

Impact of Real-Time Indocyanine Green Angiography with The SPY Fluorescence Imaging Platform on The Incidence of Ureteroenteric Stricture after Urinary Diversion

Ahmed Zakaria Ahmed Mohammed

Lecturer In Department of Urology, Faculty of Medicine, Suez Canal University, Egypt

*Corresponding Author

Article History

Received: 24.09.2025

Revised: 14.10.2025

Accepted: 29.10.2025

Published: 10.11.2025

Abstract:

Background: Ureteroenteric strictures (UES) are a frequent complication after urinary diversion, with incidences ranging from 3-10% in open cystectomy and varying in robotic procedures. Real-time indocyanine green (ICG) angiography utilizing the SPY fluorescence imaging platform may mitigate this by assessing ureteral perfusion intraoperatively. **Aim:** To assess the impact of intraoperative utilization of real-time indocyanine green angiography with the SPY fluorescence imaging platform on the rate of frequency of UES following urinary diversion. **Patients and methods:** This was a prospective comparative research at the Department of Urology, Faculty of Medicine, Suez Canal University. The research population was the patients who received the SPY-guided perfusion assessment during surgery and the control group of patients who underwent similar procedures without the use of SPY imaging. **Results:** No significant differences in age, gender, or BMI; significant difference in Charlson Comorbidity Index ($p < 0.05$). Significant reductions in UES rates with SPY ($p < 0.05$), alongside differences in follow-up, diversion types (ileal conduit, orthotopic bladder, Indiana pouch), and surgical approach. Mean ureteral excision: left 0.89 cm, right 0.85 cm. **Conclusion:** SPY fluorescence angiography significantly lowers UES incidence by ensuring adequate perfusion, supporting its integration in urinary diversion procedures.

Keywords: Ureteroenteric strictures, SPY Fluorescence Imaging, Radical Cystectomy, Indocyanine Green Angiography.

INTRODUCTION

Ureteroenteric strictures (UES) are a significant complication that can occur following urinary diversion procedures, particularly after radical cystectomy. These strictures result from the narrowing of the junction between the ureter and the segment of the intestine used in the diversion, causing potential obstruction and subsequent renal impairment. UES are associated with several risk factors, including postoperative urinary leaks and patient-specific attributes such as body mass index (1).

The incidence of UES in patients undergoing open cystectomy ranges from 3% to 10%, with the rates being notably varied in robotic surgeries, ranging from 0% to 25% (2).

Urinary diversion procedures, such as ileal conduits, are commonly performed following bladder cancer treatment or damage to the bladder (3). These procedures can lead to various complications, including early postoperative issues like urine leakage and obstruction, as well as late complications such as ureteroileal anastomotic strictures and stomal stenosis (4).

ICG fluorescence-guided surgery is especially beneficial for procedures requiring precise vascular and tissue perfusion assessments, effectively minimizing postoperative complications such as ureteral strictures by ensuring adequate blood supply to ureteroenteric anastomoses (5).

Specifically, the SPY fluorescence imaging platform, in use with real-time ICG angiography, represents an innovative approach in mitigating UES incidence (6). This platform offers detailed real-time imaging, vital for surgeons during the intraoperative phase of urinary diversions, such as the reconstruction and anastomosis of the ureters. Its ability to visualize blood flow accurately supports surgical decisions, improving the integrity of the anastomotic site and thus reducing the potential for complications like strictures (7). The present research aimed to estimate the impact of intraoperative utilization of real-time ICG angiography with the SPY fluorescence imaging platform on the rate of frequency of UES following urinary diversion.

Patients and methods

This was a prospective comparative research study at the Department of Urology, Faculty of Medicine, Suez Canal University. The research population was the patients who received the SPY-guided perfusion assessment during surgery and the control group of patients who underwent similar procedures without the use of SPY imaging.

Inclusion criteria: Cases that are having extracorporeal urine diversion with Bricker ureteroenteric anastomosis, as well as cases that have urinary diversions for medical reasons that are either benign or cancerous.

Exclusion criteria: Patients whose stricture is estimated to be related to cancerous recurrence have been excluded.

Sampling technique

The quota sampling technique was used until the required number of participants was collected.

Sample Size

The sample size has been determined utilizing the given equation: Where n = sample size, $Z_{\alpha/2} = 1.96$ (the critical value delineating the central ninety-five percent of the Z distribution from the five percent in the tail), $Z_{\beta} = 0.84$ (the critical value distinguishing the decrease twenty percent of the Z distribution from the upper eighty percent), and p_1 = prevalence/proportion of ureteroenteric stricture in the SPY group = 1.8% (8). p_2 = Prevalence/proportion of ureteroenteric stricture in the control group = 11.2% (8). q equals 1 minus P . The sample size was 107 for each group.

$$n = \left[\frac{Z_{\alpha/2} + Z_{\beta}}{P_1 - P_2} \right]^2 (p_1 q_1 + p_2 q_2)$$

MATERIAL AND METHODS

All patients were subjected to the following:

A detailed medical history was obtained, involving personal history, prior surgical interventions, radiation exposure, comorbidities, and risk factors like the Charlson Comorbidity Index (CCI) & body mass index (BMI). **Physical examination** focused on evaluating general health status, abdominal and pelvic findings, and signs of potential complications such as stomal issues or renal impairment. **Preoperative investigations** included laboratory tests (e.g., serum creatinine, assessed glomerular filtration rate) to assess renal function, complete blood count, and coagulation profile. **Imaging studies**, like magnetic resonance imaging (MRI) or computed tomography (CT) urography, were conducted to evaluate the anatomy of the urinary tract, ureteral integrity, and pelvic vasculature.

Intraoperative SPY Technique

Before harvesting the intestinal segment for urinary diversion & following the transposition of the left ureter to the right side (if applicable), twenty-five milligrams of ICG was reconstituted in ten cubic centimeter of sterile water diluent. Subsequently, three milliliters of the ICG solution were delivered intravenously, resulting in a total dosage of 7.5 milligrams. Approximately two minutes were let to elapse to facilitate tissue perfusion of indocyanine green. A surgical towel will be positioned behind the ureters to create a fluorescence-free background. The distal ureters were assessed utilizing the sterile SPY handpiece in both monochrome modes and green fluorescence. A section of healthy intestine was assessed using the SPY handpiece for comparison with ureteral tissue. An evaluation of ureteral perfusion will be conducted, & any delineation of inadequately perfused ureteral tissue will be indicated with a suture. The inadequately perfused tissue was subsequently removed, followed by the execution

of a conventional ureteroenteric anastomosis. Spatulation has been conducted at the threshold of sufficient ureteral perfusion. Upon completion of both ureteroenteric anastomoses, three milliliters (7.5 milligrams) of indocyanine green solution were supplied intravenously, and the anastomoses were evaluated utilizing the SPY handpiece in both black-and-white mode & green fluorescence mode to confirm sufficient ureteral perfusion. A Likert scale assessment form will be created for the research to provide a standardized quantitative statement of results, along with a commentary on whether SPY altered management. The qualitative evaluation of ureteral perfusion involved comparing fluorescence among the ureter & the surrounding healthy bowel. Poorly perfused has been characterized as distinctly deficient in perfusion, shown by a black representation in the black-and-white fluorescence mode. Diminished perfusion was a qualitative evaluation among the two, indicating that perfusion exists but is inferior to that of the neighboring bowel.

Follow up

Postoperatively, cases were administered care using a standardized improved recovery protocol. The externalized ureteral stents were removed after cases could tolerate a standard diet and before hospital release. Cases underwent renal ultrasonography four to six weeks post-stent removal to evaluate for hydronephrosis. Ureteroenteric anastomoses have been deemed patent if the latest upper tract imaging reveals no substantial hydronephrosis. If substantial hydronephrosis is evident and the case is asymptomatic, a loopogram has been performed to evaluate for reflux; if reflux is not detected, a diuretic renal scan has been conducted. UES is identified when hydronephrosis is evident, the loopogram indicates no reflux, and the diuretic renal scan reveals a T1/2 of greater than twenty minutes. A percutaneous nephrostomy tube was inserted for symptomatic cases, and upper urinary excretion was confirmed using an antegrade nephrostogram.

Ethical consideration

The research has been done regarding the principles stated in the Declaration of Helsinki for medical ethics for all studies, including human materials. We took the approval of the authority responsible. Every participant has the right to refuse to participate in the research. A written informed consent has been taken from every participant. We gave feedback to all the participants about the research results. All necessary measures have been implemented to safeguard the privacy of study subjects and the confidentiality of their personal data following the authorization to access medical records.

Statistical analysis

Information was analyzed, entered, and cleaned utilizing Statistical Package for Social Sciences (IBM® SPSS® Statistics version 25). Categorical parameters

have been defined as frequencies and column percentages, whereas continuous parameters have been summarized as mean and SD. Statistical analysis will be conducted using Fisher's exact or the chi-square tests for UES incidence. The normality of the continuous

information has been examined using the Kolmogorov-Smirnov test and shown that all continuous parameters aren't normally distributed. Statistical significance has been recognized if the p is less than 0.05.

RESULTS AND OBSERVATIONS:

Table (1): distribution of baseline characteristics between the examined groups

	Case group Num. = 107	Control group Num. = 107	P value
Age Mean $\pm$ SD	61.53 $\pm$ 9.24	63.26 $\pm$ 10.02	0.19
Gender			
Male	82 (76.6%)	73 (68.2%)	0.16
Female	25 (23.4%)	34 (31.8%)	
BMI Mean $\pm$ SD	26.81 $\pm$ 4.25	27.35 $\pm$ 4.36	0.36
CCI Mean $\pm$ SD	6 $\pm$ 0.95	5 $\pm$ 0.97	0.001*

P below 0.05 is statistically significant, P above 0.05: Not significant, p below 0.001 is highly significant.

CCI: Charlson Comorbidity Index, BMI: Body Mass Index.

Table 1 shows that there was statistically insignificant variance among the examined groups regarding Age, Gender and BMI while there was statistically significant variance among the examined groups regarding CCI.

Table (2): distribution of Surgical Information among the examined groups

	Case group Num. = 107	Control group Num. = 107	P value
Radiation	17 (15.9%)	16 (15.0%)	0.84
Follow-up Median	17.1	57.4	0.001*
Pelvic exenteration	8 (7.5%)	10 (9.3%)	0.84
Radical cystectomy/urinary diversion	91 (85.0%)	88 (82.2%)	
Supratrigonal cystectomy/urinary diversion	8 (7.5%)	9 (8.4%)	
Ileal conduit	105 (98.1%)	100 (93.5%)	0.03*
Orthotopic bladder	2 (1.9%)	1 (0.9%)	
Indiana pouch	0 (0.0%)	6 (5.6%)	
Robotic-assisted	39 (36.4%)	16 (15.0%)	0.001*
Open approach	68 (63.6%)	91 (85.0%)	
Stricture formation	2 (1.9%)	12 (11.2%)	0.001*

Table 2 shows that there was statistically insignificant variance between the examined groups regarding Radiation, Pelvic exenteration and Pelvic exenteration, Radical cystectomy/urinary diversion and Supratrigonal cystectomy/urinary diversion while there was statistically insignificant variance between the examined groups regarding Follow-up, Ileal conduit, Orthotopic bladder, Indiana pouch, Open approach and Stricture formation.

Table 3 shows that the mean length of left ureteral excision was 0.89 centimeter & right ureteral excision was 0.85 centimeter. Of note, the lengths marked for excision were slightly shorter, with 0.75 cm on the left and 0.73 cm on the right.

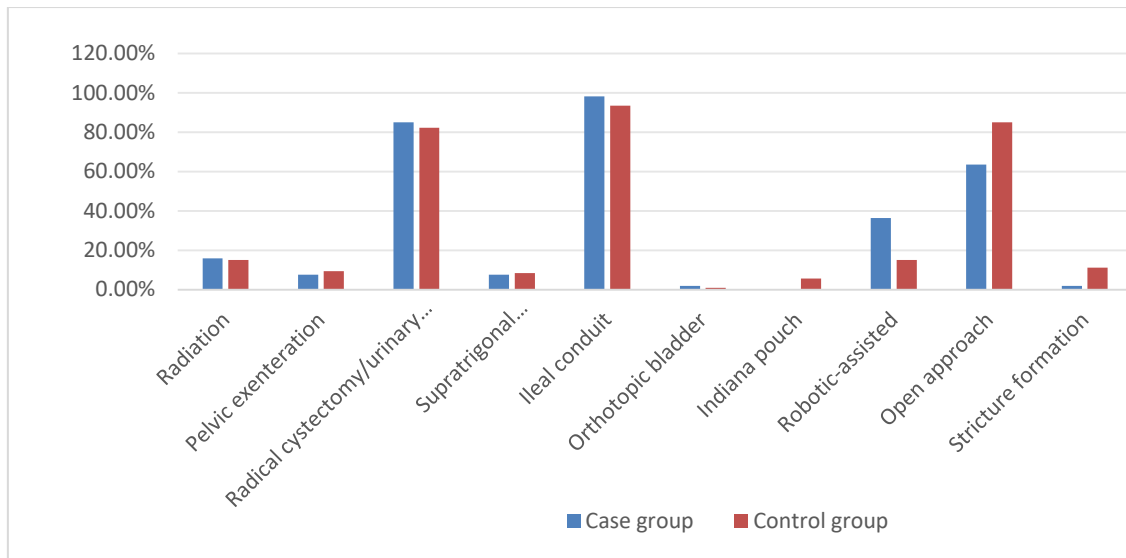


Figure (1): Surgical Information between the studied groups

Table (3): distribution of Intraoperative Ureteral

	Studied group
Left ureteral length marked for excision, centimeter	0.75 ±0.55
Right ureteral length marked for excision, centimeter	0.73 ±0.98
Left ureteral length excised, centimeter	0.89 ±0.75
Right ureteral length excised, centimeter	0.85 ±0.73

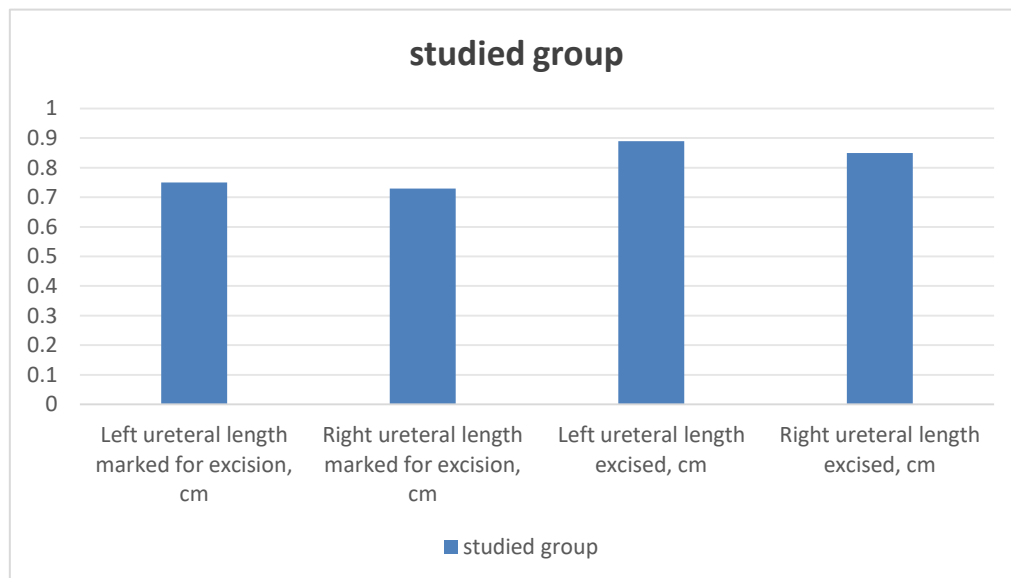


Figure (2): Intraoperative Ureteral

DISCUSSION

Our results showed that there was statistically insignificant variance among the examined groups regarding age, gender, and BMI, while there was statistically significant variance among the examined groups according to CCI.

According to Shen et al. (9), the research aimed to assess the effectiveness and safety of ureteral vascular perfusion evaluation during ureteroenteric anastomosis utilizing real-time indocyanine green angiography with the SPY fluorescence imaging platform and its subsequent effect on UES rate. The findings indicated

statistically insignificant variance between the groups concerning age, gender, and BMI (p above 0.05).

As well, Yeaman et al. (10) aimed to study the effect of SPY fluorescence angiography on the frequency of ureteroenteric strictures and reported that there was statistically insignificant variance between the examined groups regarding age, BMI, and gender (p above 0.05). while there was statistically significant variance among the examined groups according to CCI (p equal to 0.0002).

Our results illustrated that there was statistically insignificant variance among the examined groups regarding radiation, pelvic exenteration, radical cystectomy/urinary diversion, and supratrigonal cystectomy/urinary diversion, while there was statistically significant variance among the examined groups regarding follow-up, ileal conduit, orthotopic bladder, Indiana pouch, open approach, and stricture formation.

In line with Yeaman et al., (10) stated that there was statistically insignificant variance among the examined groups regarding radiation, pelvic exenteration, radical cystectomy/urinary diversion, and supratrigonal cystectomy/urinary diversion (p above 0.05), while there was statistically significant variance among the examined groups regarding follow-up (p below 0.001), open approach (p=0.0003), and stricture formation (p=0.03). On the other hand, they reported that there was statistically insignificant variance regarding ileal conduit, orthotopic bladder, and Indiana pouch (p=0.506).

Ahmadi et al. (11) aimed to assess the influence of ICG on ureteric vascularity and its effect on the frequency of uretero-enteric stricture formation following robot-assisted radical cystectomy (RARC) with intracorporeal urinary diversion (ICUD). They stated a statistically significant variance among the groups concerning monitoring (p equal to 0.014) and stricture formation (p equal to 0.02). Conversely, insignificant variance was observed between the two groups regarding ileal conduit, neobladder, and Indiana pouch (p equal to 0.543).

In contrast, Shen et al. (9) stated that there was statistically insignificant variance between the examined groups regarding diversion type (ileal conduit, Studer neobladder, Indiana pouch) (p=0.2). also reported that the median monitoring was 1 year for the SPY group and 24.3 months for the non-SPY group. Our results showed that the mean length of left ureteral excision was 0.89 centimeter and right ureteral excision was 0.85 centimeter. Of note, the lengths marked for excision were slightly shorter, with 0.75 cm on the left and 0.73 cm on the right.

According to Yeaman et al. (10), the average length of left ureteral excision was 0.87 centimeters, whereas the

average length of right ureteral excision was 0.81 centimeters. In instances where SPY had treatment alterations, the left ureteral excision measured 1.31 centimeters, whereas the right ureteral excision measured 0.88 centimeters. It was also found that SPY fluorescence angiography may be utilized through open urinary diversion to verify perfusion to the ureteroenteric anastomosis, resulting in a reduced frequency of Ureteroenteric strictures when ureteral perfusion evaluation is conducted.

According to Shen et al. (9), the median length removed for ureters exhibiting inadequate distal perfusion was 3.8 centimeters, in contrast to 2.2 centimeters for those with adequate distal perfusion (p below 0.0001). No complications related to the utilization of SPY have been observed. The application of SPY for evaluating ureteral perfusion correlated with a reduction in the ureteroenteric strictures rate following RCUD.

Furthermore, Prillaman et al. (12) sought to elucidate the methodology for employing SPY fluorescent angiography during open urinary diversion. They stated that none of the 16 enrolled cases in the experimental group exhibited ureteroenteric strictures, whereas the institutional incidence of UES in patients lacking SPY fluorescent angiography was 10.3%. It was also noted that SPY fluorescent angiography may be utilized through open urinary diversion to verify perfusion at the ureteroenteric anastomosis.

Additionally, Doshi et al. (13) analyzed ureteroenteric stricture rates and observed a reduction of 16.7% in the non-SPY group, in contrast to a drop of 3.2% in the SPY group.

CONCLUSION

This research revealed that significant differences were observed in the Charlson Comorbidity Index (CCI), follow-up duration, type of urinary diversion (ileal conduit, orthotopic bladder, Indiana pouch), surgical approach, and stricture formation rates. Although the mean excision lengths of the ureters were slightly shorter when marked under fluorescence guidance compared to actual excision lengths, this difference was minimal and unlikely to have clinical implications. Importantly, the use of SPY fluorescence angiography has been correlated with a statistically significant reduction in stricture formation, suggesting that real-time vascular assessment may enhance intraoperative decision-making and improve ureteral anastomotic outcomes. Overall, these findings suggest that integration of SPY fluorescence angiography into urinary diversion procedures offers a valuable adjunct for intraoperative decision-making and may decrease the risk of UES. Larger prospective researches with longer monitoring are warranted to validate these results and further define the role of fluorescence-guided perfusion assessment in optimizing reconstructive urologic outcomes.

DISCUSSION

1. Faraj KS, Rose KM, Navaratnam AK, Abdul-Muhsin HM, Eversman S, Singh V, et al. Effect of intracorporeal urinary diversion on the incidence of benign ureteroenteric stricture after cystectomy. *Int J Urol.* 2021;28(5):593–7.
2. McNicholas DP, El-Taji O, Siddiqui Z, Hanchanale V. Systematic review comparing uretero-enteric stricture rates between open cystectomy with ileal conduit, robotic cystectomy with extra-corporeal ileal conduit and robotic cystectomy with intra corporeal ileal conduit formation. *J Robot Surg.* 2024;18(1):100.
3. Colombo R, Naspro R. Ileal conduit as the standard for urinary diversion after radical cystectomy for bladder cancer. *European Urology Supplements.* 2010 Dec 1;9(10):736-44.
4. Kobayashi K, Goel A, Coelho MP, Medina Perez M, Klumpp M, Tewari SO, et al. Complications of ileal conduits after radical cystectomy: interventional radiologic management. *Radiographics.* 2021;41(1):249–67.
5. Fransvea P, Miccini M, Rondelli F, Brisinda G, Costa A, Garbarino GM, et al. A green lantern for the surgeon: a review on the use of Indocyanine Green (ICG) in minimally invasive surgery. *J Clin Med.* 2024;13(16):4895.
6. Shen JK, Jamnagerwalla J, Yuh BE, Bassett MR, Chenam A, Warner JN, Zhumkhawala A, Yamzon JL, Whelan C, Ruel NH, Lau CS. Real-time indocyanine green angiography with the SPY fluorescence imaging platform decreases benign ureteroenteric strictures in urinary diversions performed during radical cystectomy. *Therapeutic advances in urology.* 2019 Apr;11:1756287219839631.
7. Karmarkar R, Benjafield A, Aroori S. The role of colour segmented fluorescence (CSF) mode and same-day administration of low-dose indocyanine green in liver surgery: Our initial experience: Indocyanine green fluorescence guided resection of liver tumours. *J Fluoresc.* 2024;34(5):2133–8.
8. Yeaman CT, Winkelman A, Maciolek K, Tuong M, Nelson P, Morris C, Culp S, Isharwal S, Krupski TL. Impact of radiation on the incidence and management of ureteroenteric strictures: a contemporary single center analysis. *BMC urology.* 2021 Aug 4;21(1):101.
9. Shen JK, Jamnagerwalla J, Yuh BE, Bassett MR, Chenam A, Warner JN, et al. Real-time indocyanine green angiography with the SPY fluorescence imaging platform decreases benign ureteroenteric strictures in urinary diversions performed during radical cystectomy. *Ther Adv Urol.* 2019;11:1756287219839631.
10. Yeaman C, Ignozzi G, Kazeem A, Isharwal S, Krupski TL, Culp SH. Impact of SPY fluorescence angiography on incidence of ureteroenteric stricture after urinary diversion. *J Urol.* 2024;10–1097.
11. Ahmadi N, Ashrafi AN, Hartman N, Shakir A, Cacciamani GE, Freitas D, et al. Use of indocyanine green to minimise uretero-enteric strictures after robotic radical cystectomy. *BJU Int.* 2019;124(2):302–7.
12. Prillaman G, Yeaman C, Isharwal S, Krupski T. V01-02 USE OF SPY FLUORESCENT ANGIOGRAPHY DURING URINARY DIVERSION. *J Urol.* 2022;207(Supplement 5):e52.
13. Doshi CP, Wozniak A, Quek ML. Near-infrared fluorescence imaging of ureters with intravenous indocyanine green during radical cystectomy to prevent ureteroenteric anastomotic strictures. *Urology.* 2020;144:220–4.