Indocyanine green fluorescence: A surgeon’s tool for the surgical approach of gallstone ileus

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Abstract
Fluorescence cholangiography has been shown to improve biliary anatomy identification. A case of 60-year-old man with intestinal obstruction is reported, an entero-biliary fistula is suspected, and intravenous application of indocyanine green is decided, despite the great inflammatory process and fibrotic tissues found during the procedure, safe open cholecystectomy was achieved.

KEYWORDS
cholecystectomy, fluorescence cholangiography, gallstones, indocyanine green

1 | INTRODUCTION

Gallstone ileus is a mechanical obstruction secondary with one or more biliary stones in the small bowel or any part of the gastrointestinal tract; the stone passes through a biliary tract’s fistula.1 This stone obstructs the distal ileum and the ileocecal valve in 50%–75% of the occasions, and just 4% obstructs the outlet gastric tract.2

On the contrary, the indocyanine green is an iodized compound.3,4 It has been used in different applications since 1950, and it was approved by Food and Drug Administration (FDA) for human use until 1956. As its clearance is hepatic, it allows to effectively visualize, using fluorescence systems, the entire biliary anatomy, thus achieving intraoperative fluorescence cholangiography,3,5 avoiding the canalization of the cystic duct, and reducing the common bile duct injury.6

We present a case of a gallstone ileus patient, where we describe the application of the indocyanine green fluorescence that could help reduce common bile duct injuries and improve the therapeutic of these patients.

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2 | CASE PRESENTATION

A 60-year-old man, without any past medical history, arrives in our institution with intestinal obstruction. After the initial treatment for abdominal pain (Figure 1), it was ordered an abdominal computed tomography (CT) where it was observed intestinal dilatation, transition zone in the distal ileum, and pneumobilia suggestive images with extrahepatic duct dilatation (Figure 2).

In surgery, was found the obstruction by a biliary stone at 60 cm of the ileocecal valve (Figure 3) and an inflammatory mass with the gallbladder, hepatic angle of the colon, and duodenum in it, identifying a cholecystic-duodenal fistula and a peri-vesicular abscess.

After the extraction of the stone performing an enterotomy, a laparoscopic cholecystectomy was performed, previous 1.5 cc intravenous application of indocyanine green, with which the cystic duct, common hepatic duct, and common bile duct were properly identified, achieving a safe dissection of the structures of the hepatocystic triangle despite the great inflammatory process and fibrotic tissues, and avoiding common bile duct injuries (Figure 4).

3 | DISCUSSION

One of the proposed mechanisms for gallstone disease is a biliary tract’s fistula secondary to multiple gallbladder inflammatory events and an impacted stone; this generates an important inflammatory process; therefore, there is no consensus in the literature which is the best therapeutic approach. A laparotomy with just an enterotomy with stone extraction could generate gallstone ileus recurrences and cholangitis in 33% and 60%, and biliary symptoms up to 10%. That’s why a second approach is to perform a cholecystectomy at the same time or in two steps with similar mortality when we adjust a patient’s comorbidities is one or two steps procedure.
In 2014, a retrospective review was published considering national databases from the United States, where 3268 cases of gallstone ileus were collected. They found that the fistula’s correction is an independent risk factor for mortality, with complications including common bile duct injuries.\cite{11}

To minimize the common bile duct injuries, there are multiple strategies to perform a safe cholecystectomy which are the critical view of safety, intraoperative cholangiography, proposed steps for safe cholecystectomy by different societies, and recently, the use of intraoperative fluorescence cholangiography with indocyanine green. As its clearance is hepatic, it allows to effectively visualize, using fluorescence systems, the entire biliary anatomy and reduce complications.\cite{3,5}

In a recent meta-analysis, which included 481 patients, the ability to visualize extrahepatic biliary tree structures of usual intraoperative cholangiography was compared to indocyanine green fluorescence cholangiography. They found that fluorescence provided equal visualization of the cystic duct and the junction of the cystic duct with the common hepatic duct when compared with the usual intraoperative cholangiography. However, better visualization of the common hepatic duct was obtained with fluorescence and avoided the canalization of the cystic duct.\cite{12}

Additionally, a meta-analysis was published with studies since 2013, which included a total of 1603 laparoscopic or robotic cholecystectomies with the assistance of fluorescence cholangiography and 5070 patients taken to laparoscopic or robotic cholecystectomy with non-fluorescence cholangiography. A lower rate of common bile duct injuries and conversion to open surgery was found with the fluorescence cholangiography, 6 and 16/10,000, vs. 25 and 271/10,000 with non-fluorescence cholangiography.\cite{13}

Although larger comparative studies are required, preliminary analyses seem to indicate that intraoperative fluorescence cholangiography with indocyanine green markedly decreases the rate of common bile duct injury.\cite{13}

Taking into consideration the risk of common bile duct injuries and the risk of recurrences, but a patient without comorbidities, we decided to perform an open cholecystectomy using fluorescence cholangiography. It was possible to properly identify the common bile duct and the cystic duct to generate an adequate critical view of safety and prevent common bile duct injuries despite the severe inflammatory process. Large studies are needed to

**FIGURE 3** Transition zone generated by gallstone

**FIGURE 4** (A) Repaired cystic duct is observed, without properly identifying the different structures of the bile duct. (B and C) The extrahepatic bile duct is observed in the different light spectra
demonstrate the benefits of using fluorescence cholangiography that could change the therapeutic in the gallstone disease, and although fluorescence does not replace all the basic principles of a safe cholecystectomy, it does become an important tool to increase the safety of the procedure not only in gallstone disease patients but also in other difficult situations where we can find severe inflammatory processes.

4 CONCLUSIONS

The application of indocyanine green fluorescent could be a useful tool during the surgical management of biliary fistulas and gallstones, focused on improving the visualization of structures and decreasing the risk of injury.

AUTHOR CONTRIBUTIONS
All authors contributed to the design of this manuscript. LAN and LFCV wrote the first draft. IDLM, DGC, and MC edited and reviewed the final manuscript. MP and ANR scientifically reviewed the article.

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CONFLICT OF INTEREST
The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT
Data are available on request from the authors.

ETHICAL APPROVAL
The authors have confirmed during submission that patient consent has been signed and collected in accordance with the journal’s patient consent policy.

CONSENT
Written informed consent was obtained from the patient to publish this record in accordance with the journal’s patient consent policy.

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