ORIGINAL ARTICLE

Incidence of Iatrogenic Ureteral Injury After Laparoscopic Colectomy

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Objective: To compare the incidence of iatrogenic ureteral injury between laparoscopic and open colectomies at a single institution.

Design: From June 1, 2005, through July 31, 2010, patients were identified from a prospectively maintained database and hospital records were retrospectively reviewed.

Setting: Mount Sinai Medical Center.

Patients: Fourteen patients who underwent colectomy complicated by a ureteral injury.

Main Outcome Measures: A significant increase in ureteral injuries occurred after laparoscopic vs open procedures (0.66% vs 0.15%, $P=.007$).

Results: A total of 5729 colectomies were performed during the study period. Fourteen ureteral injuries occurred, resulting in a 0.244% incidence of iatrogenic ureteral injury. Patient demographics demonstrated that 9 injuries (64%) occurred in females and 7 patients (50%) had undergone prior abdominal operations. Operative indications were inflammatory bowel disease (n=7), diverticulitis (n=2), and malignant neoplasm (n=4). Thirteen operations (87%) in this study were elective colectomies, and 7 patients (50%) underwent laparoscopic procedures, with 2 open conversions. Of the 5729 colectomies, 4669 were open and 1060 laparoscopic. Regarding ureteral injuries, no difference was observed in intraoperative identification of ureteral injury in patients who underwent preoperative ureteral stent placement (n=4) vs those who did not (50% [2 of 4] vs 50% [5 of 10]).

Conclusions: A significant increase was found in the incidence of iatrogenic ureteral injuries with laparoscopy compared with open colectomies. Preoperative stent placement did not ensure intraoperative identification of injury. Female sex and increased operative blood loss appear to predispose patients to injury.

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IATROGENIC URETERAL INJURY IS A serious complication that can occur during abdominal or pelvic operations. These rare injuries have a documented incidence of 0.3% to 1.5%.[1-5] Despite the low incidence rate, ureteral injuries can lead to significant morbidity. As such, it is important to determine whether injuries occur more frequently in a particular patient population or during specific operative circumstances. Prior studies[6-8] have identified resection of large pelvic masses, malignant neoplasms, inflammatory disease, previous operation, or radiation therapy as risk factors for ureteral injury. To date, no data are available regarding the rate of ureteral injury in laparoscopic compared with open colon resection. This study aimed to assess whether a difference in the risk of ureteral injury exists between laparoscopic and open colectomy.

METHODS

DESIGN AND SETTING

Following approval by The Mount Sinai School of Medicine Institutional Review Board, 14 patients with ureteral injuries after colorectal operations were identified from a prospectively maintained administrative database from June 1, 2005, through July 31, 2010. Complications occurring within 30 days of surgery are prospectively captured by our institution in a rigorously maintained online morbidity and mortality database. The database is cross-referenced with incident reports generated by patient readmission or additional operation within 30 days of the original procedure and institutionally measured quality performance indicators, including ureteral injury, to ensure comprehensive reporting.

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Table 1. Patient Demographics[a]

Demographic	Open Procedures (n = 7)	Laparoscopic Procedures (n = 7)
Sex		
Male	5	0
Female	2	7
Mean age, y	55	64
Mean body mass index[b]	26	27
Average ASA score	2.4	2.6
Surgical history		
None	2	5
Subtotal colectomy	2	0
Colectomy	2	0
Hartmann procedure	1	0
Ileocolic resection	1	0
TAH/BSO	1	0
Hysterectomy	0	1
Surgical indication		
Ulcerative colitis	3	1
Crohn disease	2	1
Colon cancer	0	3
Diverticulitis	0	2
Sarcoma	1	0
Hirschsprung disease	1	0

Abbreviations: ASA, American Society of Anesthesiologists physical classification system; TAH/BSO, total abdominal hysterectomy/bilateral salpingo-oophorectomy.
[a] Data are presented as number of patients unless otherwise indicated.
[b] Calculated as weight in kilograms divided by height in meters squared.

Table 2. Intraoperative Information[a]

Variable	Open Procedures (n = 7)	Laparoscopic Procedures (n = 7)
Patients with ureteral stents	2	2
Mean OR time, min	345	303
Mean EBL, mL	1629	336
Technique		
Restorative proctocolectomy	2	0
Low anterior resection	0	3
Abdominoperineal resection	1	0
Subtotal colectomy with RPC	0	1
Subtotal colectomy	0	1
Right hemicolectomy	0	1
Hartmann procedure	1	0
Ileocolic resection with colostomy	1	0
Ileocolic resection	0	1
Diverting ileostomy	1	0
Small-bowel resection	1	0

Abbreviations: EBL, estimated blood loss; OR, operating room; RPC, restorative proctocolectomy.
[a] Data are presented as number of patients unless otherwise indicated.

The hospital records of patients with a reported diagnosis of ureteral injury after ileocolostomy (*Current Procedural Terminology* [*CPT*] codes 44160 and 44205), partial colectomy with anastomosis (*CPT* codes 44140 and 44204), partial colectomy with coloproctostomy (*CPT* codes 44146 and 44208), and subtotal colectomy or restorative proctocolectomy with ileal-rectal or ileal pouch-anal reconstruction (*CPT* codes 44150, 44152, 44153, 44210, and 44211) were then retrospectively reviewed. Ureteral injury was confirmed by intraoperative identification or postoperative radiographic imaging.

Patients with complications secondary to placement of ureteral stents, ureteral injuries secondary to noncolorectal operations, and patients transferred from outside institutions with a diagnosis of ureteral injury were excluded from the study. Use of preoperative ureteral stents is not standard at our institution and is at the discretion of the individual surgeon.

Preoperative patient demographics, body mass index, medical and surgical history, radiation therapy, nutritional status, and operative indication were reviewed. Operative records were reviewed for placement of preoperative ureteral stents, operative time, estimated blood loss, operative technique, use of intraoperative diathermy devices, and intraoperative transfusion requirement. Ureteral injuries were reviewed for location of injury, timing of diagnosis, clinical presentation, diagnostic modality, and management. Patient postoperative outcome as determined by renal function, additional morbidity, and mortality was also assessed. In an attempt to be consistent with similar accounts in other studies evaluating for variability in surgeon experience, we stratified the general volume of surgical procedures performed by each surgeon in the recruitment period (low, <20; medium, 21-39; or high, >40) that resulted in a ureteral injury.[9]

STATISTICAL ANALYSIS

Statistical analysis was conducted via the Fisher exact test. Two-tailed $P < .05$ for associations was considered to indicate statistical significance. Prism 4.0 statistical software (GraphPad Software, Inc) was used for all analyses. All analyses were reviewed with a statistician.

RESULTS

From June 1, 2005, through July 31, 2010, 14 ureteral injuries after 5729 colorectal operations were identified, resulting in an overall incidence of 0.244%. **Table 1** lists the patient demographics, clinical history, and operative indication. Mean patient age was 59.3 years (range, 16-89 years). Of the 14 injuries, 9 (64%) occurred in females and 5 (36%) in males. Inflammatory bowel disease (n=7) and colorectal carcinoma (n=3) were the most common indications for operative intervention. Five of the patients with ureteral injuries during open procedures had undergone previous operations, whereas 2 of the patients with ureteral injuries during laparoscopic procedures had undergone previous operations.

Table 2 lists the intraoperative courses of patients with ureteral injuries. Review of operative records revealed that 7 procedures were laparoscopic and 7 open. One laparoscopic procedure was converted to open because of difficulty with adhesions during trocar port placement. Another conversion occurred during adhesiolysis with a tissue fusion device (LigaSure; Covidien) when it was noted that the ureter was injured. Stratification of the 5729 colorectal operations demonstrated that 4669 were open operations and 1060 laparoscopic. A significant increase in ureteral injuries occurred after laparoscopic vs open procedures (0.66% vs 0.15%, $P=.007$). Mean estimated blood loss was 982.1 mL (range, 0-7000 mL), and 4 patients underwent placement of preoperative stents.

Table 3 lists the location of injury, timing of diagnosis, clinical presentation, diagnostic modality, and management. Mean time to diagnosis of ureteral injuries not recognized in the operating room was 7.4 days (range, 1-16

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Table 3. Description of Ureteral Injuries by Specific Injury Type

Type of Ureteral Injury	Time of Diagnosis	Symptoms	Diagnostic Modality	Management
		Open Procedures (n = 7)		
Bilateral	POD 1	Anuria	Cystourethrogram	Bilateral nephrostomy tubes
Transected distal left	Intraoperative	None	Ureter noted	Ureteroneocystostomy
Transected middle right	POD 9	Confused, fever	Cystourethrogram	Ureteroureterostomy
Partial distal left	Intraoperative	None	Ureter noted	Ureteroureterostomy
Partial distal right[a]	Intraoperative	None	Exposed stent	Ureteroneocystostomy
Partial middle left[a]	POD 7	Fever	CT A/P	Nephrostomy tube
Partial middle right	Intraoperative	None	None	Ureteroureterostomy
		Laparoscopic Procedures (n = 7)		
Transected distal left	POD 2	Fever, increased JP output	Cystourethrogram	Ureteroneocystostomy
Transected distal left[a]	POD 16	Abdominal pain	Cystourethrogram	Ureteroneocystostomy
Transected proximal right	POD 1	Acute renal failure	Cystourethrogram	Nephrostomy tube
Transected proximal left[a]	Intraoperative	None	Exposed stent	Ureteroureterostomy
Transected distal left	Intraoperative	None	Cystourethrogram	Ureteroneocystostomy
Partial proximal left	Intraoperative	None	None	Ureteroureterostomy
Transected distal right	POD 16	Abdominal pain	Cystourethrogram	Nephrostomy tube

Abbreviations: CT A/P, computed tomography of the abdomen/pelvis; JP, Jackson-Pratt drain; POD, postoperative day.
[a] Patient with stent.

days). Fever (n=3) and anuria or decreased urine output (n=2) were the most common presenting symptoms for patients with postoperative diagnosis. Retrograde pyelogram was the most frequent diagnostic modality. For patients with preoperative ureteral stent placement, no difference was demonstrated in intraoperative vs postoperative identification of injury. Of the 4 patients with preoperative ureteral stent placement, 2 injuries were identified intraoperatively. Overall, 10 injuries were managed with operative intervention in the perioperative period and 4 by either ureteral stent placement or percutaneous nephrostomy. All patients with intraoperative identification of a ureteral injury were treated operatively. **Table 4** lists the postoperative renal function results and the 30-day and 1-year follow-up results. No difference in follow-up results was found between the laparoscopic and open groups. After 1 year, 2 patients required nephrectomies. One patient from the laparoscopic group required a nephrectomy due to a ureteroenteric fistula. Another patient from the open group required a nephrectomy secondary to a failed ureteroureterostomy. The 14 ureteral injuries occurred during procedures performed by several surgeons who performed a high volume of operations. No trends were noted.

Table 4. Patient Outcomes[a]

Outcome	Open Procedures (n = 7)	Laparoscopic Procedures (n = 7)
Mean preoperative creatinine level, mg/dL	0.93	1
Mean postoperative creatinine level, mg/dL	3.5	1.5
Mean postintervention creatinine level, mg/dL	0.89	0.9
30-Day follow-up		
Mortality	0	1
Sepsis	1	0
Intra-abdominal abscess	1	0
Deep venous thrombosis	1	1
Atrial fibrillation	0	1
Enterocutaneous fistula	1	1
Colovesical fistula	0	1
Rectal fistula	0	1
Dysuria	1	1
No complications	1	2
Not available	1	2
1-Year follow-up		
Nephrectomy	1	1
Ureteroneocystostomy	0	1
Stricture/stent placed	1	0
Stent removed	3	2
Not available	2	2

SI conversion factor: To convert creatinine to micromoles per liter, multiply by 88.4.
[a] Data are presented as number of patients unless otherwise indicated.

COMMENT

Although the advantages of laparoscopy over open colectomy are well documented, no study thus far adequately assesses whether the risk of ureteral injury significantly differs between the 2 approaches. This study identified a significantly increased incidence of ureteral injury after laparoscopic vs open colectomy (0.66% vs 0.15%, $P=.007$). Consistent with our findings, several studies[2,4,5,10,11] have demonstrated increased incidence of iatrogenic ureteral injuries in laparoscopic gynecologic procedures. Potential factors contributing to this increased incidence may include decreased tactile sensation and method of dissection. Our institution favors a medial to lateral approach in laparoscopic colectomy, which may inadvertently increase the incidence of retroperitoneal violation and ureteral injury. This hypothesis is currently under investigation.

Differences in surgical indication could also contribute to the increased incidence of ureteral injury among laparoscopic procedures. Colon cancer or diverticulitis was the indication for 5 of the laparoscopic procedures.

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None of the open procedures were performed for these reasons. Colon cancer and diverticulitis have been cited as risk factors for ureteral injury, potentially leading to an increased incidence of ureteral injury among laparoscopic patients in our study. However, inflammatory bowel disease has also been cited as a risk factor for ureteral injury and was the indication for 5 of the patients who underwent open procedures vs 2 of the patients who underwent laparoscopic procedures.

In addition, 5 of the open procedure ureteral injuries occurred in patients who had undergone prior surgery, whereas only 2 of the laparoscopic injuries occurred in patients who had undergone prior surgery. We would expect a higher incidence of ureteral injury in patients who had undergone previous surgery. Although our study illustrates a statistically significant increased incidence of ureteral injury during laparoscopic vs open colectomies, we note that the overall number of ureteral injuries remains small; thus, it is unknown whether this translates into clinical significance.

Placement of preoperative ureteral stents before colorectal operation is not standard at our institution and is left to the discretion of the individual surgeon. Most surgeons, however, elect to place stents before colorectal operations involving large masses, fistulizing inflammatory bowel disease, or diverticular disease and in patients who have undergone prior pelvic surgery. This practice is based on literature advocating for prophylactic ureteral stent placement, citing that it aids in identification of the ureters, may reduce the risk of intraoperative ureteral injury, and, if injury occurs during surgery, can improve injury detection.[8,10,12-14] Interestingly, our study demonstrates that preoperative stent placement did not ensure intraoperative identification of injury. Intraoperative identification of injury occurred in only 2 of the 4 patients in whom preoperative stents were placed. Although ureteral stents may be helpful, intraoperative identification of injury is not guaranteed. Moreover, prophylactic ureteral catheterization remains controversial given that the risk of injury during initial placement is approximately 1.1%.[14-17] As such, preoperative stent placement should be tempered with risk assessment for potential complications from stents.

Although injuries can be detected intraoperatively or postoperatively, intraoperative recognition and immediate repair of ureteral injuries result in fewer complications and reduced renal function loss.[3] Unfortunately, most iatrogenic ureteral injuries are detected postoperatively.[18] These patients typically present with flank pain, fever, abdominal pain and distention, ileus, decreased urine output, or increased drainage from the drain site.[10] This study demonstrates no difference in the time of injury recognition by operative approach.

In addition, although not statistically significant, a trend toward increased incidence of ureteral injury was identified in females undergoing colorectal operations and in operations with large intraoperative blood loss. A potential reason for increased ureteral injury rate among female patients is abdominal and pelvic anatomy. We hypothesize that the significant blood loss may compromise visibility, increasing the risk of ureteral injury, particularly in laparoscopic procedures. Further studies are required to assess the potential link between sex and ureteral injury and blood loss and ureteral injury.

Limitations of this study include the retrospective review, patient sample size, and inherent bias associated with a heterogeneous population of surgeons and operative procedures. Further studies using national data to compare iatrogenic ureteral injuries in open and laparoscopic bowel resections are needed.

To our knowledge, our study is the first to compare the ureteral injury rate between patients who have undergone laparoscopic and open bowel resections. Awareness of potential ureteral injury during both open and laparoscopic bowel resections is warranted, and special attention should be given to laparoscopic procedures. The risks and benefits of prophylactic ureteral catheterization should be carefully weighed before laparoscopic and open colectomies are performed.

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INVITED CRITIQUE

Ureteral Injury During Laparoscopic Colectomy

The Need for More Information

Palaniappa and colleagues[1] describe the rate of ureteral injury in laparoscopic and open colorectal surgery at a single high-volume institution. Although the overall incidence of ureteral injury is low in this cohort, it is significantly higher in the laparoscopic compared with open surgery group. Detailed records of each patient who sustained an injury are included: presenting symptoms, diagnostic tests, location of injury, treatment, and follow-up. These are insightful details that are lacking from large studies based on administrative data. One important finding in this study is the long-term effect of these injuries, including significant reductions in renal function and the need for nephrectomy in 2 of 14 patients.

This study is reminiscent of the high rate of bile duct injuries seen in the early years of laparoscopic cholecystectomy compared with traditional open cholecystectomy. As surgeons were learning the procedure, the bile duct injury rate was 2.2% but then decreased to 0.1% to 0.5% with experience.[2,3] It was puzzling at first that the bile duct injuries persisted even after surgeons were experienced and facile with the procedure. Using human factors and cognitive analysis, it is now clear that injuries are the result of misperception of the anatomy, not a lack of skill, knowledge, or judgment.[4] Although ureteral injury is unlikely to be the result of a misidentification of anatomical structures, further study (review of operative dictations and videotapes) is needed to understand the cause of the higher rate of ureteral injury in laparoscopic colorectal surgery so training tools can be developed to raise awareness of potential pitfalls and prevent injury.

This article is particularly timely because there is a national call to increase the adoption of laparoscopic colorectal surgery. Laparoscopy has been put forth as a strategy for reducing surgical site infections (SSIs) after colorectal surgery. A series of recent articles[5,6] have reported that laparoscopic colorectal surgery has a lower SSI rate. Beginning in 2012, SSI after colorectal surgery will be reported publicly. Implementation of process measures for reduction of SSIs has been disappointing.[7-9] Therefore, surgeons may look to laparoscopy to lower their rate of SSIs. On the basis of this study, adoption of laparoscopy under these circumstances might reduce SSI rates but could also have the unintended consequence of a small but significant increase in the rate of ureteral injury.

In summary, Palaniappa and colleagues'[1] detailed description of ureteral injuries during laparoscopic and open colorectal surgery is insightful, and further investigation is needed to better understand mechanisms of injury prevention.

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