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CASE REPORT

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Diagnostic laparoscopy with indocyanine green fluorescence test for the evaluation of intestinal perfusion in abdominal blunt injury: a case report

Ze-Rui Li[1], Yi-Chiao Cheng[2] and Zhi-Jie Hong[3*]

Abstract

Background The indocyanine green (ICG) fluorescence test has become a standard test in surgical procedures, facilitating the assessment of blood perfusion in real-time. While its utility in emergency surgeries for evaluating anastomotic blood supply is well-established, its application in trauma cases, especially those involving mesenteric hematoma, remains underexplored. Herein, we present a case to illustrate the efficacy of the ICG fluorescence test in such scenarios.

Case presentation A 51-year-old man with uncontrolled hypertension suffered blunt abdominal trauma following a motor vehicle accident. We used the intra-operative ICG fluorescence test to chart the surgical plan for the patient. A combination of diagnostic laparoscopy with ICG fluorescence testing effectively excluded bowel ischemia, leading to the avoidance of intestinal resection and the need for a temporary ostomy. The patient resumed enteral nutrition.

Conclusions Our case underscores the efficacy of ICG fluorescence testing in assessing bowel viability and guiding surgical strategies in trauma patients with mesenteric hematoma. By facilitating real-time visualization of blood perfusion, ICG testing enables the adoption of conservative treatments in patients who would traditionally require more invasive surgical interventions, with minimal effect on operation time and cost.

Keywords Indocyanine green (ICG) fluorescence test, Intestinal blood perfusion, Mesenteric hematoma, Abdominal blunt injury

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Background

Assessment of blood perfusion using the indocyanine green (ICG) fluorescence test has progressively become standard practice in surgical procedures [1–3], with increasing application in decision-making in emergency surgeries, where evaluation of blood perfusion and structural conditions is crucial [4–7].

There are numerous case reports on the utility of this test for the evaluation of intestinal blood perfusion and anastomotic blood supply during emergency surgeries [8, 9]. Available reports on trauma-related cases primarily focus on intestinal injuries caused by laceration or perforation [8, 10, 11], with limited documentation of mesenteric hematoma. We present a case of mesenteric hematoma resulting from blunt abdominal trauma caused by a traffic accident. Diagnostic laparoscopy in conjunction with ICG fluorescence testing helped to effectively rule out bowel ischemia, leading to the avoidance of intestinal resection and the need for a temporary ostomy. The patient subsequently had a smooth course of recovery with restoration of enteral nutrition.

Case presentation

A 51-year-old man with a history of uncontrolled hypertension was referred to our emergency department after being struck by a motorcycle following alcohol consumption. The patient exhibited altered consciousness with hypotension. Non-contrast-enhanced computed tomography (CT) of the brain and contrast-enhanced CT of the abdomen and chest were performed after the primary examination, which included focused assessment with sonography in trauma and stabilization of vital signs with endotracheal intubation and fluid resuscitation. Abdominal CT revealed left hemoretroperitoneum, primarily in the left anterior pararenal space, and minimal hemoperitoneum (Fig. 1). Additionally, mild hyperdensity in the vicinity of the infrarenal abdominal aorta and a fracture of the left 11th rib were noted.

The laboratory investigations were unremarkable, except for the following: aspartate aminotransferase, 101 (normal level: <40) U/L; alanine aminotransferase, 43 (normal level: <41) U/L; creatinine kinase, 344 (normal range: 39–308) U/L, lactate 4.4 (normal range: 0.5–2.2) mmol/L; ethyl alcohol, 429.30 (normal level: <50.00) mg/dL; and C-reactive protein, 18.09 (normal level: <0.8) mg/dL. Venous blood gas analysis revealed pH 7.234 (normal

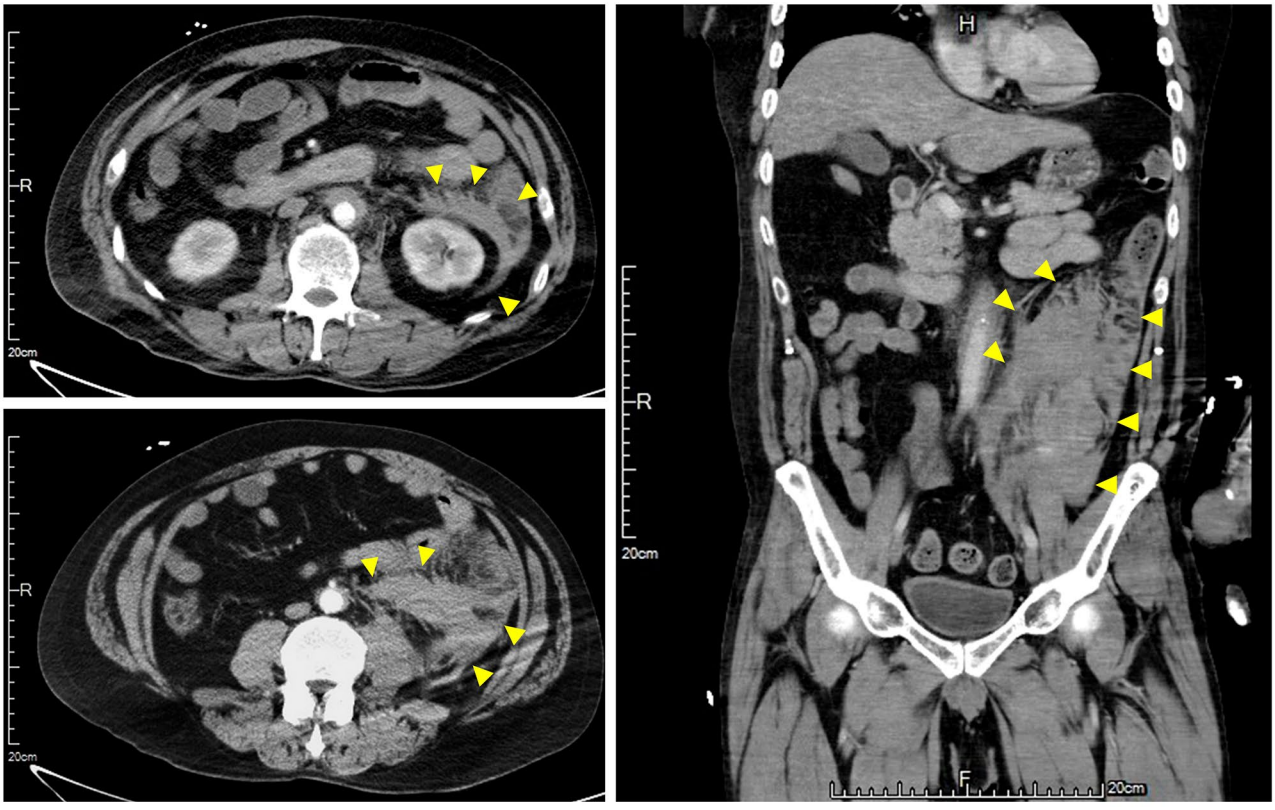

Fig. 1 Contrast-enhanced computed tomography (CT) of the upper left and lower left abdomen. Left: axial view; right: coronal view. Left hemoretroperitoneum (mainly in the left anterior pararenal space; yellow arrowheads) and minimal hemoperitoneum were observed without definite evidence of contrast extravasation

range: 7.315–7.430), $PvCO_2$ 49.9 (normal range: 38.0–49.0) mmHg, sodium bicarbonate 20.6 (normal range: 22.0–27.0) mmol/L, and base excess (extracellular fluid) 6.9 mmol/L.

The blood pressure of the patient remained low (87/65 mmHg) after initial resuscitation. We suspected hemorrhagic shock refractory to conservative treatment; therefore, the patient was subsequently transferred to the operating room for emergency surgery.

Post exclusion of traumatic aortic dissection/rupture using aortography by a cardiovascular surgeon, diagnostic laparoscopy was performed by a trauma surgeon. Bloody fluid accumulation over the pelvic cavity and left paracolic gutter was observed, with no active bleeding or organ perforation. Additionally, hematomas were noted in the left mesocolon and descending colon (Fig. 2), which necessitated consultation with a colorectal surgeon for bowel resection and temporary stoma for suspected bowel ischemia.

To further evaluate intestinal blood perfusion and bowel viability, 5 mg of ICG (DIAGNOGREEN INJ. 25MG; Daiichi Sankyo Co., Tokyo, Japan) diluted in 5 mL of water was intravenously injected to perform an ICG fluorescence test. Under the ICG scope, excellent blood supply to the transverse, descending, sigmoid colon, and rectum was observed (Fig. 3). The descending colon was viable, and consequently, neither colon resection nor ostomy was performed.

Post combined surgery, the patient was admitted to the intensive care unit for further care, with gradual resumption of nasogastric tube usage. An abdominal CT was performed again on postoperative day (POD) 4; it revealed a regressive change in the hemoretroperitoneum as compared to the findings in the previous imaging study (Figs. 1 and 4).

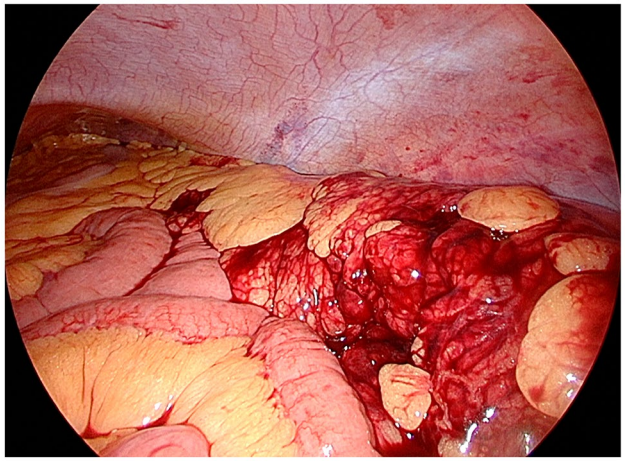

Fig. 2 Ecchymosis of the mesentery of the descending colon observed under laparoscopy

The patient was discharged on POD 26 without observation of any sequelae during subsequent outpatient follow-up visits.

Discussion and conclusions

ICG is a water-soluble tricarbocyanine dye that strongly interacts with high-density lipoproteins and moderately with low-density lipoproteins, resulting in minimal uptake by tissues other than blood after intravenous administration [12]. ICG exhibits minimal adverse reactions when administered at doses below 0.5 mg/kg. Moreover, its rapid clearance, with a short half-life of 3–5 min [13], predominantly through bile excretion [14—16], contributes to its exceptional safety profile, with no concerns regarding residual presence. Additionally, the process of ICG injection for contrast imaging is brief and does not significantly prolong overall surgical time [17].

ICG is characterized by its ability to penetrate tissues and absorb light of wavelengths in the near-infrared spectrum of 800–810 nm, enabling real-time visualization of blood perfusion. Thus, the ICG fluorescence test is particularly valuable in situations where traditional visual or tactile assessments of tissue integrity and blood circulation are challenging. These scenarios include mesenteric ischemia, intestinal anastomosis, and traumatic injuries, where bowel viability may have a critical effect on surgical planning.

The application of ICG in trauma surgery includes intra-operative localization/anatomical structure identification, tissue perfusion assessment, and intestinal or vascular anastomotic leak detection [18, 19]. Intra-operative localization/anatomical structure identification involves the identification of the cystic duct, ureters [20], nerves, blood vessels, and thoracic duct to avoid inadvertent injury to these structures during surgery [19]. Tissue perfusion assessment aids confirmation of the location of intestinal bleeding [21, 22], assessment of ischemia or inadequate perfusion at anastomotic sites [10, 11], and determination of the need for additional bowel resection or protective ostomy to prevent anastomotic leakage due to poor healing [8].

Systematic reviews and meta-analyses have demonstrated that the application of the ICG fluorescence test to determine resection margins and assess anastomotic perfusion effectively reduces the incidence of leakage and associated complications, including fistula formation, re-operation, permanent stoma, gastrointestinal dysfunction, wound-related complications, intestinal strictures, poor quality of life, and mortality [18].

Arezzo et al. [23] have reported the effective reduction of risk of anastomotic leakage, regardless of sex, age, body mass index (BMI), or distance from the tumor to the anal border, using intra-operative assessment of rectal tumor

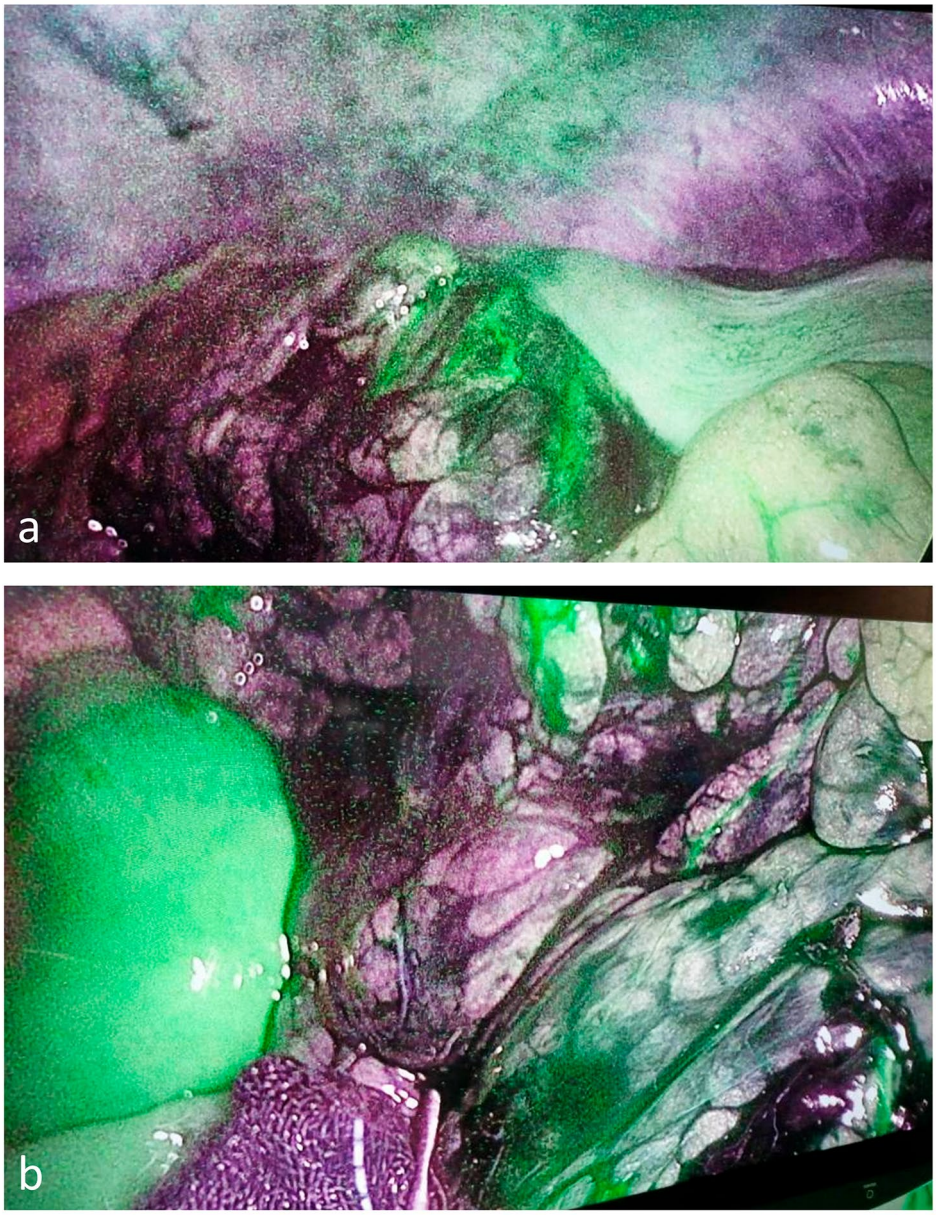

Fig. 3 Laparoscopic view with ICG scope post administration of intravenous ICG. Good blood supply of the descending colon (a) and mesenteric ecchymosis of the descending colon (b) was evident

surgical anastomotic perfusion through ICG imaging. Degett et al. [24] and Campbell et al. [25] have published systematic reviews and meta-analyses on the use of ICG in gastrointestinal surgeries, including assessment of blood perfusion at esophageal and colorectal anastomotic sites. In these studies, the anastomotic leakage rates were found to be reduced from 8.5 to 3.3% and from 20 to 0%, respectively. Despite negative reviews from a few studies, which have reported no significant differences after post-ICG use [26], it is worth noting that the added surgical time and cost of this technique are minimal.

Fransvea et al. [9] conducted a systematic literature review and concluded that surgical approaches were changed in 36% of patients with intestinal ischemia who underwent ICG fluorescence testing. Among these, a more conservative treatment strategy was adopted in 21.6% of cases, resulting in substantial clinical benefits in 11% of patients. These included a reduction in the length of the resected intestine and a decrease in surgery-related complications. A comparison between visual inspection and ICG findings revealed discordance in 35% of judgments, which aligned closely with the aforementioned 36% of patients for whom surgical approaches were modified.

ICG has also been widely used in patients with trauma to assess intestine and solid organ viability and tissue

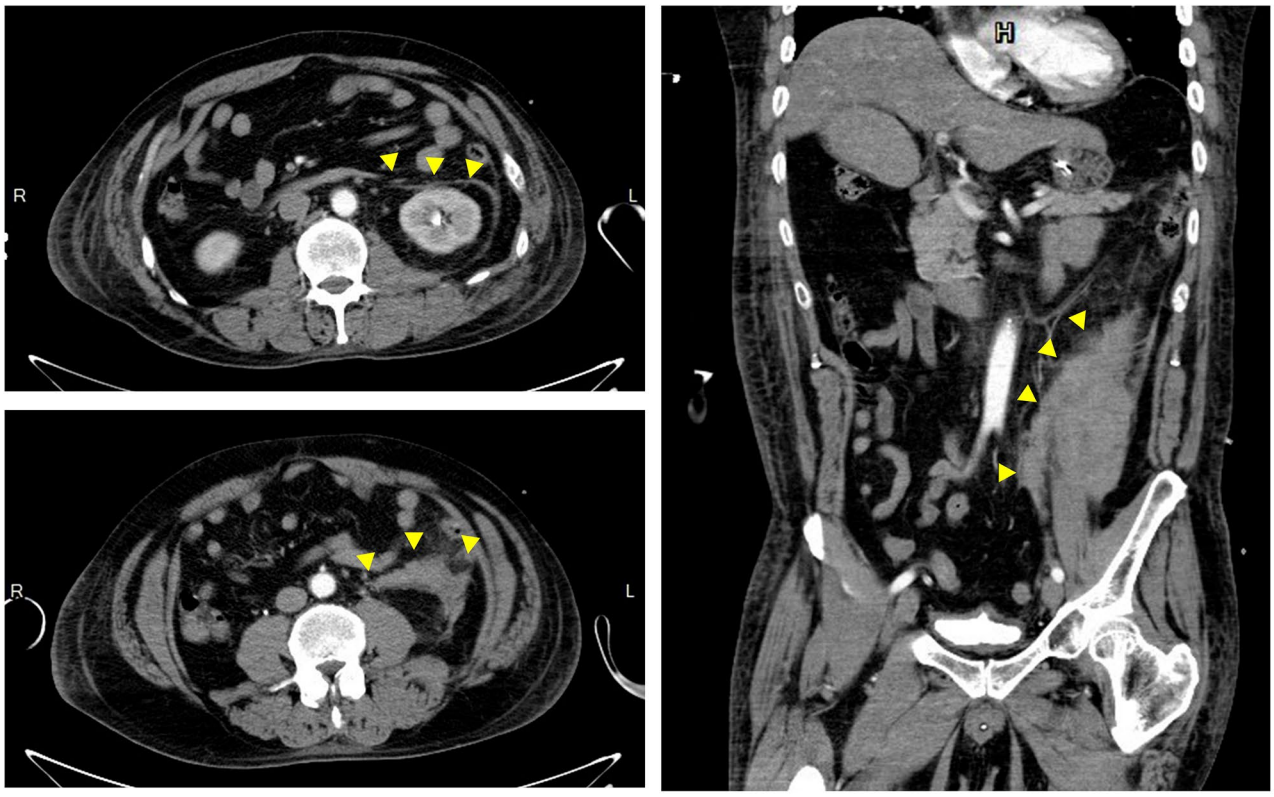

Fig. 4 Repeat contrast-enhanced CT of the abdomen on POD 4. Regressive change was noted in comparison to findings in the prior CT (Fig. 1): yellow arrowheads

ischemic damage in the head, face, and limbs. Surgical plans were modified in 23.9% of cases as a direct consequence of ICG fluorescence test results [9]. These included changes in the surgical field and, in some instances, a shift toward more conservative treatments that led to the avoidance of organ or intestinal resections. Cumulatively, these findings underscore the relevance of ICG fluorescence testing in guiding surgical decisions.

Our case was complicated by the fact that hematomas in the mesentery and serosa hampered visual observation of external appearances, peristalsis, and palpation, rendering determination of the viability of the intestine difficult. Therefore, we employed the ICG fluorescence test to determine bowel viability from the mesocolonic hematoma, and the visible fluorescence in mesentery and mesocolon under ICG scope vision indicated excellent blood supply to the descending colon (Fig. 3). This led to the revision of our final surgical plan and avoidance of bowel resection.

A case was previously presented at the 2016 Canadian Surgery Forum [27] with features similar to our case, which involved a 45-year-old female in a motor vehicle accident who suffered abdominal blunt trauma resulting in intra-abdominal bleeding and mesenteric hematoma of the small intestine. The patient underwent ICG angiography intra-operatively on account of the significant size of the hematoma, which revealed ischemia of the small intestine that necessitated small bowel resection.

According to the guidelines set by the American College of Radiology (ACR) [28], CT angiography (CTA) is the preferred diagnostic tool when acute bowel ischemia is suspected. CTA is favored for its speed, accuracy, and noninvasive nature. It is also highly accurate in grading the degree of arterial stenosis when compared to other imaging modalities, such as digital subtraction angiography, ultrasound (US), and magnetic resonance angiography, with reported sensitivity and specificity rates as high as 93–100%. Thus, "CTA of the abdomen and pelvis with IV contrast" is deemed "Usually Appropriate" for suspected acute mesenteric ischemia.

Our team's literature review yielded no head-to-head studies comparing the diagnostic accuracy of intraoperative ICG with preoperative CT. Given the scarcity of case reports involving intraoperative ICG, it is expected that comparative diagnostic studies are also lacking.

Among the numerous published cases on the intraoperative utilization of the ICG fluorescence test, we believe ours is the first on the usage of ICG to assess the possibility of colonic ischemia due to colonic mesenteric

hematoma and to demonstrate successful conservative treatment. The ICG fluorescence test does not alter the overall need and indications for damage control surgery in acute care settings, especially in light of the current lacuna in large controlled studies for more robust evidence [9]. However, the success of our case highlights the usefulness of evaluation of intestinal blood perfusion during diagnostic laparoscopy for abdominal blunt injury with potentially threatened blood supply to the mesentery of the colon.

Abbreviations

ICG	Indocyanine green
CT	Computed tomography
POD	Postoperative day
BMI	Body mass index

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Author contributions
All authors contributed to data curation. The study concept and methodology were outlined by ZJH and YCC. Formal analysis and data interpretation were performed by YCC and ZRL. The first and subsequent drafts of the manuscript were written by ZRL and YCC. The study was supervised by YCC and ZJH. All authors reviewed the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The protocol was approved by the Tri-Service General Hospital Institutional Review Board. Written informed consent was obtained from all participants and from a parent and/or legal guardian.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Competing interests
The authors declare no competing interests.

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