cholangiography, in LC with cholecystitis, and compared the delineation of the cystic duct (CD) between ICG cholangiography and magnetic resonance cholangiopancreatography (MRCP).

Participants comprised 65 patients undergoing LC using ICG cholangiography.

Fifty-eight patients (89.2%) were diagnosed with gallbladder stones and 32 (49.2%) with acute cholecystitis. ICG cholangiography identified CD in 54 patients (83.1%) and did not identify CD in 11 patients (16.9%). The mean value of the fluorescence intensity in the identified CD group by ICG cholangiography was 57.9 ± 31.5 arbitrary unit and that in the not identified CD group by ICG cholangiography was 24.4 ± 10.1 arbitrary unit (P < .001). Compared with the patients in the identified CD group, those in the not identified CD group had higher incidence of acute cholecystitis (P < .001), and higher conversion rates (P = .003). A correlation between the delineation of CD by ICG cholangiography and MRCP was analyzed, and it revealed a correlation between each other (P = .002).

Inflammation had harmful effects with regard to the passing of CD. If we can identify CD or common bile duct with ICG cholangiography, we may be able to perform LC with confidence, even in the presence of severe inflammation.

Keywords: acute cholecystitis, indocyanine green cholangiography, laparoscopic cholecystectomy, magnetic resonance cholangiopancreatography

1. Introduction
Laparoscopic cholecystectomy (LC) is one of the most common operations in the surgical field, with more than 60,000 operations performed in Japan and approximately 750,000 in the United States every year. Bile duct injury is rare, with an incidence of 0.3% to 0.7%, but it can lead to serious consequences. Surgery for cholecystitis tends to be difficult for even experienced doctors and has a high risk of complication.

Intraoperative fluorescent imaging with indocyanine green (ICG) has been employed for confirming the patency of vascular reconstruction surgery, liver transplantation, anastomosis of the gastrointestinal tract, brain aneurysms, identification of sentinel lymph node navigation, and hepatocellular carcinoma detection. Recently, an intraoperative cholangiography technique in LC involving the excretion of fluorescent ICG in the bile after intravenous injection has been used to determine the bile duct anatomy. Currently, some detailed reports have been published on LC using intraoperative ICG cholangiography and suggested its safety and feasibility. In this study, we evaluated the features of intraoperative ICG cholangiography, including LC for cholecystitis, and compared the delineation of the cystic duct (CD) between ICG cholangiography and magnetic resonance cholangiopancreatography (MRCP).

2. Patients and methods
2.1. Patient characteristics
The study population comprised 65 patients undergoing LC using ICG cholangiography for gallbladder stones, gallbladder...
73 patients received cholecystectomy for gallbladder stones, gallbladder polyps, and acute cholecystitis (March 2015 to March 2017). Basically, all patients underwent preoperative MRCP or endoscopic retrograde cholangiopancreatography (ERCP) to estimate whether aberrant bile duct exists and especially, ERCP was performed for patients who were suspected common bile duct (CBD) stones. In this series, 8 other patients were excluded from the study because 5 of them had iodine allergy (as ICG contains iodine) and 3 had undergone open surgery from the start (Fig. 1).

2.2. Informed consent
This study was approved by the ethics committees of Kagoshima Kouseiren Hospital (registration number 2017042601) and was conducted according to the ethical guidelines of the Declaration of Helsinki. Written informed consent was obtained from each patient.

2.3. LC and ICG cholangiography
In our hospital, LC has been performed by young surgeons who have worked for several years under a supervisory doctor. For fluorescence, 2.5-mg ICG (2.5 mg/mL; Diagnogreen, Daiichi Sankyo, Tokyo, Japan) was intravenously injected approximately 2 hours before surgery. Laparoscopic imaging was performed using the D-LIGHT P System (Karl Storz Endoscopes, Tuttingen, Germany) through a standard 12-mm umbilical trocar port. This imaging system comprises 2 wavelength-isolated light sources: a white light source and a near-infrared light source that produce light of 805-nm wavelength, and this imaging system detects infrared light of 835 nm. During operation, we have repeatedly performed ICG cholangiography before or after dissection of the Calot triangle. After dissecting the Calot triangle possibly, ICG cholangiography was performed to identify the anatomy of the CD and CBD and the picture was taken for the evaluation (Fig. 2). After that we made sure of critical view of safety and removed gallbladder. Then, we retrospectively evaluated the delineation of CD and CBD in each intraoperative picture of ICG cholangiography using Image J software (National Institutes of Health, Rockville, MD) and compared the fluorescence intensity between the identified CD or CBD group and the not identified CD or CBD group. Additionally, a correlation between the delineation of CD by ICG cholangiography and MRCP was analyzed.

Surgical complications were evaluated by the Clavien–Dindo classification,[12] and a complication with a score higher than grade III was defined as surgical complication in this study.

2.4. Diagnosis for acute cholecystitis
We adopted the 2013 Tokyo Guidelines (TG13) as the criteria for acute cholecystitis.[13]

2.5. Clinical factors
Clinical factors selected for evaluation were age, gender, surgical complication, bleeding, operation time, hospital stay, with or without stone, with or without acute cholecystitis, with or without conversion, visualization of CBD and preoperative laboratory values (white blood cell [WBC], serum aspartate aminotransferase [AST], serum alanine aminotransferase [ALT], serum total bilirubin [T-Bil], serum alkaline phosphatase [ALP], serum albumin, and serum C-reactive protein [CRP]).

2.6. Statistical analyses
The Chi-squared test was used to evaluate categorical variables, and the unpaired t test was used to evaluate continuous variables. Data are presented as mean ± standard deviation. A probability (P) value of <.05 was considered statistically significant. Statistical analyses were performed using the SPSS statistical software package (version 24; SPSS, Chicago, IL).

3. Results

3.1. Baseline characteristics
Patients comprised 31 men and 34 women, with a median age of 61.34 (range, 32–90) years. Fifty-eight patients (89.2%) were preoperatively diagnosed with gallbladder stones and 7 patients...
(10.8%) with gallbladder polyp or adenomyomatosis. Concomitant diagnosis of CBD stones was made in 16 patients (24.6%). In the patients with gallbladder polyps, 1 (1.5%) was diagnosed with gallbladder cancer through postoperative pathologic examination. Thirty-two patients (49.2%) were diagnosed with acute cholecystitis according to TG13. Seven patients (10.7%) were converted to open surgery. The median operation time was 132.82 (range, 30–255) minutes. There were no surgical complications with scores higher than grade III as per the Clavien–Dindo classification (Table 1). All patients underwent preoperative cholangiography, including MRCP (n=56), and/or endoscopic retrograde cholangiography (n=20).

### 3.2. Delineation of the CD using laparoscopic fluorescence imaging systems

The ICG cholangiography using laparoscopic fluorescence imaging systems showed 54 patients (83.1%) in the identified CD group (Fig. 2) and 11 patients (16.9%) in the not identified CD group (Fig. 3). The mean value of the fluorescence intensity in the identified CD group was 87.6±31.5 arbitrary unit (maximum value 156.2, minimum value 50.2) and that in the not identified CD group was 24.4±10.1 arbitrary unit (maximum value 35.9, minimum value 10.4). Significant difference was found between 2 groups (P<.001). Compared with patients in the identified CD group, those in the not identified CD group had higher WBC counts (P<.001), higher CRP levels (P<.001), longer operation times (P=.018), higher incidence of acute cholecystitis (P<.001), and higher conversion rates (P=.003). Meanwhile, no significant difference was found in the transaminase value and existence of gallbladder stones between the 2 groups. CBD was not identified in 4 patients (6.2%) (Table 2).

### Table 1

| Patients’ characteristics. |
|---------------------------|
| **Baseline characteristics** |
| Number | 65 |
| Age, y | 61.34±15.33 |
| Gender, male:female | 31:34 |
| Gall bladder stone, cases, % | 58, 89.2 |
| Common bile duct stones, cases, % | 16, 24.6 |
| Gall bladder polyp, cases, % | 6, 9.2 |
| Gall bladder cancer, case, % | 1, 1.5 |
| Cholecystitis, cases, % | 32, 49.2 |
| Conversion, cases, % | 7, 10.7 |
| Median operation time, min | 132.82±43.73 |
| Surgical complication, case | 0 |

Data are presented as median ± standard deviation.

---

**Figure 2.** Upper panel was detected by a “white” light source and cystic duct was detected in lower panel by a “near infrared” light source after dissecting Calot triangle.

**Figure 3.** Cystic duct was not detected in lower panel by a “near infrared” light source after dissecting Calot triangle.
3.3. Delineation of the CBD using laparoscopic fluorescence imaging systems

The ICG cholangiography using laparoscopic fluorescence imaging systems showed 61 patients (93.8%) in the identified CBD group and 4 patients (6.2%) in the not identified CBD group. The all cases of the not identified CBD group were included in the not identified CD group. The mean value of the fluorescence intensity in the identified CBD group was 81.99 ± 34.56 arbitrary unit (maximum value 163.3, minimum value 32.4) and that in the not identified CBD group was 15.57 ± 8.18 arbitrary unit (maximum value 24.0, minimum value 9.4). Significant difference was found between the 2 groups (P = .002). Compared with patients in the identified CBD group, those in the not identified CBD group had higher WBC counts (P = .035), higher CRP levels (P = .037), higher incidence of acute cholecystitis (P = .036), and higher conversion rates (P = .009). Meanwhile, no significant difference was found in operation times between the 2 groups (Table 3).

Table 2
The delineation of cystic duct by indocyanine green cholangiography.

|                      | Identified group, 54 cases, 83.1% | Not identified group, 11 cases, 16.9% | P     |
|----------------------|-----------------------------------|--------------------------------------|-------|
| Age, y               | 59.78 ± 15.02                     | 68.73 ± 14.91                       | .076  |
| Fluorescence intensity, arbitrary unit | 87.60 ± 31.50                   | 24.40 ± 10.10                       | <.001 |
| WBC, count/mm³       | 7129 ± 3577                       | 13578 ± 5928                        | <.001 |
| CRP, mg/dL           | 2.69 ± 5.38                       | 12.04 ± 9.49                        | <.001 |
| T-Bil, mg/dL         | 1.46 ± 1.47                       | 2.20 ± 1.37                         | .127  |
| AST, U/L             | 111.07 ± 224.01                   | 211.73 ± 296.73                     | .205  |
| ALT, U/L             | 121.78 ± 237.89                   | 195.82 ± 203.92                     | .340  |
| ALP, U/L             | 323.04 ± 215.32                   | 463.64 ± 279.82                     | .066  |
| Surgical complication, case | 0                               | 0                                   |       |
| Bleeding, mL         | 30.37 ± 111.04                    | 26.18 ± 31.93                       | .902  |
| Operation time, min  | 127.06 ± 40.47                    | 160.91 ± 50.20                      | .018  |
| Hospital stay, d     | 9.76 ± 7.42                       | 10.82 ± 5.62                        | .657  |
| GB stone, yes/no     | 47/7                              | 11/0                                | .096  |
| CBD stone, yes/no    | 12/42                             | 4/7                                 | .321  |
| Acute cholecystitis, yes/no | 21/33                           | 11/0                                | <.001 |
| TG13 severity grade  | Grade I/II/III 17/4/0              | 5/6/0                               | .040  |
| Conversion, yes/no   | 3/5                              | 4/7                                 | .003  |
| Not identified CBD, case | 0                               | 4                                   | <.001 |

Data are presented as median ± standard deviation.
ALP = alkaline phosphatase, ALT = alanine aminotransferase, AST = aspartate aminotransferase, CBD = common bile duct, CRP = C-reactive protein, GB = gallbladder, T-Bil = total bilirubin, TG13 = the 2013 Tokyo Guidelines, WBC = white blood cell.

Table 3
The delineation of common bile duct by indocyanine green cholangiography.

|                      | Identified group, 61 cases, 93.8% | Not identified group, 4 cases, 6.2% | P     |
|----------------------|-----------------------------------|--------------------------------------|-------|
| Age, y               | 60.43 ± 15.17                     | 74.50 ± 11.09                       | .074  |
| Fluorescence intensity, arbitrary unit | 81.99 ± 34.56                   | 15.57 ± 8.18                        | .002  |
| WBC, count/mm³       | 7908 ± 4528                       | 12977 ± 5260                        | .035  |
| CRP, mg/dL           | 3.81 ± 6.55                       | 11.41 ± 12.19                       | .037  |
| T-Bil, mg/dL         | 1.54 ± 1.48                       | 2.15 ± 1.48                         | .429  |
| AST, U/L             | 117.61 ± 218.54                   | 288.25 ± 472.40                     | .168  |
| ALT, U/L             | 129.89 ± 231.38                   | 217.00 ± 273.16                     | .340  |
| ALP, U/L             | 323.04 ± 215.32                   | 463.64 ± 279.82                     | .467  |
| Surgical complication, case | 0                               | 0                                   |       |
| Bleeding, mL         | 28.74 ± 104.56                    | 43.75 ± 48.54                       | .778  |
| Operation time, min  | 130.62 ± 43.82                    | 165.75 ± 29.51                      | .121  |
| Hospital stay, d     | 9.62 ± 7.11                       | 14.76 ± 6.19                        | .165  |
| GB stone, yes/no     | 54/7                              | 4/0                                 | .473  |
| CBD stone, yes/no    | 14/47                             | 2/2                                 | .224  |
| Acute cholecystitis, yes/no | 28/33                           | 4/0                                 | .036  |
| TG13 severity grade  | Grade I/II/III 20/8/0             | 2/2/0                               | .387  |
| Conversion, yes/no   | 5/56                              | 2/2                                 | .009  |
| Identified cystic duct, yes/no | 54/7                            | 0/4                                 | <.001 |

Data are presented as median ± standard deviation.
ALP = alkaline phosphatase, ALT = alanine aminotransferase, AST = aspartate aminotransferase, CBD = common bile duct, CRP = C-reactive protein, GB = gallbladder, T-Bil = total bilirubin, TG13 = the 2013 Tokyo Guidelines, WBC = white blood cell.
3.4. Delineation of CD by MRCP

Among 65 patients, 56 (86.2%) were preoperatively examined using MRCP and analyzed as previously described. Compared with patients in the identified CD group of MRCP, those in the not identified CD group of MRCP had higher WBC counts (P = .005), higher CRP levels (P = .001), higher incidence of gallbladder (GB) stones (P = .037), and higher incidence of acute cholecystitis (P = .009). CBD was detected in all patients (Table 4). A correlation between the delineation of CD by ICG cholangiography and MRCP was analyzed, and it revealed a correlation between each other (P = .002) (Table 5).

4. Discussion

The ICG is a tricarbocyanine dye. Following intravenous injection, it rapidly and completely binds to albumin and is selectively taken up by hepatocytes and excreted into the bile. The ICG shows a bile juice passage, and the inflammatory thickness of the tissue around the gallbladder is directly associated with the difficulty in dissecting the tissue. Therefore, significant correlation was found in the delineation of CD between ICG cholangiography and MRCP (Table 4). The results indicated that inflammation had harmful effects with regard to the passing of CD or CBD and increased the difficulty of the operation. During operation, we have repeatedly performed ICG cholangiography before or after dissection of the Calot triangle. Our presented data showed the strongest intensity of ICG cholangiography during operation. Actually, most of data were obtained after ultrasonography examination.

The ICG shows a bile juice passage, and the inflammatory thickness of the tissue around the gallbladder is directly associated with the difficulty in dissecting the tissue. Therefore, significant correlation was found in the delineation of CD between ICG cholangiography and MRCP (Table 4). The results indicated that inflammation had harmful effects with regard to the passing of CD or CBD and increased the difficulty of the operation. During operation, we have repeatedly performed ICG cholangiography before or after dissection of the Calot triangle. Our presented data showed the strongest intensity of ICG cholangiography during operation. Actually, most of data were obtained after ultrasonography examination. The ICG shows a bile juice passage, and the inflammatory thickness of the tissue around the gallbladder is directly associated with the difficulty in dissecting the tissue. Therefore, significant correlation was found in the delineation of CD between ICG cholangiography and MRCP (Table 4). The results indicated that inflammation had harmful effects with regard to the passing of CD or CBD and increased the difficulty of the operation. During operation, we have repeatedly performed ICG cholangiography before or after dissection of the Calot triangle. Our presented data showed the strongest intensity of ICG cholangiography during operation. Actually, most of data were obtained after ultrasonography examination.

The ICG shows a bile juice passage, and the inflammatory thickness of the tissue around the gallbladder is directly associated with the difficulty in dissecting the tissue. Therefore, significant correlation was found in the delineation of CD between ICG cholangiography and MRCP (Table 4). The results indicated that inflammation had harmful effects with regard to the passing of CD or CBD and increased the difficulty of the operation. During operation, we have repeatedly performed ICG cholangiography before or after dissection of the Calot triangle. Our presented data showed the strongest intensity of ICG cholangiography during operation. Actually, most of data were obtained after ultrasonography examination.

Table 4

| Age, y | 61.03±15.51 | 70.04±12.83 | .241 |
| WBC, count/mm³ | 7469±4555 | 8968±4965 | .524 |
| CRP, mg/dL | 2.28±5.26 | 5.39±10.15 | .341 |
| T-Bil, mg/dL | 1.09±0.57 | 3.04±1.81 | <.001 |
| GB, stone, yes/no | 35/7 | 14/0 | .037 |
| CBD, stone, yes/no | 8/34 | 4/10 | .452 |
| Acute cholecystitis, yes/no | 16/26 | 11/3 | .008 |
| T-Bil, mg/dL | 121.6±306.9 | 242.2±225.7 | .421 |
| ALP, U/L | 267.0±163.7 | 587.2±245.1 | .002 |
| Surgical complication, case | 0 | 0 | .527 |
| Bleeding, ml | 37.90±125.38 | 16.29±27.90 | .527 |
| Operation time, min | 128.93±43.00 | 134.50±45.19 | .680 |
| Hospital stay, d | 10.71±8.12 | 8.79±5.27 | .410 |
| Data are presented as median ± standard deviation. |

Table 5

| Age, y | 61.03±15.51 | 70.04±12.83 | .241 |
| WBC, count/mm³ | 7469±4555 | 8968±4965 | .524 |
| CRP, mg/dL | 2.28±5.26 | 5.39±10.15 | .341 |
| T-Bil, mg/dL | 1.09±0.57 | 3.04±1.81 | <.001 |
| GB, stone, yes/no | 35/7 | 14/0 | .037 |
| CBD, stone, yes/no | 8/34 | 4/10 | .452 |
| Acute cholecystitis, yes/no | 16/26 | 11/3 | .008 |
| T-Bil, mg/dL | 121.6±306.9 | 242.2±225.7 | .421 |
| ALP, U/L | 267.0±163.7 | 587.2±245.1 | .002 |
| Surgical complication, case | 0 | 0 | .527 |
| Bleeding, ml | 37.90±125.38 | 16.29±27.90 | .527 |
| Operation time, min | 128.93±43.00 | 134.50±45.19 | .680 |
| Hospital stay, d | 10.71±8.12 | 8.79±5.27 | .410 |

Data are presented as median ± standard deviation.

ALP = alkaline phosphatase, ALT = alanine aminotransferase, AST = aspartate aminotransferase, CBD = common bile duct, CRP = C-reactive protein, GB = gallbladder, T-Bil = total bilirubin, TG13 = the 2013 Tokyo Guidelines, WBC = white blood cell.

Table 5

| The comparison of the delineation of cystic duct between ICG cholangiography and MRCP. |
|-----------------|--------|--------|--------|
| ICG: identified cystic duct | Yes | No | P |
| MRCP: identified cystic duct | Yes | 44 | 2 | .002 |
| No | 6 | 4 | |

ICG = Indocyanine green, MRCP = Magnetic Resonance Cholangiopancreatography.
identification.\textsuperscript{[19]} Taken together these reports, 2.5 to 10 mg ICG administration just before operation or 10 to 12.5 mg ICG administration on the day before operation were both acceptable dose of ICG and dosing time in ICG.

Thus, if we could identify CD or CBD with ICG cholangiography before dissection of Calot triangle, we might have confi’dently performed LC even in the presence of severe inflammation. In our experience, ICG cholangiography is useful for LC.

Because this study was not a randomized control trial, there was a limitation and we could not demonstrate the safety of LC combined with intraoperative ICG cholangiography compared with normal LC.

5. Conclusion

We might have been able to perform LC with more con’dence, and we had been able to identify CD or CBD with ICG cholangiography.

Inflammation had harmful effects with regard to the passing of CD. If we can identify CD or CBD with ICG cholangiography, we may be able to perform LC with con’dence, even in the presence of severe inflammation.

Acknowledgment

The authors thank Dr M. Shimonosono, Dr H. Shimomura, Dr M. Wada, Dr K. Minamimagari, and Dr Y. Tsuruta as LC operators.

Author contributions

Conceptualization: Kiyokazu Hiwatashi, Hiroshi Okumura, Tetsuro Setoyama, Yoshito Ogura, Kunia ki Aridome, Shigeho Maenohara, Shoji Natsugoe.

Formal analysis: Kiyokazu Hiwatashi.

Investigation: Kiyokazu Hiwatashi, Tetsuro Setoyama, Kei Ando.

Methodology: Kiyokazu Hiwatashi, Hiroshi Okumura.

Project administration: Shigeho Maenohara.

Supervision: Hiroshi Okumura.

Writing - original draft: Kiyokazu Hiwatashi.

Writing - review & editing: Kiyokazu Hiwatashi, Hiroshi Okumura.

References

[1] Ishizawa T, Bandai Y, Iijichi M, et al. Fluorescent cholangiography illuminating the biliary tree during laparoscopic cholecystectomy. Br J Surg 2010;97:1369-77.
[2] Kubota K, Kita J, Shimoda M, et al. Intraoperative assessment of reconstructed vessels in living-donor liver transplantation, using a novel fluorescence imaging technique. J Hepatobiliary Pancreat Surg 2006;13:100-4.
[3] Saito T, Yano M, Motoono M, et al. Subtotal gastrectomy for gastric tube cancer after esophagectomy: a safe procedure preserving the proximal part of gastric tube based on intraoperative ICG blood flow evaluation. J Surg Oncol 2012;106:107-10.
[4] Raabe A, Beck J, Gerlach R, et al. Near-infrared indocyanine green video angiography: a new method for intraoperative assessment of vascular flow. Neurosurgery 2003;52:132-9.
[5] Ohdaira H, Nimura H, Mitsu smori N, et al. Validity of modi’ed gastrectomy combined with sentinel node navigation surgery for early gastric cancer. Gastric Cancer 2007;10:117-22.
[6] Gotoko K, Yamada T, Ishikawa O, et al. A novel image-guided surgery of hepatocellular carcinoma by indocyanine green fluorescence imaging navigation. J Surg Oncol 2009;100:75-9.
[7] Mitsuhashi N, Kimura F, Shimizu H, et al. Usefulness of intraoperative fluorescence imaging to evaluate local anatomy in hepatobiliary surgery. J Hepatobiliary Pancreat Surg 2008;15:508-14.
[8] Tagaya N, Shimoda M, Kato M, et al. Intraoperative exploration of biliary anatomy using fluorescence imaging of indocyanine green in experimental and clinical cholecystectomies. J Hepatobiliary Pancreat Sci 2010;17:595-600.
[9] Aoki T, Murakami M, Yasuda D, et al. Intraoperative fluorescent imaging using indocyanine green for liver mapping and cholangiography. J Hepatobiliary Pancreat Sci 2010;17:590-4.
[10] Schols RM, Connell NJ, Stassen LP. Near-infrared fluorescence imaging for real-time intraoperative anatomical guidance in minimally invasive surgery: a systematic review of the literature. World J Surg 2015;39:1069-79.
[11] Vlek SL, van Dam DA, Rubinstein SM, et al. Biliary tract visualization using near-infrared imaging with indocyanine green during laparoscopic cholecystectomy: results of a systematic review. Surg Endosc 2017;31:2731-42.
[12] Dindo D, Demartines N, Clavien PA. Classiﬁcation of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205-13.
[13] Yokoe M, Takada T, Strasberg SM, et al. Tokyo Guidelines Revision Committee. New diagnostic criteria and severity assessment of acute cholecystitis in revised Tokyo Guidelines. J Hepatobiliary Pancreat Sci 2012;19:578-85.
[14] Cherrick GR, Stein SW, Levy CM, et al. Indocyanine green: observations on its physical properties, plasma decay, and hepatic extraction. J Clin Invest 1960;39:592-600.
[15] Lsandman ML, Kwant G, Mood G, et al. Light-absorbing properties, stability, and spectral stabilization of indocyanine green. J Appl Physiol 1976;40:575-83.
[16] Kono Y, Ishizawa T, Tani K, et al. Techniques of fluorescence cholangiography during laparoscopic cholecystectomy for better delineation of the bile duct anatomy. Medicine (Baltimore) 2015;94:e1003.
[17] Booger LSF, Handgraaf HJM, Huurman VAl, et al. The best approach for laparoscopic fluorescence cholangiography: overview of the literature and optimization of dose and dosing time. Surg Innov 2017;24:386–96.
[18] Zarrinpard A, Dutton EP, Mobley C, et al. Intraoperative laparoscopic near-infrared fluorescence cholangiography to facilitate anatomical identification: when to give indocyanine green and how much. Surg Innov 2016;23:360–5.