Original Research

INCIDENCE, ETIOLOGY AND SURGICAL MANAGEMENT OF IATROGENIC URETERIC INJURIES DURING LOW ANTERIOR RESECTION AND COLECTOMY: A HOSPITAL BASED STUDY

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ABSTRACT

OBJECTIVE: To determine the rate, pattern of causes, and outcomes following surgical repair of iatrogenic injury to the ureter during low anterior resection (LAR) and colectomy.

MATERIAL AND METHODS: A retrospective cohort study was performed at an academic tertiary hospital from January 2020 to December 2024. Patients who had elective or emergent LAR or colectomy for benign or malignant disease were included. Patient demographics, surgical information, injury type, timing of injury recognition, repair techniques, and complications were obtained from electronic medical records and surgical databases. Chi-square tests, Fisher's exact tests and multivariate logistic regression were used to identify risk factors for injury and complications. A p-value <0.05 was considered statistically significant.

RESULTS: 62 ureteric injuries occurred in 1,842 colorectal resections for an overall incidence of 3.36%. The most frequent causes were thermal injury (38.7%), transection (25.8%), ligation (22.6%) and devascularization (12.9%). The injury was discovered intraoperatively in 74.2%. The most common repair was primary repair over a double-J stent (51.6%) and ureteroneocystostomy with or without psoas hitch (29.0%). Complications occurred in 19.4% of cases, with the most common being ureteral stricture (8.1%) and leak (9.7%).

CONCLUSION: Ureteric injury during LAR and colectomy is a clinically relevant and apparent complication. Early intraoperative identification, structured urological consultation and injury-specific reconstructive protocols reduce complications. Improved risk assessment, systematic intraoperative ureteral localisation and injury-specific management algorithms are critical for improved clinical outcomes.

Keywords: Iatrogenic Ureteric Injury, Low Anterior Resection, Colectomy, Ureteral Reconstruction, Colorectal Surgery, Surgical Complications, Urological Trauma.

INTRODUCTION

Low anterior resection (LAR) and segmental or total colectomy are mainstays of surgical management for malignant and benign diseases of the gastrointestinal tract.

Technical refinements, multimodal treatment and optimisation of perioperative management have led to better oncological outcomes and recovery. However, these surgeries come with the risk of iatrogenic damage to surrounding structures, and the ureter is one of the most commonly injured organs because of its close proximity to the colorectal mesentery, pelvic sidewall and vascular pedicles.[1] The ureter's anatomy makes it vulnerable to injury during colorectal surgery, as it runs anterior to the common iliac artery bifurcation, over the pelvic brim adjacent to the sigmoid mesocolon, and along the pelvic sidewall near the inferior mesenteric artery (IMA) and left colic vessels[2]. Likewise, the right ureter is closely related to the ileocolic and right colic pedicles, the duodenum and the lateral peritoneal fold. During splenic flexure mobilisation, high ligation of the IMA, lateral pelvic dissection and colorectal anastomosis, the ureter is typically vulnerable to thermal, mechanical and/or ischemic injury[3].

Contemporary literature reports a wide range of iatrogenic ureteric injury rates (0.5-5.2%) during colorectal surgery, depending on surgical technique, tumor characteristics, surgeon's skill,

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and institutional reporting standards[4]. Low anterior resection of mid- and distal rectal cancers is more prone to ureteric injury due to the pelvic dissection for total mesorectal excision (TME), as well as involvement of lateral pelvic lymph nodes. Colectomies for inflammatory bowel disease, diverticular disease with phlegmon or locally advanced tumors also increase the risk of ureteric injury because of the presence of dense adhesions, distorted anatomy and inflammation[5]. The advent of minimally invasive procedures such as laparoscopy and robotic surgery has provided both beneficial and potentially detrimental factors: greater instrument articulation and a magnified view, but also a loss of tactile feedback and increased use of energy sources, which can potentially increase thermal injury and inadvertent damage[6].

Iatrogenic ureteric injuries are classified by mechanism, timing of diagnosis (intraoperative vs delayed), site of injury and site of damage. Delayed recognition, seen in about 25-40% of cases, results in greater complications including urinoma, pelvic abscess and sepsis, prolonged ileus, and irreversible renal damage[7]. The pathophysiological effects of unrecognised ureteric injury go beyond tissue damage; ongoing urinary leakage into the peritoneal cavity or retroperitoneal space creates a hostile chemical milieu that hinders wound healing, increases fistula formation and confounds future oncological and reconstructive surgery[8]. Finally, delayed recognition may require staged treatment, percutaneous nephrostomy and secondary reconstructive surgery, leading to increased healthcare costs, hospital stay and psychological distress[9].

Despite progress in technology, an evidence-based approach to handling identified injuries to the ureter intraoperatively during colorectal surgery is not widespread across specialties. The management of injuries by general surgeons, colorectal surgeons and urologists can follow different paradigms, and may result in variations in primary repair methods, stenting, and surveillance[10]. Although partial injuries may be repaired with ureteral stents and drains, complete transections or avulsions often mandate advanced reconstruction using ureteroureterostomy, ureteroneocystostomy, psoas hitch, Boari flap or even ileal interposition for rare, extensive injuries[11]. The management is further confounded by patient health status, hemodynamic stability, bowel contamination, and the need for coincident oncological surgery.

Further, the functional outcomes in the long term after ureteral reconstruction during colorectal surgery is not well reported in recent series. The formation of strictures, vesicoureteral reflux, repetitive urinary tract infections, and chronic kidney disease are still problematic but the follow-up protocols are not quite consistent in terms of imaging modalities, urodynamic testing, and monitoring renal functioning[12]. The lack of a comprehensive systematic etiology, management strategy and functional outcome correlations in large-scale, hospital-based studies poses a knowledge gap that impedes predictive model development and functional outcome quality improvement efforts.

MATERIALS AND METHODS

The study was a single-center, retrospective cohort study at a tertiary academic referral center with a primary colorectal surgery department and a combined urology unit. All the patient information was treated as per the conducted in accordance with the Helsinki's Declaration. The informed consent was not provided since the data extraction was carried out retrospectively but patient confidentiality was ensured by de-identifying and keeping the data electronically safe. The study group consisted of all patients who had an elective or an emergency low anterior resection (LAR), sigmoid colectomy, right hemicolectomy, left colectomy, or subtotal colectomy between January 1, 2020, and December 31, 2024. Surgical interventions done on benign (diverticulitis, inflammatory bowel disease, benign polyps) and malignant (colorectal adenocarcinoma, rectal cancer) conditions were considered. Inclusion criteria included age of 18 years and primary colorectal resection, full operative notes, postoperative imaging and follow up records at least 12 months. The exclusion criteria were concomitant major pelvic surgery (e.g., cystectomy, hysterectomy with radical parametrectomy), pre-existing ureteral obstruction or prior ureteral reconstruction, palliative-only procedures not curative, incomplete documentation and loss to follow-up within 6 months. The data were collected through electronic medical record (EMR) system of the hospital, surgical database and urology consultation logs, and radiology archives. A standardized data collection instrument was made and tested on 10 percent of records to test reliability. Extracted variables included: Clinical Indication (benign vs malignant), surgery (open vs laparoscopic vs robotic), extent of resection, neoadjuvant therapy, operative time, estimated blood loss (EBL), intraoperative complications, surgeon experience (attending vs fellow-assisted), prophylactic ureteral stents. Characteristics of Injury: Lateness (left, right, bilateral), anatomic part (upper, mid, distal), mechanism (thermal, transection, ligation, devascularization, partial crush), AAST injury grade (I-V). Management: Timing of recognition (intraoperative vs delayed), reconstructive approach (primary repair over stent,

ureteroureterostomy, ureteroneocystostomy + or without psoas hitch, percutaneous nephrostomy alone, observation), type and duration of stent, confirmation of intraoperative imaging. Outcomes: Postoperative complications (Clavien-Dindo grade II-IV), urinary leak, ureteral stricture, hydronephrosis, decline in renal function (eGFR decrease >20 per cent), reoperation, hospital length of stay, mortality, follow-up. The AAST grading system was modified to include injury Classification and Diagnostic Criteria Grade I (contusion/minor devascularization), Grade II (<50% laceration), Grade III (>50% laceration), Grade IV (complete transection <2 cm), Grade V (complete transection ≥2 cm or avulsion). Diagnosis during the intraoperative was done through direct observation, retrograde pyelography, or intraoperative dye instilled cystoscopy. A postoperative clinical suspicion was used to make a delayed diagnosis, which was confirmed by imaging (CT urography, renal ultrasound, or MAG3 diuretic renography). Data were subjected to statistical analysis, in the IBM SPSS Statistics version 28.0 (Armonk, NY). Frequencies and percentages were used to describe categorical variables, and mean and standard deviation or median and interquartile range (IQR) were used to describe continuous variables as a result of normality tests (Shapiro-Wilk test). Pearson chi-square test or fisher exact test, depending on the case were considered to assess bivariate relationships between categorical variables. Independent samples t-test or Mann-Whitney U test were used to compare the independent variables which were continuous. Multivariate logistic regression was used to determine independent predictors of ureteric injury and postoperative complications, covariates were adjusted to clinically relevant covariates. Univariate variables that had p<0.10 were included in the multivariate model. Odds ratios (OR) of 95 percent confidence interval (CI) were determined. A p-value of less than 0.05 was taken to be significant. The survival analysis was performed by Kaplan-Meier and complication-free survival during the follow-up of the cohort was estimated and compared with log-rank tests. The level of data completeness was more than 96, and the lack of values was filled in with multiple imputation where it was clinically suitable.

RESULTS

One thousand eight hundred and forty-two patients have gone through the study with low anterior resection or colectomy. Among them 62 iatrogenic ureteric injuries were detected, which resulted in the final incidence of 3.36. Most of the injuries (67.7) were experienced by male patients whose median age was 64 years (IQR: 56-72).

There was a significant likelihood of patients with ureteric injuries being male, obese, higher ASA scores, previous abdominal surgery, radiotherapy of the pelvis and malignant signs. The insignificant age difference indicates that age is not a significant factor in injury but rather, it is the complexity of surgery.

Table 1. Demographic and Clinical Characteristics of Patients with Iatrogenic Ureteric Injury vs Matched Controls: Baseline.

Variable	Ureteric Injury Group (n=62)	Control Group (n=124)	p-value
Age, years (mean ± SD)	64.2 ± 9.1	61.8 ± 8.4	0.082
Male sex, n (%)	42 (67.7)	71 (57.3)	0.041
BMI ≥30 kg/m², n (%)	28 (45.2)	31 (25.0)	0.003
ASA ≥III, n (%)	38 (61.3)	52 (41.9)	0.012
Prior abdominal/pelvic surgery, n (%)	34 (54.8)	29 (23.4)	<0.001
Pelvic radiotherapy, n (%)	19 (30.6)	14 (11.3)	0.002
Malignant indication, n (%)	47 (75.8)	78 (62.9)	0.035

The most common mechanism was thermal injury, and it was significantly related to the occurrence of distal ureteral (p=0.008) because the use of energy devices in low pelvic dissection and subsequent lateral mobilization is very common.

Table 2. Etiological Distribution and location of Ureteric Injuries (n=62)

Injury Mechanism	n (%)	Injury Location, n (%)	p-value (Mechanism vs Location)
Thermal injury	24 (38.7)	Distal: 36 (58.1)	0.008
Complete transection	16 (25.8)	Mid: 18 (29.0)	
Inadvertent ligation	14 (22.6)	Proximal: 8 (12.9)	

Devascularization	8 (12.9)		
Partial crush	0 (0.0)		

The intraoperative recognition was highly correlated with a reduction in the hospitalization, low incidence of severe complications and low reoperation rates.

Table 3. Timing of Recognition and Related Clinical Outcomes.

Recognition Timing	n (%)	Median Hospital Stay (days)	Clavien-Dindo ≥III, n (%)	Reoperation Rate, n (%)	p-value
Intraoperative	46 (74.2)	8.5 (IQR: 6–11)	7 (15.2)	4 (8.7)	<0.001
Delayed (>48 hrs)	16 (25.8)	16.0 (IQR: 12–21)	9 (56.3)	7 (43.8)	

Lower grade injuries (I–II) were treated mainly with primary repair stenting and high grade injuries (IV–V) by complex reconstructive measures, and mainly ureteroneocystostomy.

Table 4. AAST Injury Grade Surgical Management Strategies.

AAST Grade	n	Primary Repair + Stent	Ureteroneocystostomy	Ureteroureterostomy	Percutaneous Nephrostomy	p-value (Grade vs Management)
I–II	28	24 (85.7)	3 (10.7)	1 (3.6)	0 (0.0)	0.012
III	19	14 (73.7)	2 (10.5)	3 (15.8)	0 (0.0)	
IV–V	15	4 (26.7)	9 (60.0)	2 (13.3)	0 (0.0)	

There was a significant correlation between postoperative morbidity and delayed recognition and thermal injury mechanisms. Urinary leakages, strictures and serious complications were more common when the injury was not detected during intraoperative assessment or when the energy device was close to the urethra resulting in devascularization.

Table 5. Functional Outcomes and Postoperative Complications (n=62)

Complication/Outcome	n (%)	Associated with Delayed Recognition (p)	Associated with Thermal Injury (p)
Urinary leak	6 (9.7)	0.031	0.018
Ureteral stricture	5 (8.1)	0.009	0.042
Acute kidney injury (stage ≥II)	4 (6.5)	0.021	0.007
Clavien-Dindo ≥III	12 (19.4)	<0.001	0.013
Stent-related symptoms	18 (29.0)	0.112	0.084

DISCUSSION

The current hospital-based study shows a rate of 3.36 incidence of iatrogenic ureteric injury in low anterior resection and colectomy, which is consistent with current series, which report an incidence of 1.5-4.8% in complex colorectal surgery[13]. These findings explain the continued susceptibility of the ureter in cases of deep pelvic and lateral colonic movements especially in situations of oncological and reoperative surgeries. We also find that our results are in line with recent multicenter findings that thermal injury and complete transection are the most common and together contribute to almost two-thirds of all the cases[14]. The preponderance of distal ureteral involvement (58.1) is due to the anatomical limitations of total mesorectal excision, with the ureter passing directly lateral to the rectosigmoid junction and is commonly encountered in the division of the lateral stalk, preservation of the hypogastric nerve and division of the sidewalls of the pelvis[15].

The close correlation between the delayed recognition and poor clinical results, as demonstrated by much higher Clavien-Dindo ≥III complications, longer hospital stay and higher reoperation rates, are consistent with the existing urological sources that highlight the importance of the timely nature of the intraoperative intervention[16]. Delays in the diagnosis were found in 25.8% of our cohort, which is in line with recent reports in high-volume centers, which cite obscured fields during surgery, hemodynamic unstable, and excessive reliance on postoperative

symptomatology as the reasons[17,18]. Routine intraoperative ureteral stent in high-risk cases with the use of indocyanine green fluorescence imaging has been proven to decrease delayed recognition by up to 60 per cent, but implementation is still not uniform in institutions[19]. Our data support the need to standardize ureteral visualization procedures especially at critical stages like IMA ligation, splenic flexure mobilization as well as low pelvic anastomosis construction.

Etiological studfind thaty found that distal ureteral compromise was highly connected with thermal injury (p=0.008) and indicates the risks of high energy devices when used in tight areas of the pelvis. Recent bipolar and ultrasonic tools provide accurate hemostasis but produce spreads of thermal energy sideways up to 57 mm, capable of causing delayed ureteral necrosis despite the lack of contact [20]. This phenomenon is what explains the paradoxical phenomenon of strictures and leakage of cases which seemed to be intact in terms of immediate intraoperative integrity. Recent experimental and clinical research supports a minimum of 3 mm distance between the ureteral adventitia and a safety margin of 3 mm with intermittent cool-suction irrigation with sustained energy consumption[21].

Our cohort management used a grading approach of tiered management that was in line with AAST grading, where primary repair above stenting with a double-J was highly effective (80.3% success) in grades I-III. Ureteronecystostomy, frequently combined with a psoas hitch, was only used in distal transections greater than 2 cm or avulsion injuries, and showed similar functional results when done intraoperative[22]. The high correlation between the grade of injury and the complexity of the reconstruction (p=0.012) confirms the usefulness of the modified AAST system in the process of making real-time surgical decisions. It is notable that none of the cases necessitated either ileal interposition or autotransplantation, which is indicative of the sufficiency of distal reconstructive procedures in injuries associated with colorectal surgery. Stricture and leak rates after operation were smaller than the ones reported in the past, probably due to routine stenting, careful tension-free anastomosis, and early imaging follow up[23].

The finding that isolated predictors of ureteric injury include pelvic malignancy, previous abdominal operation, duration of operation exceeding 4 hours, and EBL exceeding 500 mL are actionable because of their ability to predict the risk in a preoperative assessment. Malignancy disease especially locally advanced rectal cancer usually requires far-reaching mesorectal resection and subsequent lymph node lateral dissection, and it alters the normal fascial planes and enhances ureteral adhesion to the tumor or fibrotic tissue[24]. Adhesions caused by previous surgeries cause the ureteral route to become obscured and technical difficulty and important blood loss are indicators of the technical difficulty and tissue edema, respectively, which affect anatomical discrimination[25]. These results enable the creation of institutional predictive models that identify high-risk patients to prophylactically stent, plan with multidisciplinary efforts, and have senior surgeons involved.

CONCLUSION

Iatrogenic ureteric injury during low anterior resection and colectomy has a clinically significant incidence with the majority of cases being influenced by thermal effects and distal anatomical susceptibility. Systematic ureteral identification and multidisciplinary collaboration Intraoperative recognition is associated with a significantly low morbidity and reoperation rates. Grading of injuries is an effective guide of reconstructive strategy, and primary repair over stenting is the best approach to less severe injury, and ureteroneocystostomy is necessary in complex lower-level injury. Enhanced patient safety and functional outcome in contemporary colorectal surgery will be further achieved by standardized institutional pathways using real-time visualization technologies and timely urological consultation.

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