



Does Early Ureteroneocystostomy After Iatrogenic Ureteral Injury Jeopardize Outcome?

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OBJECTIVE	To compare the outcomes of patients who underwent early repair (≤ 7 days) of iatrogenic ureteral injury with ureteroneocystostomy and compare them to those repaired in a delayed fashion (> 7 days).
METHODS	A retrospective review of billing data between 2012 and 2018 identified patients who underwent ureteroneocystostomy for a benign ureteral disease. Inclusion criteria included all ureteral injuries related to a laparoscopic, robotic, or open surgical injury. Patients with ureteral injury related to radiation, stones, or reconstructive surgery were excluded. Patients undergoing reconstruction during the initial injury or within ≤ 7 days were designated as having undergone early repair, while the remaining were considered delayed repair. Demographics, as well as inpatient and postdischarge data were acquired, and statistical analysis was performed comparing the 2 groups.
RESULTS	Sixty-seven patients met inclusion criteria. Early repair was performed on 12 patients, while 55 underwent delayed repair. No significant difference in age, gender, Charlson Comorbidity Score, laterality, stricture location, or history of pelvic/abdominal radiation was noted. Inpatient complications were significantly higher in the immediate group (58 vs 18%, $P = .004$). Thirty- and 90-day complications were similar. Two patients in the delayed group and none in the immediate group demonstrated stricture recurrence ($P = .710$). A higher rate of Boari flap ureteral reconstruction was performed in the delayed cohort ($P = .001$).
CONCLUSION	In this cohort, there was no detectable difference in outcomes when comparing early and delayed ureteroneocystostomy for iatrogenic ureteral injuries. UROLOGY 136: 245–250, 2020. © 2019 Elsevier Inc.

Ureteral injury is an uncommon but relevant complication of abdominopelvic surgery.¹ Surgeries most frequently associated with a ureteral injury include gynecologic, colorectal, and urologic.^{2–4} Reconstruction of a distal ureteral injury frequently requires a ureteroneocystostomy, which can be performed open, laparoscopically, or with robotic assistance.^{1,5–8} The timing of repair is dependent on when the injury was identified, characteristics of the injury, mechanism of injury, patient factors (eg, presence of infection, radiation damage, intraoperative stability), and surgeon factors (eg, surgeon availability and experience). The optimal time for reconstructing an injured ureter has not been established. Patients with ureteral injury identified immediately or soon after the inciting surgery who undergo early repair (ER) may experience decreased morbidity.⁹ Patients who undergo a delayed approach often spend several months

with increased morbidity due to the potential presence of a nephrostomy tube, drain, or urethral catheter, which can be associated with pain, infection, and increased health care visits. Despite these issues, there can be legitimate reasons why it may be in the best interest of a patient to undergo a delayed repair (DR). One concern is whether the true extent of the intraoperative injury is identifiable at the time of surgery. Cautery injury may lead to ischemia that may not manifest until days to weeks later. An attempt to perform a ureteroneocystostomy without full knowledge of the extent of cautery effect may lead to failure due to stricture recurrence. Also, a trial of ureteral stenting may be sufficient treatment for mild injuries, which may allow avoidance of the morbidity of ureteral reconstruction.

We sought to determine whether outcomes differed between patients who underwent early ureteroneocystostomy for an iatrogenic ureteral injury, vs those who underwent a delayed approach. We hypothesized that there would not be any detectable difference in complications or outcomes between the 2 groups, and early ureteroneocystostomy could be safely performed when clinically appropriate.

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METHODS

After institutional IRB-approval, we identified all patients who underwent a ureteroneocystostomy January 2012 and March 2018 using billing data (CPT codes 50780, 50782, 50783, 50785, 50947, 50948, and 50949). Retrospective chart review was performed and patients who underwent ureteroneocystostomy for treatment of a ureteral injury related to a laparoscopic, robotic, or open surgical procedure were included in the study cohort. Patients undergoing ureteroneocystostomy for ureteral strictures related to previous radiation therapy, complications from ureterolithiasis or ureteroscopy, and previous ureteral reconstructive surgeries were excluded.

Demographics, details of the ureteral injury and reconstruction, inpatient and postdischarge data were collected from the electronic medical record. Per our standard pathway, all patients undergoing DR had a prior retrograde or antegrade ureterogram within 3 months of the ureteral reconstruction, which was used to characterize the location and extent of the injury. Patients who underwent ureteroneocystostomy between the time of initial intraoperative injury and 7 days after the causative surgery were designated as having undergone ER. Seven days was chosen based on the practice pattern at our institution to offer ER to ureteral injuries identified within 7 days of injury. Those that underwent ureteroneocystostomy >7 days after the injury were considered as having undergone DR. Patients who underwent ER were compared to DR patients. Our primary outcome was radiologic failure, defined as recurrent hydronephrosis on ultrasound, computed tomography, or magnetic resonance imaging, obstruction on MAG3 diuretic nuclear medicine dynamic renal imaging (with $t_{1/2} > 20$ minutes), or identification of stricture on retrograde pyelogram or antegrade nephrostogram as defined as a narrowed ureteral lumen with proximal hydroureter. At the time of this cohort, a standard radiologic follow-up protocol did not exist and was determined by the surgeon. Statistical analysis was performed using SPSS statistical software (IBM, Armonk, NY). Continuous variables were analyzed using a 2-tailed *t*-test,

while chi-squared testing was performed for categorical variables. A *P* value <.05 was considered significant.

RESULTS

A total of 67 patients were identified. ER was performed on 12 patients by 11 unique urologists, all of whom were repaired at the time of the intraoperative ureteral injury. The remaining 55 underwent DR by 11 surgeons with a mean time to repair of 9.2 months. Demographic data are displayed in Table 1. The distribution of Charlson comorbidity scores amongst each group varied significantly, with a higher rate of patients in the ER group having a high Charlson comorbidity score (*P* <.05). The surgeries that led to ureteral injury were similar in each group (*P* =.53), with the majority being due to gynecologic or colorectal surgery. Seven iatrogenic ureteral injuries managed with DR were due to vascular surgery (3), spinal surgery (3), or prostatectomy (1). No significant difference in ureteral injury location was noted between the groups (*P* =.38).

Intraoperative and postoperative results are presented in Table 2. ER was associated with a longer mean total operative time (431 vs 228 minutes, *P* <.01) and median estimated blood loss (900 vs 100 mL, *P* =.02), although this included the nonurologic surgery in the ER group. Primary ureteroneocystostomy or psoas hitch was performed in 11 (92%) ER patients, as compared to 28 (51%) DR patients. Boari flap was performed more frequently in those that underwent a delayed approach (*n* = 27, 49%) than those performed early (*n* = 1, 8%).

A significantly higher rate of patients who underwent ER experienced a complication while inpatient (58% vs 18%, *P* <.01), but no difference was seen in the severity of inpatient complications, the number of outpatient complications or readmission (Table 2). Both ER and DR groups were followed similarly with imaging (15 vs 15 months, *P* =.98). Over this interval, 0 and 2 failures (*P* =.71) in the ER and DR groups

Table 1. Patient demographics and details of the iatrogenic ureteral injury

	Early Reconstruction <i>n</i> = 12	Delayed Reconstruction <i>n</i> = 55	<i>P</i>
Age, years mean (SD)	47.9 (15)	49.2 (13)	.51
Gender, <i>n</i> (%)			.57
Male	1 (9)	8 (15)	
Female	11 (91)	47 (85)	
Charlson Comorbidity Score, <i>n</i> (%)			.048
0 (Low)	5 (42)	20 (36)	
1-3 (Moderate)	1 (8)	23 (42)	
≥4 (High)	6 (50)	12 (22)	
Laterality, <i>n</i> (%)			.64
Left	7 (58)	28 (51)	
Right	5 (42)	27 (49)	
Ureteral injury location, <i>n</i> (%)			.38
Mid-ureter	0 (0)	8 (15)	
Iliac vessels	2 (17)	8 (15)	
Distal ureter	10 (83)	39 (71)	
Cause of ureteral injury, <i>n</i> (%)			.532
Colorectal surgery	4 (33)	17 (31)	
Gynecologic oncology surgery	3 (25)	8 (15)	
Benign gynecologic surgery	5 (42)	23 (42)	
Other	0 (0)	7 (13)	

Table 2. Intraoperative and postoperative outcomes

	Early Repair <i>n</i> = 12	Delayed Repair <i>n</i> = 55	<i>P</i>
Op time*, min mean (SD)	431 (160)	228 (96)	<.001
EBL*, cc median (range)	900 [100-2500]	100 [10-1300]	.017
Surgery type, <i>n</i> (%)			.001
Primary Ureteroneocystostomy	11 (92)	19 (35)	
Psoas Hitch/Boari flap	1 (8)	36 (65)	
Surgery approach, <i>n</i> (%)			.23
Open	12 (100)	49 (89)	
Robotic	0 (0)	6 (11)	
Length of stay, days	6.5 (2-13)	3 (1-13)	.228
median (range)			
Urethral catheter duration, days	11 (3-40)	13 (1–38)	.230
median (range)			
Ureteral stent duration, days	38 (24-89)	34 (18-119)	.255
median (range)			
Inpatient complication, <i>n</i> (%)	7 (58)	10 (18)	.004
Inpatient complication type†, <i>n</i> (%)			.79
Clavien 1 or 2	6 (50)	9 (16)	
Clavien 3 or 4	1 (8)	1 (2)	
Outpatient complication, <i>n</i> (%)			
30 day	5 (42)	13 (24)	.412
90 day	7 (58)	20 (36)	.160
Readmission, <i>n</i> (%)	6 (50)	14 (25)	.229
Radiologic failure, <i>n</i> (%)	0 (0)	2 (4)	.710
Radiologic follow up, months	15 (16)	15 (16)	.952
mean (SD)			
Symptomatic follow up, months	27 (16)	22 (18)	.339
mean (SD)			

* Includes nonurologic surgery.

† There were no Clavien 5 complications.

respectively. The 2 failures were subsequently managed with chronic ureteral stenting (1) and salvage ureteroneocystostomy with Boari flap (1).

DISCUSSION

In this retrospective study of patients who underwent ureteroneocystostomy with or without psoas hitch or Boari flap for iatrogenic ureteral injury from laparoscopic, robotic, or open surgery, we evaluated the relationship between the timing of reconstruction and outcomes. Patients who underwent early ureteral repair were found to have similar outcomes to those who were managed via a delayed approach. No significant differences in outpatient complications, readmission, or radiologic failure were detected. Although the location of ureteral injury was similar between the groups, a higher rate of Boari flap was performed in the delayed group. Our study demonstrates that ER of an iatrogenic ureteral injury can be performed safely without jeopardizing outcomes. To our knowledge, our study is the largest to compare outcomes between early and delayed ureteroneocystostomy for iatrogenic ureteral injury, demonstrating the feasibility of ER.

There are several concerns about early ureteral reconstruction after iatrogenic ureteral injury. The true extent of the injury may take several weeks to fully manifest, supporting a delayed approach to allow permanently injured tissue to present itself. Ostrzenski et al¹⁰ presented a review of 70 ureteral injuries from 2491 laparoscopic

gynecologic surgeries and found that electrocautery was involved in 24.3% of cases. Han et al¹¹ reported 11 patients who underwent immediate laparoscopic ureteroneocystostomy or ureteroureterostomy for ureteral injury. Three patients (27%) had stricture recurrence requiring an additional intervention, a higher failure rate than what is typically reported. One explanation for this high rate of failure is the progression of unrecognized ischemic injury leading to stricture development.

In our series, we report 12 patients who sustained an iatrogenic ureteral injury and underwent early ureteral reconstruction. No failures were detected with a mean radiologic follow-up of 15 months and symptomatic follow-up of 27 months, and outpatient complications and readmission occurred at a similar rate to the delayed reconstruction cohort, supporting the belief that early ureteroneocystostomy is feasible without jeopardizing outcomes.¹² We noted that our ER cohort was performed by 11 different surgeons. As ureteroneocystostomy is a basic tenant of urologic surgery, urologists should understand that it is acceptable to perform ER if appropriate, and does not need to be performed by high-volume surgeon.¹³

Although the injury may worsen over time, improvement can also be seen as tissue trauma heals. Decompression with a percutaneous nephrostomy tube or indwelling ureteral stent may allow the surrounding tissue to recover and allow the proximal margin of the healthy ureter to be more distal than was evident intraoperatively at the time of injury. This may allow an easier reconstruction and

make a primary ureteroneocystostomy more likely. In our series, we found that a delayed approach was associated with the increased use of a Boari flap reconstruction (49% vs 8%, $P < .01$), despite no significant difference in the location of the ureteral injury ($P = .38$). The difference in the rate of Boari flap is likely multifactorial. Location is only one factor that contributes to the complexity of a ureteral injury. Increasingly complex injuries may have preferentially been temporized with a percutaneous nephrostomy tube or ureteral stent and subsequently approached in a delayed fashion. Due to the retrospective nature of our study, the complexity of the injury and its influence on the approach of reconstruction is challenging to determine. In a similar fashion, most early ureteral repairs were performed by the on-call urologist, who was not necessarily someone who specialized in genitourinary reconstruction. This may lead to a different comfort level with performing reconstruction of more complex injuries, particularly those who had delayed detection.

Cautery injuries not detectable at the time of the injury may progress proximally as they fully manifest, which could subsequently require a Boari flap for reconstruction. Progression of ureteral strictures during the delayed approach may also be secondary to ureteral stent-related fibrosis or recurrent UTI's. As the ureteral stricture travels proximally, there is a higher chance that a Boari flap is required to traverse the gap between the healthy ureter and the bladder.

During a delayed approach, postsurgical fibrosis of the periureteral and peri-vesical regions is allowed to set in. The extent of fibrosis can be quite severe, particularly when a patient develops a urinoma. The degree of fibrosis can significantly impact the complexity of ureteral reconstruction to the point that a patient requires a ureteral transection higher than the location of injury rather than attempting to perform a complex distal ureterolysis. This may convert the case from a primary ureteroneocystostomy to a Boari flap.

Although limited to a few series, the success rate of Boari flap ureteral reconstruction reported in the literature is high.¹⁴ We similarly noted no increased failure rate when a Boari flap was utilized, however there are likely unmeasured consequences that would make a less complicated reconstruction preferable when feasible. Bothersome postoperative voiding symptoms after ureteral reconstruction has not been studied, however anecdotally seems to be worse in patients who require a Boari flap. This may lead to higher utilization of pharmacologic and procedural interventions for Boari flap patients. Further studies are required to determine this association.

In our series, we noted a significantly longer operative time, higher estimated blood loss, and a higher rate of primarily low-severity inpatient complications in the early reconstruction group. Operative time and estimated blood loss included nonurologic surgery, which likely explains the significant difference between the 2 groups. We attribute the higher rate of inpatient complications to their initial complicated surgery rather than solely due to the

ureteral reconstruction, however the retrospective nature of this study does not allow us to differentiate this.

Although this is the largest series to compare early vs delayed ureteroneocystostomy after iatrogenic ureteral injury, our study is limited by a small cohort of patients who underwent an ER. This is likely due to a combination of a high rate of delayed recognition of ureteral injuries, the relative rarity of injuries at our institution, and the overall low rate of iatrogenic ureteral injuries.^{2,10} Also, this is a single institution study, which limits the generalizability of our findings. A prospective trial randomizing patients to an early vs delayed approach would be the gold standard in determining differences between the 2 approaches. Alternatives to management of ureteral injuries include ureteroureterostomy, pyeloplasty, nephrectomy, or ureteral stenting without the need for reconstruction. These patients were not included, and therefore limits the ability to generalize our results to all iatrogenic ureteral injuries. A limitation of our study is the lack of data regarding when the injuries were identified secondary to the fact that many injuries occurred and were identified at an outside institution prior to referral. This limits our ability to comment on whether patients in the DR cohort were candidates for ER. Finally, our results are limited by the lack of patient-reported outcomes.

We found that outcomes amongst patients who undergo ER of an iatrogenic ureteral injury had similar outcomes to those who underwent a delayed approach, while those repaired later had a higher rate of a Boari flap reconstruction. This suggests that a practitioner could potentially expect equivalent success with ER and should not delay reconstruction in fear of worse outcomes, such as increased readmission, failure, or complications attributable to the ureteral reconstruction. The lack of difference for the surgeon is in stark contrast to what the patient experiences when requiring a delayed approach. Patients who require delayed reconstruction often experience additional hospitalizations, procedures, emergency department visits, imaging studies, among many other factors that all contribute to the economic burden of the injury. Lost income while awaiting reconstruction is also a significant financial impact for patients as well. Early repair and subsequent recovery may allow patients and the health system to mitigate some of this financial strain.

Early repair is contingent upon early detection of ureteral injuries, which is a significant barrier to timely repair. Of recognized ureteral injuries, 50%-70% of injuries are not recognized acutely.^{1,3,10,15,16} Given the increased morbidity associated with delayed recognition, the ureters should be fully evaluated intraoperatively during surgeries where the ureter is susceptible to injury. A high index of suspicion for ureteral injury is required for patients presenting soon after surgery with complications suggestive of ureteral injury, including flank pain, fevers, abdominal pain, nausea, emesis, ileus, and incisional or vaginal drainage.¹ The urologist should also strongly consider ER when consulted.

CONCLUSION

Early repair of iatrogenic ureteral injuries was not associated with an increased rate of outpatient complications or stricture recurrence compared to DR in this cohort. We suggest that, if possible and appropriate, effort should be made to identify and subsequently repair iatrogenic ureteral injuries early to minimize morbidity for the patient as well as avoid a potentially increasingly complex ureteral reconstruction.

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EDITORIAL COMMENT

In this article the authors present their institution's experience with "early" vs "late" repair of iatrogenic ureteral injuries. Their cohorts did not display any significant differences in outcomes regardless of whether the repair was within 7 days from injury or later. It is commendable that the 2 groups had such extensive follow-up, likely related to the fact that these patients had iatrogenic injuries and not the typical traumatic injury.¹

These findings support the American Urological Association Urotrauma Guidelines that state "surgeons should repair traumatic ureteral lacerations at the time of laparotomy in stable patients."² In our experience, we also find that immediate repair is technically easier than waiting over a week, as urinomas and inflammation make dissection of tissues planes and mobilization of the ureter over the iliac vessels more challenging. Furthermore, repair of the ureter as early as possible not only minimizes patient morbidity associated with longer term percutaneous nephrostomy tube and catheter drainage, but also helps alleviate prolonged stress on the original surgeon.

Not mentioned in this paper is the likely impact of shortening lengths of stay and ambulatory surgery on the feasibility of early identification and repair. With the rise of ambulatory surgery centers, pelvic surgeries such as hysterectomies are being performed in centers that do not necessarily have urologists readily available and with the minimally invasive skills to perform a ureteral repair at the time the injury occurs. This may require patients to undergo either open repair, or wound closure with admission and temporization or transfer until definitive repair. This seems to be the case with the delayed cohort in this article as many of these patients were referred from outside institutions. Complicating this is that while one third of ureteral injuries are recognized immediately in open surgery, fewer injuries are identified during minimally invasive surgery.³ Thankfully, this article also confirms usually excellent outcomes with delayed repair.

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AUTHOR REPLY

We appreciate the thoughtful commentary and agree with the points that were raised. As mentioned in the editorial, early repair is often easier when significant inflammation has not been



allowed to set in. Barriers to early repair are numerous. If a ureteral injury is identified intraoperatively, a urologist may not be available for repair, as may occur if the inciting surgery is performed at an ambulatory surgery center or institution without routine urologic coverage. If a urologist is available, they may not feel comfortable with repair. If the reason is due to lack of experience with minimally-invasive ureteral reconstruction, the patient would most benefit from conversion to an open approach with immediate repair after a discussion with the patient's family. Although this conversion increases the morbidity to the patient, it pales in comparison to the morbidity of temporary nephrostomy tube or catheter drainage with delayed repair. If the urologist has limited experience with performing a ureteral reimplantation, temporary drainage with immediate transfer to a center with experience in ureteral reconstruction for early repair allows the patient to avoid months of morbidity. We are often hopeful that placement of a ureteral stent will be sufficient in healing a ureteral injury. Although it has success with grade 1 injuries, those of higher grade will likely develop a stricture or persistent leak requiring reconstruction at a later date if not repaired immediately.

We found that many delayed repairs were required due to delayed recognition of the injury. Ureteral injury is an uncommon occurrence during colorectal and gynecologic surgery, and

therefore the index of suspicion for a ureteral injury when a patient presents with postoperative abdominal pain, nausea, emesis, or pelvic cramping may be low. Colorectal and gynecologic surgeons are often unaware that early identification can lead to significantly less morbidity for their patients, and the data presented in this paper has been used to educate our local gynecologists and colorectal surgeons about the impact of early identification.

Beyond patient morbidity, iatrogenic ureteral injury has a significant financial impact on the patient as well as medicolegal implications for the surgeon. Further studies are needed to evaluate the difference in "cost" for patients who undergo early repair vs those performed in a delayed fashion. If asked, I expect most patients would prefer early repair if possible now that evidence exists that timing does not necessarily jeopardize outcomes. Our group continues to investigate ways to make earlier repair happen for the benefit of our patients, and we would encourage others to do the same.

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