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Use of Indocyanine Green During Robot-assisted Ureteral Reconstructions

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Abstract

Background: Although there are reports of robot-assisted ureteral reconstructions (RURs) with excellent safety and efficacy, the procedures remain technically challenging. In the robotic setting the surgeon must rely on visual cues in the absence of tactile feedback. Indocyanine green (ICG) is a dye that can be visualized under near-infrared fluorescence (NIRF).
Objective: To describe our novel technique, which utilizes intraureteral injection of ICG and subsequent visualization under NIRF to facilitate RUR, and report our outcomes after these procedures.
Design, setting, and participants: This is a retrospective review of 25 patients who underwent 26 RURs for various ureteral pathologies between June 2012 and October 2013.
Surgical procedure: After full disclosure, all patients consented to off-label use of ICG. A ureteral catheter and/or percutaneous nephrostomy tube were used to inject 10 ml of ICG into the diseased ureter, above and below the stricture. Intraoperatively, NIRF was activated to assist in identification of the ureter and to localize the margins of ureteral strictures.
Measurements: Postoperatively, RURs were assessed for clinical success (absence of symptoms attributable to ureteral pathology) and radiological success (absence of a ureteral stricture on imaging).
Results and limitations: Our technique provided visual cues and aided in successful performance of 26 RURs in 25 patients. The procedures included ureterolysis ($n = 4$), pyeloplasty ($n = 8$), ureteroureterostomy ($n = 9$), and ureteroneocystostomy ($n = 5$). There were no perioperative complications attributable to ICG use. At a mean overall follow-up of 12 mo, all procedures were clinically and radiologically successful. This study is limited by the small sample size and short-term follow-up.
Conclusions: Intraureteral injection of ICG and subsequent visualization under NIRF facilitates RUR by aiding in rapid and accurate identification of the ureter, and precise localization of the proximal and distal ureteral stricture margins. In our experience, our technique is safe, easy to perform, and reproducible.
Patient summary: In this report, we describe a new technique to facilitate robot-assisted ureteral reconstructions using intraureteral injection of ICG and subsequent visualization under near-infrared fluorescence. More specifically, our technique allows for rapid and accurate identification of the ureter, and precise localization of ureteral strictures.

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1. Introduction

Robot-assisted surgery maintains the benefits of minimally invasive surgery and provides surgeons with the ability to see in magnified three-dimensional vision, operate in limited anatomic spaces, and suture with precision. These attributes make the robotic modality well equipped for technically demanding surgeries such as robot-assisted ureteral reconstructions (RURs), including ureterolysis, pyeloplasty, ureteroureterostomy, and ureteroneocystostomy [1]. Although reports suggest that RURs are feasible and safe [2–6], the procedures remain challenging to perform.

Identification of the ureter may be particularly difficult in the setting of peri-ureteral inflammation, which often accompanies the underlying pathology and disrupts normal dissection planes and causes fibrotic ureteral encasement. Precise localization of ureteral strictures is critical, as the surgeon must excise the entirety of the diseased segment to minimize the risk of stricture recurrence, but preserve as much healthy ureter as possible to maximize the possibility of a tension-free anastomosis. These surgical aims may be especially difficult in the robotic setting because the surgeon must rely largely on visual cues in the absence of tactile feedback [7,8].

Indocyanine green (ICG) is a dye that can be visualized under near-infrared fluorescence (NIRF). ICG is well suited for intraoperative use as a real-time contrast agent because it has a high signal-to-noise ratio, an ability to penetrate tissue, and an excellent safety profile [9]. We hypothesize that intraureteral injection of ICG with subsequent visualization under NIRF may facilitate RUR. The purpose of our report is to detail our technique for ICG use during RURs and to report our outcomes.

2. Patients and methods

2.1. Patient cohort

After obtaining Institutional Review Board approval, we performed a retrospective review of 25 patients who underwent 26 RURs for various ureteral pathologies between June 2012 and October 2013. A single surgeon (DDE) performed the procedures using the da Vinci Si (Intuitive Surgical, Sunnyvale, CA, USA) with integrated Firefly NIRF imaging capability. After grouping the cohort by procedure performed, patient demographics and perioperative outcomes were analyzed.

2.2. Preoperative evaluation

Ureteral obstructions were evaluated using computed tomography (CT), cystography, ureteroscopy, antegrade/retrograde ureteropyelography, and/or a nuclear renal scan, as indicated by the primary pathology. After discussing all available treatment options, all patients opted for RUR with intraureteral ICG injection and visualization under NIRF. All patients consented to intraureteral ICG administration after full disclosure. More specifically, as ICG is FDA-approved for intravenous use only, all patients understood that our technique involves off-label use of ICG. In addition, all patients understood that although the adverse effect profile of intravenous ICG is favorable, the adverse effect profile of intraureteral ICG has not yet been clearly elucidated.

2.3. Surgical technique

2.3.1. ICG preparation and administration

ICG was prepared on receipt in the operating room by dissolving 25 mg of sterile IC-Green (Akorn Inc., Lake Forest, USA) in 10 ml of distilled water. A 6F ureteral catheter was inserted into the diseased ureter, and retrograde pyelography was performed to localize the stricture. Through the ureteral catheter, 10 ml of ICG was injected retrogradely into the lumen, above and below the level of stenosis. In patients with a nephrostomy tube, anterograde pyelography was performed at time of retrograde pyelography. To ensure that ICG was administered above and below the level of stenosis in such patients, 5 ml of ICG was injected anterogradely through the nephrostomy tube and 5 ml of ICG was injected retrogradely through the ureteral catheter. Immediately after injection, the ureteral catheter and/or nephrostomy tube were clamped to maximize ICG retention in the ureter. The ureteral catheter was secured to the Foley catheter and left in the surgical field.

2.3.2. Patient and robot set-up

Patient positioning and port placement were dependent on the stricture location (Fig. 1). All RURs were performed using a 0° lens in the robotic camera arm, Maryland bipolar forceps in the left robotic arm, and a Cobra grasper (Intuitive Surgical, Sunnyvale, CA, USA) in the fourth robotic arm. In the right robotic arm, a monopolar cautery hook was used for blunt dissection and monopolar shears were used for sharp dissection.

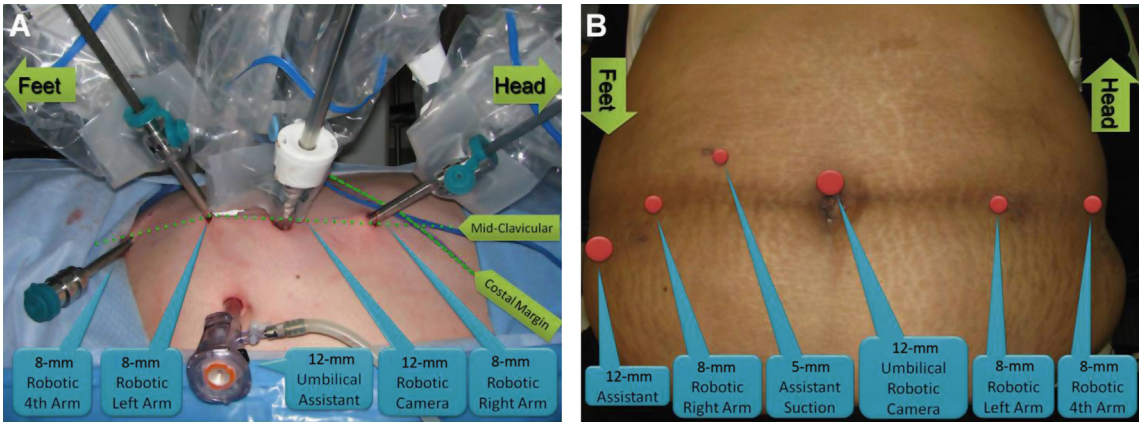

Fig. 1 – Patient positioning and port placement. (A) Patients with proximal and middle ureteral pathology are placed in full flank position with the table in full flexion; a total of five ports are utilized. (B) Patients with distal ureteral pathology are placed in a modified dorsal lithotomy position with the table in a steep Trendelenburg position; a total of six ports are utilized.