



# Etiology, characteristics and management of ureteric injury: experience from a nationwide study

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**Background:** To investigate the common etiologies, characteristics, and management of ureteric injury.

**Methods:** A nationwide study was performed in 38 medical centers from Mar 2017 to Mar 2019. The data of patients with ureteric injury were retrospectively collected.

**Results:** Overall, 294 patients were included in this study. Ten cases (3.4%) were due to abdominal injuries, and 284 cases (96.6%) were due to iatrogenic injuries, including 48.6% from urological procedures, 41.9% from gynecological procedures, 6.3% from general surgery, and 3.2% from other treatments. Most urological injuries (79.7%) were caused by endourological procedures. Injury occurred in the distal ureter in 178 cases (60.5%), the mid-ureter in 31 cases (10.5%), and the proximal ureter in 85 cases (28.9%). Only 51 patients (17.3%) were diagnosed immediately during primary surgery. Immediate ureter reconstruction was performed in 30 patients (58.8%), while delayed urinary diversion was performed in 148 patients (60.9%) in the delayed diagnosis group. The side and the location of the injury were different between the urological and nonurological injury groups ( $P < 0.001$ ). Ureteric injuries were diagnosed timelier in the urological group than in the nonurological group ( $P = 0.037$ ).

**Conclusions:** Iatrogenic injury was the most common cause of ureteric injury. The majority of iatrogenic injuries were caused by urological procedures and were primarily due to aggressive endourological techniques. Depending on the condition of the patient, the time of diagnosis, and the location and length of the ureteric injury, different management strategies should be applied.

**Keywords:** Ureteric injury (UI); trauma; iatrogenic injury; endoscopy

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## Introduction

Ureteric injury (UI) is an uncommon condition. UI can be caused by external or iatrogenic factors, and iatrogenic ureteric injury (IUI) is the most common cause of UI (1,2). Due to the anatomical location of the ureter, gynecological, urological, general and other pelvic or abdominal surgeries can result in UI. The majority of IUIs occur during gynecological procedures and in the distal section of the ureter (1-3). With the development and acceptance of minimally invasive procedures, the frequency and major etiologies of UI have changed (4-6). The incidence of UI due to urological, gynecological and colorectal surgeries has increased (7), and the use of endourological and laparoscopic procedures has gradually resulted in an increased number of IUIs (4,5).

Notably, the clinical signs of UI are often nonspecific, and diagnostic tests are often specific but not sensitive; therefore, UIs are difficult to identify during or after surgery, and the diagnosis may be easily delayed (3,8). Some UIs may result in intraabdominal or pelvic sepsis, urinary fistulae, renal damage or even death (9). Thus, timely and effective management provides the best prognosis (1). The proper method for ureteral repair depends on the location, etiology, extent, and length of the UI (2). At present, there is no large-scale study of ureteral injury in China. Thus, we performed this multicenter study to summarize the etiologies and general management of UIs. We present the following article in accordance with the STROBE reporting checklist (available at <https://tau.amegroups.com/article/view/10.21037/tau-21-998/rc>).

## Methods

From Mar 2017 to Mar 2019, a nationwide survey on UIs was performed under the Chinese Urological Association Chinese Reconstructive Urology Consortium (CUA-CRUC) in 38 medical centers. The inclusion criteria were an immediate diagnosis of UI due to abdominal trauma or surgery, the presence of ureteric strictures associated with a previous abdominal trauma history and the presence of ureteric strictures after medical treatment, such as urological, gynecological, or general surgeries. The exclusion criteria were as follows: ureteric strictures associated with lithiasis, congenital diseases or urothelium tumors; or ureteral reconstruction surgery failure. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The Ethics Committee

of Peking University First Hospital approved the study protocol (No. 2019-SR-134). Informed consent was obtained from all participants.

A standardized form was used to retrospectively collect the information. The collected data included age; sex; clinical symptoms; UI etiology; type of prior surgery (such as laparoscopic or open surgery); side and location of the UI; diagnostic time and examination method; and management and perioperative data. The definition of the location of the UI was the primary site of the UI, which was divided into three parts: the upper, middle and lower sections. Based on the etiology of UI, IUIs were divided into urological and nonurological group. Immediate diagnosis was defined as the discovery of ureteral injury during the primary operation that caused the injury. Those UI that was not diagnosed until symptoms or abnormal imaging examination was defined as delayed diagnosis. Complications were evaluated according to the Clavien-Dindo classification system (10).

## Statistical analysis

Demographic data and operative clinical variables were collected in a database with Microsoft Excel<sup>®</sup>, version 2019. All analyses were performed with SPSS<sup>®</sup> Statistics, version 24.0. Independent samples T tests were used for the quantitative variables. Chi-square tests and Fisher's exact tests were used for the qualitative variables. A two-sided  $P < 0.05$  indicated statistical significance.

## Results

A total of 294 patients, including 199 women and 95 men, were involved in our research. Their ages ranged from 6 to 85 years (mean 47 years). Ten (3.4%) patients suffered from abdominal trauma, while most of the patients (96.6%) presented with IUIs. UI occurred in the distal third of the ureter in 178 cases (60.5%), in the middle third in 31 cases (10.5%) and in the proximal third in 85 cases (28.9%).

In the abdominal trauma group, there were 8 men and 2 women. Their ages ranged from 21 to 61 years (mean 35 years). Penetration or blunt trauma each caused ureteric injury in 5 patients. The injury occurred most frequently in the proximal third of the ureter in 9 patients (90.0%), while only 1 patient (10.0%) had a distal UI. Six patients had flank pain, and among them, 3 patients had urinary leakage. One patient had only urinary leakage. Regarding management, only 1 patient (10.0%) was found to have

**Table 1** Ureteral management in the abdominal trauma group

Primary treatment	Number	Further treatment	Number
Immediate diagnosis			
Ureteroureterostomy (O)	1	–	–
Delayed diagnosis			
Nephrostomy	5	Ureteroureterostomy (LS, O)	LS, 1; O, 1
		Boari-flap with ileal ureter (O)	1
		Pyeloplasty (O)	1
Nephrostomy with ureteral stent	1	–	–
Ureteroneocystostomy (O)	1	–	–
Pyeloplasty (O)	1	–	–
Ureteroureterostomy (O)	1	–	–

LS, laparoscopic; O, open.

UI during emergency surgery, and a ureteroureterostomy was performed immediately. Two patients (20.0%) were diagnosed at less than 48 hours, and the other 7 patients (70.0%) were diagnosed at more than 48 hours after primary surgery. Enhanced computed tomography urography (CTU) was the most common (80.0%) radiologic examination performed to diagnose UI. Two patients (20.0%) were diagnosed by retrograde urography. Nephrostomy was performed before ureter reconstruction in 5 patients, while 4 patients underwent ureteral surgery directly (see *Table 1* for details).

In the IUI group, there were 197 women and 87 men. Their ages ranged from 6 to 85 years (mean 47 years). IUI occurred during gynecological surgery in 119 cases (41.9%), during general surgery in 18 cases (6.3%), during urological procedures in 138 cases (48.6%), and during other treatment (including orthopedic surgical procedures and radiotherapy) in 9 cases (3.2%). There were 132 left-side ureteric injuries, 132 right-side ureteric injuries and 20 bilateral ureteric injuries. The distal third of the ureter was the most affected, occurring in 177 cases (62.3%), while UI occurred in the proximal section in 76 cases (26.8%) and in the middle section in 31 cases (10.9%).

Regarding diagnosis and management, 50 (17.6%) IUIs were found during primary surgery. Fifteen patients were treated with a ureteral stent, 6 patients were treated with nephrostomy, and 29 patients (58.0%) were treated with immediate ureteral reconstruction (see *Table 2* for details). Ureteral reconstruction was performed by the same approach in 44.8% (13/29) patients, including 2

robotic, 2 laparoscopic, and 9 open procedures. One patient had a conversion from laparoscopy to open surgery due to UI. Of the 15 endourological ureteral injuries, 13 patients underwent open reconstruction and 2 patients underwent laparoscopic procedures. Reconstruction of non-urological ureteral injuries was performed by urologists. Most of the patients (234 cases, 82.4%) were diagnosed after primary surgery. The proportion of no drainage in immediate diagnosis group was higher, and the proportion of nephrostomy in delay group was higher (see *Table 3* for details). Regarding delayed IUI diagnosis, the clinical symptoms included anuria, flank or abdominal pain; vaginal urinary leakage; hematuria; and fever. Only 3 patients presented without clinical symptoms. The patients were diagnosed by multiple examinations, including retrograde pyelography, intravenous pyelography, enhanced CTU, urinary ultrasonography and endoscopy. The most frequent diagnostic method for IUI was enhanced CTU (142 cases, 50.0%). Regarding management, ureteral stent placement and nephrostomy were performed in 72 and 52 cases, respectively, and used in combination in 19 patients (total 143 cases, 61.1%), while a secondary ureteral surgery was performed at a later date. Primary ureteral reconstruction was performed in 91 patients (38.9%) (see *Table 2* for details).

Depending on the location of the UI, different types of ureteral reconstructions were performed (see *Table 4* for details). Ureteroureterostomy was the most common procedure performed to rebuild upper and mild ureteral defects, and ureteroneocystostomy was most commonly

**Table 2** Ureteral management in the iatrogenic group

Primary treatment	Number	Further treatment	Number
Immediate diagnosis			
Ureteroureterostomy with/without ureteral stent			
RA	2	-	-
LS	2		
O	11		
Boari-flap with/without psoas hitch			
LS	2	-	-
O	3		
Ureteroneocystostomy			
O	3	-	-
Ileal ureter			
O	3	-	-
Autotransplantation			
O	3	-	-
Ureteral stent	15	Ureteroneocystostomy (LS)	1
Nephrostomy	6	Boari-flap with/without psoas hitch (LS)	2
		Ureteroureterostomy (LS)	1
		Ureteroneocystostomy (O)	1
		Ileal ureter (LS)	1
Delayed diagnosis			
Nephrostomy, ureteral stent or both	143	Ureteroneocystostomy (RA, LS, O)	RA, 1; LS, 4; O; 16
		Ureteroureterostomy (LS, O)	LS, 10; O, 7
		Ileal ureter (LS, O)	LS, 4; O, 14
		Boari-flap with/without psoas hitch (LS, O)	LS, 4; O, 7
		Pyeloplasty (RA, LS, O)	RA, 1; LS, 1; O, 1
		Nephrectomy (O)	3
		Balloon dilatation (URS)	3
		Pelvis flap (O)	2
		Oral mucosa grafts (LS)	2
		Psoas hitch (O)	1
		Ileal ureter with Boari-flap (O)	1
		Ileal ureter with bladder augmentation (O)	1
		Pyeloureterostomy in transplanted kidney (O)	1

**Table 2** (continued)

Table 2 (continued)

Primary treatment	Number	Further treatment	Number
Ureteroneocystostomy			
LS	12	–	–
O	33		
Ureteroureterostomy with/without ureteral stent			
LS	14	–	–
O	16		
Pyeloureterostomy			
LS	3	–	–
O	1		
Psoas hitch			
O	3	–	–
LS	1		
Boari-flap			
O	3	–	–
Nephrectomy			
O	2	–	–
Ileal ureter			
LS	1	–	–
Autotransplantation			
O	1	–	–
Balloon dilatation			
URS	1	–	–

RA, robot-assisted; LS, laparoscopic; O, open; URS, ureteroscopic.

Table 3 Drainage method in different sub-group

Variables	Ureteral stent	Nephrostomy	Both	None	P
Etiology, n (%)					0.043
Trauma	0	5 (50.0)	0	5 (50.0)	
Iatrogenic	87 (30.6)	58 (20.4)	19 (6.7)	120 (42.3)	
Diagnosis, n (%)					0.011
Immediate	15 (29.4)	6 (11.8)	0	30 (58.8)	
Delay	72 (29.6)	57 (23.5)	19 (7.8)	95 (39.1)	

**Table 4** The type of ureteral reconstruction in different locations.

Location of ureteric injury	Ureteral reconstruction	Cases, n
Upper ureter	Ureteroureterostomy	28
	Ileal ureter with/without Boari-flap	12
	Pyeloureterostomy	7
	Boari-flap with psoas flap	5
	Nephrectomy	4
	Autotransplantation	3
	Pelvis flap	2
	Balloon dilatation	2
	Oral mucosa grafts	2
	Autotransplantation	2
Middle ureter	Ureteroureterostomy	12
	Boari-flap	2
	Ureteroneocystostomy	1
	Ileal ureter	1
Lower ureter	Ureteroneocystostomy	70
	Ureteroureterostomy	24
	Boari-flap or/with psoas hitch	19
	Ileal ureter	11
	Balloon dilatation	2
	Pyeloureterostomy (after autotransplantation)	1
	Ileal ureter with bladder augmentation	1
	Autotransplantation	1
	Ureteroureterostomy	1

performed for distal ureteral strictures. Eight patients suffered from urinary infection (grade ≤ II), 8 suffered from urinary fistula (grade ≤ II), 3 suffered from intestinal obstruction (grade II), 1 suffered from wound infection (grade II), 1 suffered from intestinal fistula (grade II) and 1 suffered from bladder tamponade (grade IIIa).

There was no difference in age between the urological and nonurological groups (P=0.085) (see Table 5 for details). Bilateral IUI occurred in only the nonurological group and was due to gynecological surgery (17 cases, 85.0%) and radiotherapy (3 cases, 15.0%). There was a significant difference in sex between the urological and nonurological

**Table 5** The characteristics of the urological and nonurological groups.

Characteristics	Urological group	Nonurological group	P value
Sex, n			
Male	78	9	<0.001
Female	60	137	
Age, years (mean ± SD)	48±10.8	45±13.3	0.085
Side, n			
Left	70	62	<0.001
Right	68	64	
Bilateral	–	20	
Location, n			
Upper	71	5	<0.001
Middle	20	11	
Lower	47	130	
Diagnosis, n			
Immediate	31	19	0.037
Delayed	107	127	
Drainage, n (%)			
Ureteral stent	31 (22.5)	56 (38.4)	<0.001
Nephrostomy	32 (23.2)	26 (17.8)	
Stent + nephrostomy	4 (2.9)	15 (10.3)	
None	71 (51.4)	49 (33.6)	

groups (P<0.001). In the nonurological group, most UIs (130 cases, 89.0%) occurred in the distal third of the ureter, while the proximal third of the ureter was the most affected part in the urological group (P<0.001). The proportion of preoperative ureteral stents in nonurological UIs was higher (P<0.001, Table 5). In the gynecological and general surgery groups, 74 patients (54.0%) underwent open surgical interventions, 62 patients (45.3%) underwent laparoscopic surgeries, and only 1 patient (0.7%) underwent robot-assisted surgery. In the urological group, 15 cases (10.9%) suffered from open surgical intervention, 11 cases (8.0%) suffered from laparoscopic surgery, 2 cases (1.4%) suffered from ultrasonic lithotripsy, and 110 cases (79.7%) suffered from endourological techniques. More patients had ureteric injuries during urological procedures than during

nonurological procedures ( $P=0.037$ ).

## Discussion

The ureter is a moveable and flexible retroperitoneal organ that lies on the surface of the psoas muscle and is protected by the muscles and vertebral column (2,11). Because of the anatomical location of the ureter, UI is rare in patients with abdominal trauma and accounts for less than 1% of all genitourinary injuries from external trauma (12). The mechanism of injury can be blunt, penetrating or gunshot trauma. Best *et al.* reported that 96% of ureteric injuries were caused by gunshot, and the other 4% was caused by blunt trauma (13). In our research, though abdominal trauma was not a common cause of UIs, 3.4% (10 cases) suffered from abdominal trauma, which was higher than that in previous studies. Regrettably, only 1 patient was diagnosed immediately, and a ureteroureterostomy was performed. In acute trauma, UI can be initially missed and recognized in a delayed fashion only when clinical signs are present (14). The timely diagnosis and management of patients can result in a good prognosis. Therefore, vigilance and careful examination for ureteral injury should be carried out in trauma patients although the incidence is low. In stable patients, immediate ureteral reconstruction is recommended, while in unstable patients, urinary diversion is preferred.

In contrast to abdominal trauma, iatrogenic injury is a common cause of UI (2). A total of 284 patients (96.6%) suffered from UIs in our research. Urological injury was the most common cause (48.6%) of IUI, followed by gynecological (41.9%) and general (6.3%) surgeries. Most urological injuries (79.7%) were treated by endourological procedures. It has been reported that UIs occur in 0.03–1.5% and 0.23–0.44% of gynecological and general surgeries, respectively (15–18). Research from Finland showed that IUIs have increased markedly and that gynecological laparoscopic procedures account for more than half of these injuries (7). It has also been reported that the rate of urological UIs has increased more than the rate of nonurological injuries because of the use of endourological procedures (5). In addition, we found that the proximal section of the ureter was the most affected part in the urology group. This may be associated with the aggressive use of endoscopy. Furthermore, gynecological surgery and radiological therapy often resulted to bilateral UIs. Both proximal and bilateral UIs were complicated to reconstruct, we suggest that indwelling ureteral stents and

indocyanine green fluorescence imaging can be used to identify the ureter during complex abdominal and pelvic surgery in order to reduce the incidence of ureteral injury. For endourological operation, attention should be paid to direct injury and thermal effect injury, selecting the appropriate sheath, and indwelling the stent according to the situation.

Regarding the diagnosis of IUI, early recognition and repair of the injury during primary surgery can result in reduced morbidity, increased ease of repair, and an improved outcome for the patient. However, most of the IUIs patients (234 cases, 82.4%) suffered a delayed diagnosis until clinical symptoms occurred in our research. Similar results were observed in other studies, with the initial diagnosis of IUIs ranging from 31.7% to 80% (3,7,19–21). A delayed diagnosis may result in an increase in complications, including urinoma, abscess, ureteric stricture, ureteric fistula, and potential loss of an ipsilateral renal unit (22). Enhanced CTU was most frequently used to diagnose UI.

Depending on the condition of the ureter and renal function, different types of ureter repair techniques are required to achieve successful ureter reconstruction. Drainage may be a consideration for “ureteral rest” before reconstruction in complicated UIs. In our research, 51 patients (17.3%) were diagnosed during primary surgery, while most of the diagnoses (82.4%) were delayed. In terms of immediate treatment, 21 patients (41.2%) were treated with ureteral stenting or nephrostomy, and the majority of patients (58.8%, 30/51) were treated with ureteral reconstruction, including ureteroureterostomy, uretero-vesicostomy, the Boari-flap, the psoas hitch, ileal ureter replacement or even autotransplantation procedures. Regarding delayed primary management, nephrostomy and ureteral stenting were performed in 148 cases (60.9%, 148/243). The types of ureteral reconstruction surgery, such as the pelvis flap, oral mucosa grafts and ileal ureter with the Boari-flap, were more varied and complicated in the delayed diagnosis group than in the immediate diagnosis group.

To our knowledge, our research is the first and largest UI study in China; it was a multicenter nationwide study involving 38 medical centers. However, our study still had several limitations. First, it was a 2-year retrospective research study that considered the demographics, etiologies and management of the cases, but there were no perioperative or follow-up data. Second, the patients were operated on by multiple different urologic surgeons. We

did not collect information on the surgeons' experience, which may have influenced the diagnosis and management. Third, most of the patients were diagnosed 48 hours after surgery; thus, they may have been transferred to different hospitals, so we lacked some precise surgical information of the first surgical procedure. These evaluations would be excellent directions for further research. A larger and longer prospective medical study with long-term follow-up will be conducted in the future based on the results of our research.

## Conclusions

Iatrogenic injury was the most common cause of UI. The majority of iatrogenic injuries were caused by urological procedures, primarily due to the aggressive use of endourological techniques. Gynecologists, urologists and general surgeons should be aware of UI during both open and laparoscopic procedures. CTU was the most common radiologic examination used to diagnose UIs. To achieve the best prognosis, different management strategies, including ureter repair and urinary diversion, should be performed depending on the condition of the patient, the time of diagnosis and the location and length of the UI.

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