



What is the added value of intraoperative indocyanine-green in right colectomy for cancer?

Simona Macina, Luigi Boni, Massimiliano Della Porta, Ludovica Baldari, Elisa Cassinotti

Department of General Surgery, University of Milan, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy

Correspondence to: Simona Macina. Department of General Surgery, University of Milan, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Via F. Sforza, 28 20122 Milan, Italy. Email: simona.macina@gmail.com.

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Introduction

Indocyanine-green (ICG) fluorescence imaging is an emerging technology utilized for intraoperative decision-making. In the last few years, the use of fluorescence to enhance visualization during open and laparoscopic surgery has been widely investigated in different surgical procedures. When the ICG is injected intravenously, it binds the plasmatic lipoproteins and gives information on the organ's perfusion and vascular anatomy; when injected directly into the tissue, it follows the lymphatic drainage helping the surgeon to identify the lymphatic pathway. So, the possible use of ICG during right hemicolectomy are different: perfusion control, identification of embryological planes and control of lymphatic drainage.

Perfusion control

Regardless improvement in laparoscopic skills and the surgical techniques, anastomotic leak rate in colorectal surgery might varies between 3% and 20% (1). Several factors might influence the good healing of gastrointestinal anastomosis but, among them, several studies demonstrated that adequate blood supply is essential (2). Although several techniques have been proposed, bowel perfusion is usually done by surgeons' subjective evaluation of the color of the serosa or the pulsation of marginal arteries (3). Fluorescence angiography, performed by injecting few cc of a well-known fluorophore called ICG allow to perform a real time, intraoperative angiography that confirm or not the perfusion of the segment of bowel to be anastomosed (4).

The operative protocol might vary according to surgeons' preferences but in general, once completed

the colectomy, just before fashioning the anastomosis, intravenous injection of 3 mL diluted ICG at a concentration of 0.2 mg/kg is carried out and, usually after 20–30 seconds (depending from the patient's blood pressure and cardiac output) switching the camera to a near-infra-red (NIR) light, fluorescent perfusion of the bowel is confirmed and the exact colic margins where a good blood supply is present can be precisely estimated. Although most of the published studies focused on left hemicolectomy and rectal resection all demonstrated the usefulness of this technique with a percentage of change in resection margin around 5–7% as well reduction in the overall leak rate (5,6).

Identification of embryological planes

Recently, a new concept of the mesentery as a separate "organ" with its own lymphatic and a vascular watershed area has been introduced by Keller *et al.* (7). This anatomical concept has its surgical contra part with the complete mesocolic excision (CME) as treatment for right colon cancer proposed by Hohenberger *et al.* (8). Nevertheless, the routine used of CME is controversial as well as technically demanding. Recently Keller *et al.* (7) proposed the use of fluorescence to enhance the identification of the mesenteric plane by injecting 1 mL of ICG (concentration 5 mg/10 mL) into the subserosa layer of the colon waiting for ICG to spread into the mesentery to help surgeons to define the embryological planes. This concept has been also investigated in gastric cancer where endoscopic injection of ICG the day before surgery can help during the lymphadenectomy to define the mesogastric area. While in gastric cancer surgery results seems promising (9), in

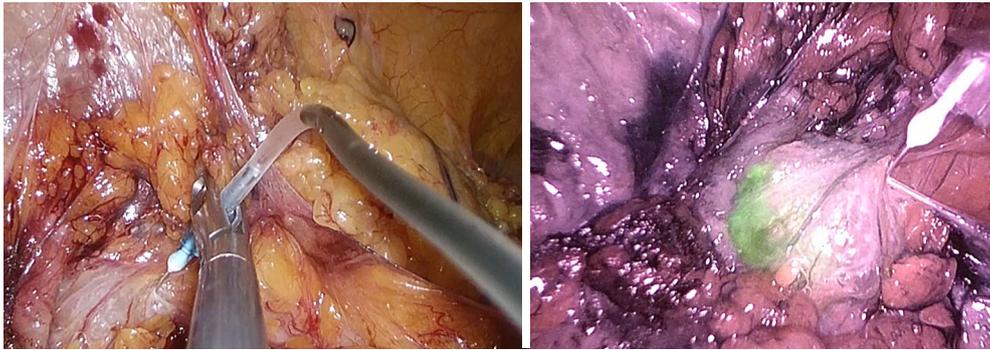


Figure 1 The figure shows the intraoperative injection of ICG in subserosal layer during right hemicolectomy. ICG, indocyanine-green.



Figure 2 The figure shows the identification of the lymphatic route and the lymph nodes along the ileo-colic vessels.

colorectal surgery this is still experimental.

Control of lymphatic drainage

Opposite to the concept of CME, especially in case of early stage cancers (T1-2) where lymph node metastases are less frequent, lymphatic mapping/drainage of the area around the tumor can also be evaluated using intra-operative laparoscopic or endoscopic injection of ICG. After few minutes from the injection, ICG will be drained by the local lymphatic defining fluorescent lymphatic route and the lymphatic “basin” for this specific tumor/patient.

This technique has been proposed also in case of early gastric cancer with extremely interesting preliminary results (9) to perform a “selective” rather than an extensive and complex lymphadenectomy (10).

In colorectal surgery the “lymphatic basin” theory should be considered as in its infancy and to be used in course of clinical trial to prove its oncological value. In this case, at the beginning of the procedure, the tumor is localized

and minimal mobilization of the colon is performed. At this point, using a fine needle 3 cc of ICG are injected in subserosal layer, paying attention to avoid accidentally spillage of the fluorophore. After few minutes by switching to NIR light the lymphatics as well as the lymph nodes, draining from that area will become evident allowing to identify the lymphatic route and, in theory, to customize the lymphadenectomy (Figures 1,2).

Discussion

This paper highlights that ICG fluorescent use has possible applications in general surgery procedures and in particular during right hemicolectomy: control of tissue perfusion and vascular anatomy and evaluation of lymphatic draining pathway. Fluorescence-guided surgery is an innovative way of integration between surgery and images, providing better surgical and oncological results.

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