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Case Report

Real-Time Near-Infrared ICG Fluorescence Ureterography in Complex Rectal Resections: A Report of Two Cases

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ABSTRACT

Iatrogenic ureteric injuries are a well-documented consequence of non-urological abdomino-pelvic surgeries. Colorectal resections for benign inflammatory diseases are associated with obliteration of the planes. In such situations, identifying and securing the ureter during laparoscopy is challenging due to the absence of tactile feedback. We describe the use of real-time near-infrared Indocyanine green (ICG) fluorescence guidance to avoid iatrogenic ureteric injuries during complex colorectal resections featuring extensive pelvic adhesions. The inert nature of ICG, its affinity for urothelium, ability to detect leaks, low cost, and convenience of use with real-time augmented images during surgery make real-time, near-infrared ICG fluorescence ureterography a crucial tool in a colorectal surgeon's armamentarium during complex colorectal surgery.

Background

Iatrogenic ureteric injuries are a well-documented complication of non-urological abdomino-pelvic procedures. The reported incidence of ureteric injury following colorectal surgery is in the range of 0.28%–7.6% [1]. In comparison to colorectal procedures, gynaecological procedures account for the majority of these injuries [2]. The incidence is highest after laparoscopic endometriosis surgery [3]. Adhesions in the pelvis as a result of inflammatory disorders are a risk factor for ureteric injury. Intraoperative identification of the ureters is accomplished through the use of the ureters' intrinsic characteristics, identification of the peristalsis and vascularty on the surface, and additional aids such as ureteral catheters and illuminated stents [4]. Regardless of these precautions, ureteric injuries continue to occur.

We describe the use of real-time near-infrared fluorescence guidance to avoid iatrogenic ureteric injuries during two difficult colorectal resections involving extensive pelvic adhesions. Both procedures began with the cystoscopic placement of ureteral catheters and the instillation of 5 mg of Indocyanine green (ICG) diluted in 20 ml of saline into both ureters. Fluorescence in both ureters was visualized in real-time intraoperatively. We employed the Maxer Endoscopy GmbH's (Germany) VironX system in conjunction with the NIR light. The fluorescence image was augmented in real time by a white light image, enabling easy and confident dissection around the inflammatory areas adjacent to the ureter. In both situations, real-time ICG near-infrared fluorescence (NIRF) was critical for preserving the ureter.

Case Report

Case No. 1

A 42-year-old lady with a diagnosis of benign rectal stricture had complained of worsening constipation for six years. She had numerous colonoscopies, which revealed a concentric narrowing at the upper rectal level with a normal rectal mucosa at the site. The mucosal biopsy revealed no evidence of dysplasia or malignancy. Multiple colonoscopic dilatations of the rectal stricture were performed on her. Once the stricture was deemed to be undilatable, she was referred to us for surgery. At our center, colonoscopic examination revealed a non-negotiable stricture in the upper rectum with normal mucosa. Contrast-enhanced computed tomography (CECT) of the abdomen and pelvis with rectal contrast indicated a thickened upper rectal wall that was pulled toward the right pelvic wall; delayed scans revealed the right ureter was located

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near the rectal thickening. She underwent ICG-guided laparoscopic segmental resection of stricture bearing segment and colorectal anastomosis with a covering loop ileostomy after an informed consent. The left ureter was free, whereas the right ureter was in close proximity to the thickened rectal wall. ICG NIRF guided resection was carried out by dividing the mesorectum staying away from the ureter (Figure 1).

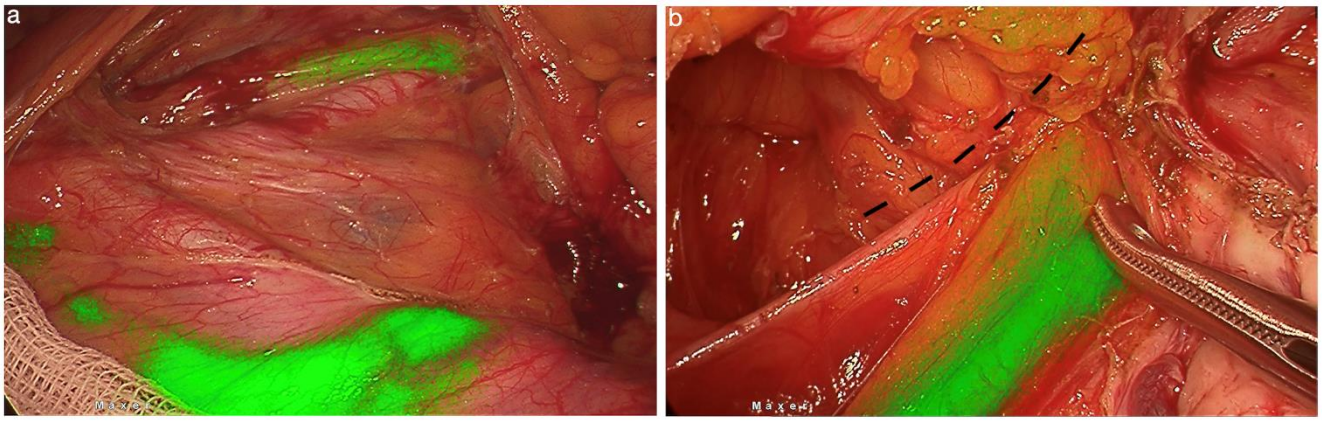

Figure 1: a) Early identification of the ureters crossing the internal iliac vessels at the pelvic brim, **b)** Right ureter in proximity to the scarred area on the right pelvic wall, with the identification of the ureter the dissection was carried out keeping away from the ureter dividing the mesorectum (along the dashed line) to complete the procedure.

Case No. 2

An 80-year-old gentleman with no medical comorbidities presented to the OPD with complaints of recurring urinary tract infections for six months and fecaluria for two weeks. Cystoscopy revealed unhealthy granulation tissue on the posterior bladder wall on the left side, approximately 3-4 cm above the level of the ureteric orifice. A CECT of the abdomen and pelvis revealed multiple sigmoid diverticulae and a recto-sigmoid pericolic abscess. Fat stranding between the rectosigmoid and posterior bladder wall was lost. Contrast instillation in the rectal cavity confirmed the presence of a colovesical fistula. The patient was diagnosed with a complicated diverticular disease—Stage I Hinchey's grade with fistulation. After informed consent, the patient was offered surgery and underwent ICG-guided laparoscopic division of the fistula, anterior resection, and covering ileostomy, followed by ileostomy closure. During surgery the left ureter could be visualized on NIRF to be coursing behind the region of fistula. This enabled the dissection to be carried out away from it prior to looping and division of fistula (Figure 2).

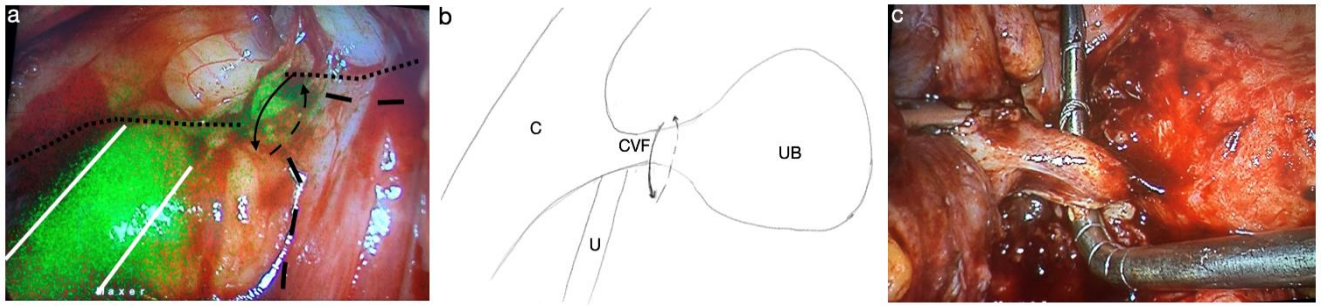

Figure 2: a) Early identification of the left ureter (parallel white lines) which is coursing posterior to the region of the colovesical fistula in close proximity to the bowel (dotted boundary line) and the bladder (dashed boundary lines). This enabled us to carry out the dissection close to the colovesical fistula staying away from the ureter (curved lines), **b)** Illustration showing the colon 'C', bladder 'UB' and the colovesical fistula 'CVF' with ureter 'U' posteriorly close to the fistulous area and the area of the dissection (curved lines), **c)** Looped colovesical fistula.

Discussion

Prophylactic ureteral stents are used to assist the surgeon with intraoperative identification during difficult colorectal resections. Due to the absence of tactile feedback during laparoscopy, visual signals are required to aid with dissection and safeguarding of the ureter. This purpose is well served by real-time NIRF ureterography. Complex colorectal resections in benign conditions like diverticular abscess with/without fistulae and rectal strictures secondary to pelvic endometriosis can be challenging, due to dense inflammation. This necessitates continual visualization of the ureters during the dissection. The affinity of ICG for urothelium and the fact that fluorescence persistence of 4-5 hours is advantageous in these procedures since the surgical period is longer in comparison to a conventional rectal resection for malignancy. Additionally, ureteral catheter placement enables repeat instillation when necessary.

During laparoscopic sigmoid or rectal surgeries, iatrogenic ureteric trauma to either the right or left ureter is possible. In the vast majority of colorectal resections for cancer, it is the left ureter that is at increased risk. This is because the dissection is carried out mediolaterally on the left side, the retraction of the mesosigmoid, and the instruments work in a "right-to-left" orientation. In general, a preliminary dissection posterior to the inferior mesenteric artery to establish an appropriate window is a

requirement to view and dissect the ureter off from the mesosigmoid and, more caudally, the proximal mesorectum.

In inflammatory conditions such as in Case 1, the initial dissection may not provide an adequate window to visualize the ureter and ICG NIRF can help early in surgery to locate the same and helps the surgeon in deciding the safe planes of dissection. Since there is no need for complete mesocolon/mesorectal excision in benign conditions, it follows that, after confirmation of the location of ureter on ICGF, the dissection can be kept away from the ureter, at the risk of leaving behind some mesocolonic or mesorectal tissue on the ureter. The NIRF is noticeable despite the ooze in the field, supporting the progress of dissection, which would practically be impossible without visual guidance.

Exposing the right ureter in the case of adhesion of the rectum to the right pelvic wall and pelvic brim can be problematic. For a laparoscopic left-sided colorectal resection, the surgeon and camera assistant stand on the right side of the patient with the monitor placed at the left foot end of the patient. Additionally, a left tilt along with a steep Trendelenberg position are utilised to keep small bowel loops out of the pelvis and away from the mesosigmoid. In inflammatory conditions, small bowel adhesions in the pelvis and to the mesosigmoid might require lysis early in the course of surgery. Despite these efforts, exposing the right ureter above the pelvic brim in an inflammatory condition can be difficult in these patients. As illustrated in Case 2, ICG NIRF helps locate the right ureter just above the pelvic brim and tracing it caudally is an advantage. Similar to Case 1, having the ureter in view enabled the dissection to be done away from it, enabling fistula looping and takedown. If a similar patient undergoes open surgery, the tactile sensation of the ureteral stent or the catheter enables cutting away from the ureter into the mesorectum to preserve the ureter. In the absence of tactile feedback, visualizing the ureter continually with ICG NIRF allows one to complete this step laparoscopically.

Unlike in ICG fluorescence cholangiography, where the fluorescence is caused by ICG excreted in bile, the fluorescence in this case is caused by ICG adhering to the urothelium. A leak of the fluorescent material in the former indicates a biliary system breach, while in the latter this would not be evident. However, a repeat instillation through the ureteral catheter at the conclusion of the procedure would demonstrate leakage from the ureters in the event of a breach. This was used to confirm the integrity of the bladder wall in the patient with a colovesical fistula.

The operating time and cost increases associated with patient repositioning and redraping are identical to those associated with the use of ureteral stents. Furthermore, the risks of urinary tract infection and temporary hematuria are theoretically comparable to those associated with routine ureteral catheterization. Additionally, ICG is a non-toxic substance with few adverse effects. Thus, the benefits of using ICG real-time NIRF in difficult colorectal resections exceed the risks.

The inert nature of ICG, its affinity for urothelium, ability to detect leaks, low cost, and convenience of use with real-time augmented images during surgery make real-time, near-infrared ICG fluorescence ureterography a crucial tool in a colorectal surgeon's armamentarium during complex colorectal surgery.

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Conflicts of Interest

None.

Availability of Data and Materials

All the data regarding the manuscript is available on request.

Author Contributions

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Abbreviation

CECT: Contrast-Enhanced Computed Tomography
ICG: Indocyanine Green
ICGF: Indocyanine Green Fluorescence
NIRF: Near-Infrared Fluorescence

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