



Robotic excision of a colonic neoplasm with ICG as a tumor localizer and colonoscopic assistance

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Introduction

Laparoscopic-assisted polypectomy was introduced in the early 1990s, primarily as a method to monitor the safe endoscopic removal of neoplasia when the risk for perforation exists, or to facilitate endoscopic access by mobilizing the colon laparoscopically [1–6]. Endoscopic full-thickness excision has also been described with laparoscopic assistance [7], but such techniques have been poorly photo-documented in the published literature and have not been well-described utilizing robotic platforms. The da Vinci Robotic Surgical System (Intuitive Surgical, Inc, Sunnyvale, CA, USA) has the advantage of improved surgeon-endoscopist cooperativity due to TilePro [8–10]—a viewing system similar to picture-in-picture which allows the operator to maintain a direct video input from the colonoscopic camera.

Part of the challenge of laparoscopic or robotic assisted polypectomy is the requirement for the lesion to be accurately localized. Due to its translucent properties when viewed within the near infrared spectrum [11], indocyanine green (ICG) can be used as a tumor localizer [12–16]. In this report, the detailed technique of robotic-assisted polypectomy with TilePro and hybrid colonoscopic assistance is demonstrated using ICG for target localization.

Case details

In this clinical vignette, a 56-year-old female with a body mass index of 36.2 kg/m² was found to have a bulky 4.0 cm tubular adenoma in the transverse colon. It was on a very broad stalk

and was deemed too high risk for endoscopic excision. The patient was, therefore, referred for surgical resection after India ink tattooing of the lesion (the regional hospital does not have advanced endoscopic capabilities). Operating time was 57 min, there were no intraoperative or perioperative complications, and the patient was discharged on postoperative day 1. Final pathology revealed a tubulovillous adenoma and the excision margins were negative. At 6-week follow-up, the patient's postoperative course was unremarkable. The technical steps of excision are detailed in the following section, and can also be found in the supplemental multimedia content available online.

Technical steps

The patient is positioned in modified lithotomy (Lloyd-Davies) position in preparation for combined colonoscopic and robotic access into the abdominal cavity. Mechanical bowel preparation is given on the day before surgery, and colonoscopy is performed, to localize the lesion, immediately prior to obtaining abdominal access. The colonoscope is then left in situ, and the video image is projected onto the da Vinci Xi operating console. ICG is reconstituted in aqueous solution and 1–2 ml are injected into the submucosal plane in close proximity to the neoplasm, allowing ICG to be used as a target localizer (Fig. 1). Due to its quantum yield, half-life, and other biochemical properties [17], ICG should be administered immediately prior to surgery to insure adequate fluorescence imaging.

Upon establishing pneumoperitoneum and introducing a laparoscopic camera capable of near infrared imaging (Stryker Camera 1588 System, Stryker, Inc., Kalamazoo, MI, USA) the lesion, which is often not easily visualized with white light video, can be localized in near infrared (NIR) mode when the lesion has been injected with ICG (Fig. 2a, b). It is at a point after localization that robotic trocars are introduced and optimally directed toward the target lesion. When permissible, reduced port robotic dissection can be performed to limit per-case operation cost [18].

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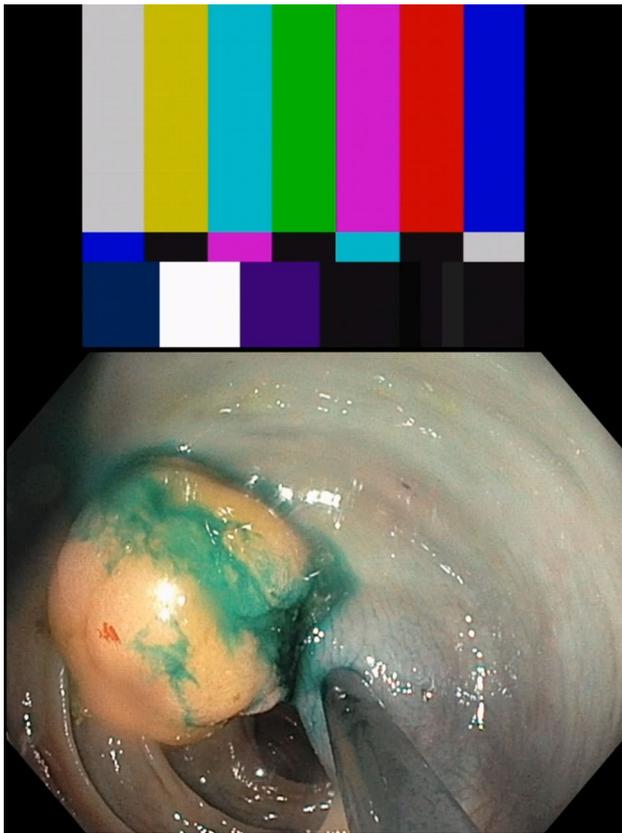


Fig. 1 Although the target lesion has been previously localized with India ink submucosal tattooing, colonoscopy is repeated immediately prior to operation and the lesion is marked, this time with an injection of 2 ml ICG for improved localization during robotic polypectomy. The video image is projected onto the surgeon's da Vinci Xi surgical console via TilePro. When the robotic cart is docked, and the robotic camera activated, the surgeon will be able to view both video inputs simultaneously which will allow for improved cooperativity between surgeon and endoscopist

Next, the now visible target is approached robotically, and omentum or other structures are mobilized to expose the target segment of bowel containing the neoplasm, which can be simultaneously viewed endoscopically at the surgeon console via TilePro (Fig. 3). Next, with direct endoscopic control (operated by a bedside assistant), the robotic surgeon can perform a colotomy and perform the polypectomy (Fig. 4). If the polyp is mobile, it can be delivered outside the lumen for extra-luminal robotic resection (Fig. 5). TilePro allows the surgeon to visualize this step from the perspective of the lumen and simultaneously from the abdominal cavity. The polypectomy can be carried out using scissor tip dissection for improved precision. Upon completion of the robotic polypectomy, the colonoscope is escorted through the colotomy in preparation for specimen retrieval (Fig. 6), which can be facilitated with the aid of a Roth Net (Fig. 7). The scope is withdrawn transanally, and the specimen is retrieved without the need for increased abdominal wall access trauma.

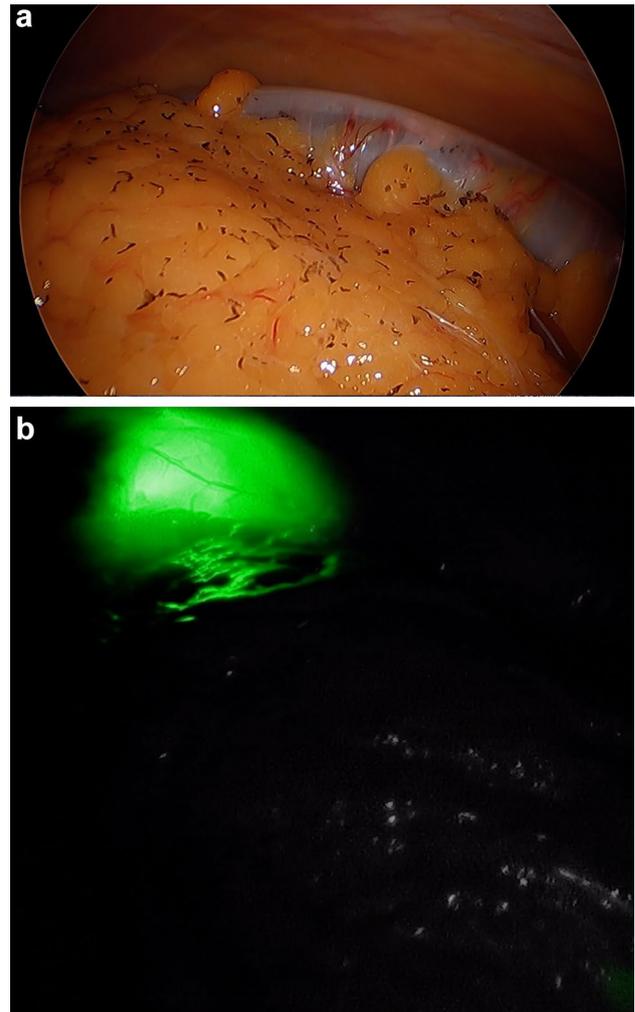


Fig. 2 **a** White light image of the abdominal cavity reveals a thick omentum with a peppering of India ink from the prior tattoo applied by the gastroenterologist, but the actual neoplasm is not visible in this view. **b** Toggling into FireFly™ near infrared mode allows the lesion to be easily visualized even though it lies beneath a dense sheet of omentum, demonstrating a clear advantage of ICG as a tumor localizer when injected at the target site

Next, the colotomy can be re-approximated utilizing a single running self-locking suture (2-OV-Lock suture, Ethicon, Inc.) transversely to minimize narrowing (Fig. 8). Upon re-approximation of the bowel wall, the colonoscope is re-introduced, the suture line examined, and an air-leak test performed (Fig. 9).

Discussion

Robotic-endoscopic polypectomy is feasible and in the era of organ preservation can, in highly select cases (Table 1), remove the need for en bloc radical resection. In this brief report, an illustrative atlas of the key steps of this operation

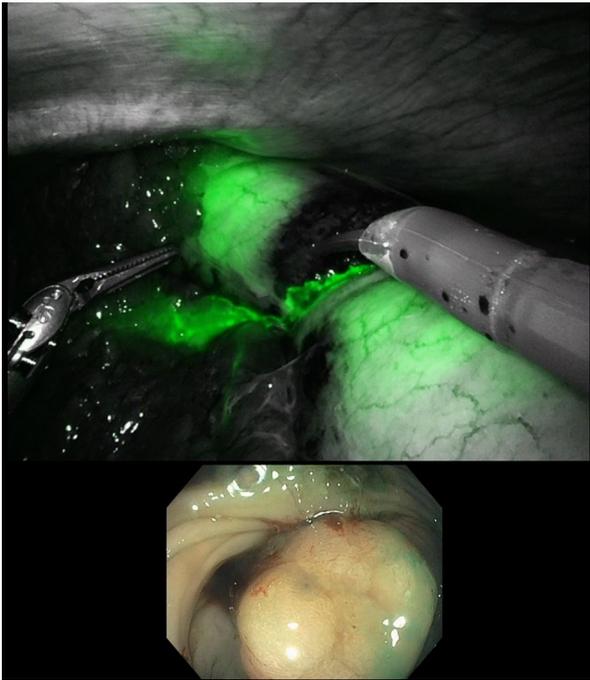


Fig. 3 The omentum has been swept cephalad to expose the distal transverse colon and the ICG tattooed lesion. Note that the central darkening and absence of ICG uptake is due to the India ink tattoo

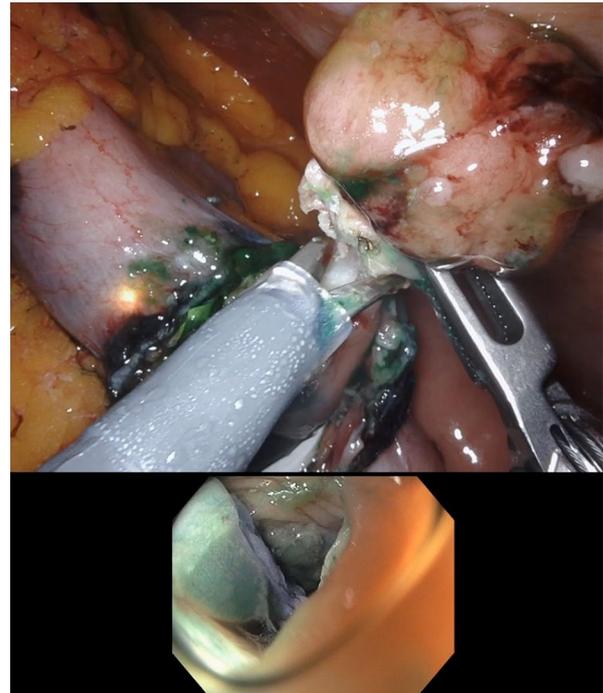


Fig. 5 Robotic polypectomy using a grasper and scissor tip for dissection along a broad stalk. Care is taken to transect the stalk near its base. The histopathology revealed invasive neoplasia. In this example, the stalk was judged to be too broad to safely transect using a pure endoscopic snare technique

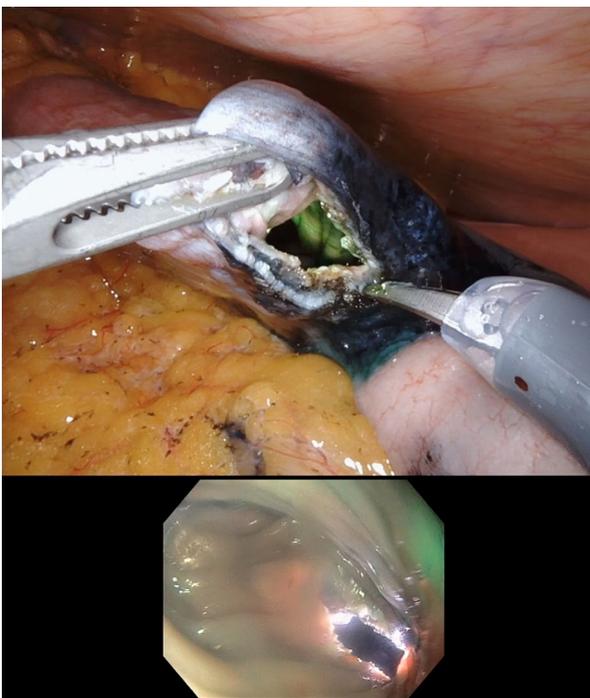


Fig. 4 Reduced-port robotic access (with only two 8 mm working arms) is performed to limit abdominal wall access trauma. An additional 5 mm trocar was used to provide stable pneumatics and for bedside assistance. Here, the colotomy has been made along the antimesenteric boarder of the colon so as to gain access to the target lesion, which is pedunculated on a very broad stalk

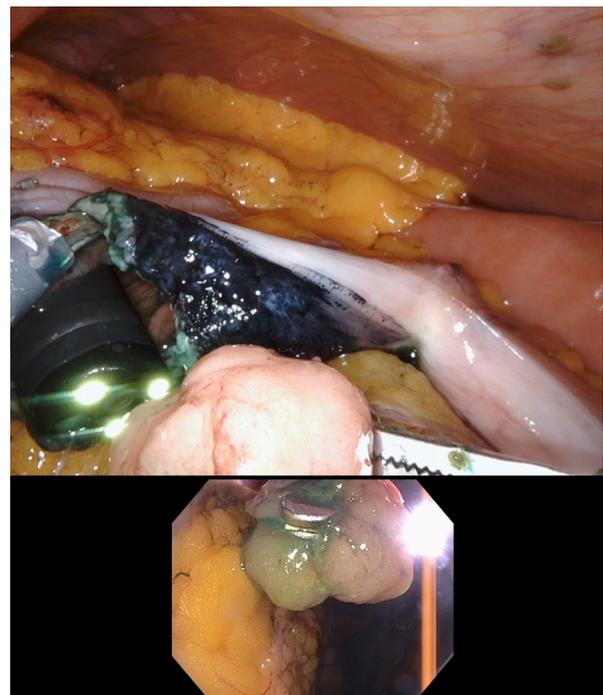


Fig. 6 The colonoscope is escorted out of the bowel lumen and into the abdominal cavity with robotic assistance in preparation for extraluminal deployment of a Roth net. Note that the colon is completely deflated and collapsed due to the colotomy

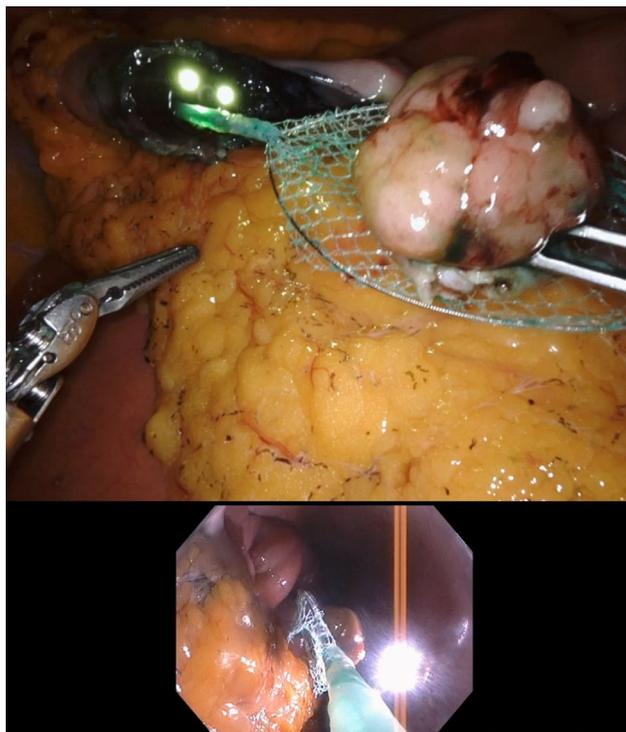


Fig. 7 A Roth net has been deployed in the abdominal cavity and the robotic surgeon assists with delivery of the lesion onto the net. The specimen will then be retrieved transanally as the scope is withdrawn. This demonstrates how TilePro can be used to facilitate robotic-endoscopic cooperativity

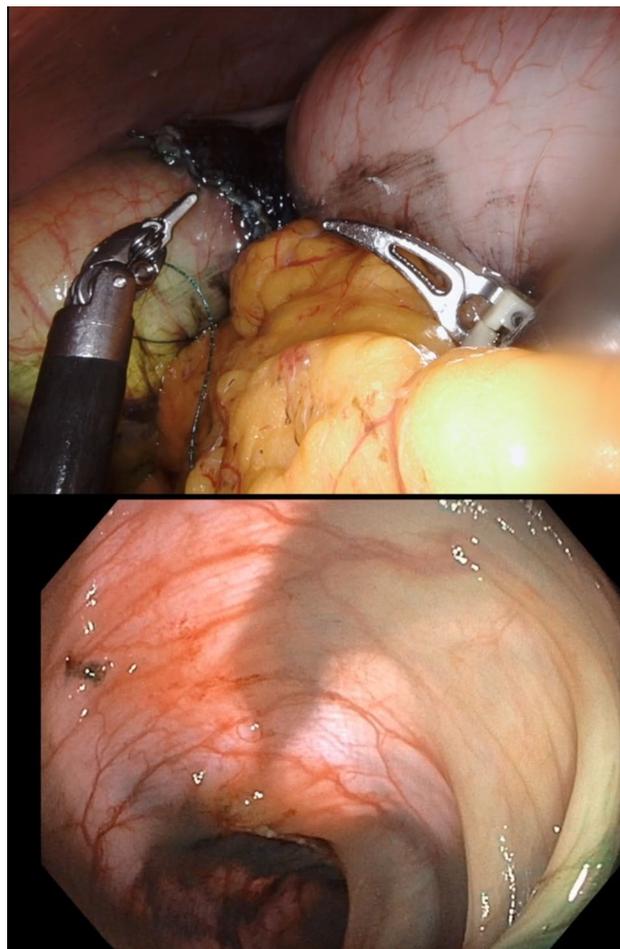


Fig. 9 The colonoscope is reintroduced and the bowel distended with air as the final stitches are placed. An air-leak test may then be performed by flooding the field with saline. It is also possible to examine the suture line endoscopically to assure adequate tissue apposition

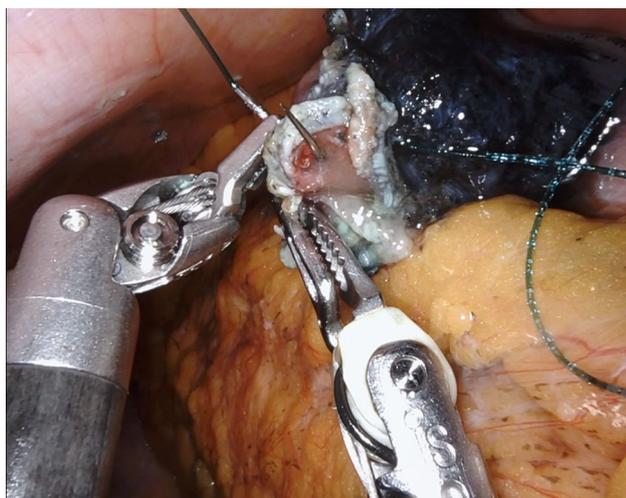


Fig. 8 With the colonoscope withdrawn, the colotomy is reapproximated transversely with a single running 3-0V-lock barbed suture as shown

is provided. Such a technique represents a melding of key developments in surgery and endoscopy. Hybrid applications whereby a string of technological advancements become

fused to form a single procedure will likely form the foundation of future advancements in surgery [19].

While it is arguable that a pure endoscopic approach utilizing endoscopic mucosal resection [20] or even full-thickness endoscopic resection [21] is feasible, and could eliminate abdominal wall access trauma altogether, there is an added advantage in robotics in which the mass excision and bowel wall closure can be quite precisely and accurately performed, and the ability to perform an air-leak test to assess the integrity of the closure with the approach described adds an additional layer of safety otherwise not possible with pure endoscopic techniques. Furthermore, in many centers, specialized endoscopy is not available; even in 2019, this remains dependent on the center, available resources, and expertise.

Table 1 General considerations and candidacy for robotic polypectomy with colonoscopic-assistance

The neoplasm is benign^a
 The neoplasm is non-obstructing
 The neoplasm does not lie along the mesenteric border^b
 The neoplasm is not amenable to transanal excision^c
 The neoplasm is not amenable to safe endoscopic resection
 EMR and other advanced endoscopic techniques are not available^d
 The patient is able to undergo a mechanical bowel preparation
 The lesion is assessable via colonoscopy and can be localized with ICG
 The patient does not have an allergy to ICG^e

EMR endoscopic mucosal resection, *ICG* indocyanine green

^aNeoplasia which is either biopsy-proven invasive adenocarcinoma or believed to be malignant by morphologic features and pit pattern should undergo en bloc, radical resection

^bLesions that encroach along the mesenteric border may be technically more difficult to excise, unless the lesion is pedunculated. Sessile lesions in this region are probably best treated with segmental resection

^cWhen the lesion lies beneath the peritoneal reflection, it is best approached via transanal minimally invasive surgery (TAMIS) or transanal endoscopic microsurgery (TEM)

^dNot all hospital systems have advanced endoscopic capabilities and/or the expertise to perform such complex techniques. In such instances, minimally invasive surgery with polypectomy may be a valid alternative

^eAllergy to indocyanine green is rare, but is a contraindication to administration. In general, patients with known iodine allergy should not be given ICG as there is believed to be at least partial cross-reactivity

Conclusions

Robotic polyp excision is feasible, but should be considered only in highly select instances. The technique and approach illustrated here represent an important fusion of advancements in the field of colorectal surgery, including the unique utilization of robotic-endoscopic cooperativity and near infra-red-based tumor localization.

Compliance with ethical standards

Conflict of interest Dr. S. Atallah reports consultancy (such as consulting fees and honoraria) from Medtronic Inc., Applied Medical, and ConMed Inc. Dr. S. Larach holds stock options with Applied Medical Inc. A. Oldham and A. Kondek have no disclosures to report.

Ethical approval This research was performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained in accordance with the standards set forth by hospital regulations.

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