



## Original Research

# The Predictive Factors of Renal Loss After Iatrogenic Ureteral Avulsion in the Medicolegal Perspective

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### Abstract

**Objectives:** As an effective and minimally invasive technique, ureteroscopy has some potential intraoperative complications. Ureteral avulsion is among these complications, although rare. This study aimed to determine factors predicting nephrectomy by considering ureteral avulsion from a medicolegal perspective for the 1st time in the literature.

**Methods:** A total of 33 patients with ureteral avulsion during ureteroscopic surgery, who presented to various hospitals in Turkey between September 2004 and April 2019 and whose cases were being reviewed at the Institution of Forensic Medicine with regard to malpractice, were evaluated retrospectively. The patients who underwent nephrectomy after ureteral avulsion were evaluated as Group 1, and those who underwent reconstructive surgery as Group 2.

**Results:** The mean age of the patients was 39.5±12.1 years. Seventeen (51.5%) patients had partial and 16 (48.4%) had complete ureteral avulsion. Nephrectomy was performed in 14 (42.4%) patients, and ureteral reconstruction in 19 (57.5%) patients. It was determined that the patients in Group 1 had more proximal stones and a higher degree of hydronephrosis compared to Group 2. Complete avulsion developed in 71.4% of the patients in Group 1 and in 31.6% of those in Group 2. After avulsion, 78.6% of the patients in Group 1 were treated in a state hospital, and 63.2% of those in Group 2 were treated in a tertiary referral hospital. The increase in the degree of hydronephrosis, presence of complete avulsion, and intervention at a state hospital were determined as independent predictive factors for nephrectomy.

**Conclusion:** This is the first study with the largest cohort in the literature to medicolegally evaluate ureteral avulsion and determine predictive factors for nephrectomy. Although each patient should be treated with different methods in the presence of ureteral avulsion, our study aimed to provide a common approach to this catastrophic complication.

**Keywords:** Medicolegal perspective, Nephrectomy, Ureteral avulsion, Ureteroscopy

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In the past two decades, ureteroscopy (URS) has been increasingly used for the endoscopic treatment of ureteral stones or excision of ureteral neoplasms. As an effective and minimally invasive technique, URS has some potential intraoperative complications.<sup>[1]</sup> Iatrogenic ureteral injuries during the ureteroscopic treatment of renal and ureteral stones are not common. These injuries are listed as various complications ranging from simple mucosal damage to catastrophic ureteral avulsions.<sup>[2]</sup> Although ureteral injury rates have decreased with the increase in surgical experience and technological developments in URS devices since the 1990s, studies conducted with large series report the incidence of ureteral perforation as 0–18% and that of ureteral avulsions as 0–0.5%.<sup>[1,3]</sup> Conventionally, the term ureteral avulsion refers to an upper urinary tract injury associated with the loss of full-thickness continuity of the ureter due to blunt trauma, especially as a result of acute deceleration/acceleration movement that occurs during traffic accidents. With the growing use of endourological procedures, this term has also been defined as a diffuse degloving injury resulting from the stretching mechanism of the ureter, which eventually leads to a rupture from the most weakened area.<sup>[4,5]</sup> The mechanism of ureteral avulsion is usually formed by an attempt to extract a stone that is too large to pass through the ureter by applying excessive force. Furthermore, the use of a basket or a large-diameter (>9 Fr) ureteroscope, the urologist's lack of experience, and ureteral inflammation have been reported as risk factors for ureteral avulsion.<sup>[6]</sup>

The classical treatment of ureteral avulsion is open repair.<sup>[6,7]</sup> During this surgery, ureteral reimplantation, autotransplantation, or nephrectomy is applied depending on the localization of the injury, condition of the ureter, experience of the surgeon, and general condition of the patient.<sup>[3]</sup> However, due to the limited case series and reports on this subject in the literature, there is still no consensus on the optimal surgical method, and ureteral avulsion, a catastrophic complication, can also result in the requirement of nephrectomy.<sup>[8]</sup> This study with a high patient volume aimed to determine factors predicting nephrectomy by considering ureteral avulsion from a medicolegal perspective for the 1<sup>st</sup> time in the literature.

## Methods

After receiving the necessary Ethics Committee approval (2019/172), the data of ureteral avulsion cases, which were examined in terms of medical malpractice, were retrospectively evaluated by reviewing the case files obtained from the Institution of Forensic Medicine of the Republic of Turkey. The study included a total of 33 cases, who underwent surgery for ureteral avulsion as a result of interven-

tions performed in different hospitals in Turkey between 2004 and 2019, were examined medicolegally, and had sufficient clinical findings in their files. The opinion of the Forensic Medicine Board included in the files and the personal/private information of the patient and surgeon were not evaluated.

From the files of the cases, demographic data, stone characteristics (diameter [mm], location, and impaction status), clinical characteristics, operational characteristics (stone basket use, lithotripsy techniques, anesthesia method, and diameter of ureteroscope), level of the hospital where the intervention was performed, and time of intervention were examined. Although the cases included in the study consisted of those that were subjected to a preliminary medicolegal examination by an independent specialist physician due to the legal regulations in Turkey and were considered to require a further evaluation, the final result of the medicolegal process was not included in the files.

The patients were divided into two groups as those who underwent nephrectomy (Group 1) and those who underwent reconstructive surgery (Group 2) after ureteral avulsion.

## Statistical Analysis

Categorical data were given as numbers and colon percentages. The normal distribution of the continuous variables was tested with the Shapiro-Wilk test. Normally distributed continuous variables were presented as mean and standard deviation, while non-normally distributed continuous variables were presented as median and interquartile range. Means of two normally distributed groups were compared using Student's t-test. The Mann-Whitney U-test was used for the comparison of the means between non-normally distributed groups. The frequency of categorical variables was compared using the Pearson Chi-square and Fisher's exact tests.  $P < 0.05$  was regarded as statistically significant. The multivariate logistic regression analysis was used to identify possible factors that predicted renal loss after ureteral avulsion. Statistical analysis was performed using the Statistical Package of the Social Sciences (SPSS) version 21 (IBM SPSS Statistics; IBM Corp., Armonk, NY).

## Results

Of a total of 33 patients included in this study, 75.7% ( $n=25$ ) were male and 24.3% ( $n=8$ ) were female. The mean age of the patients was  $39.5 \pm 12.1$  years. Seventeen (51.5%) patients had partial and 16 (48.4%) had complete ureteral avulsion, and 14 (42.4%) patients had right ureteral avulsion and 19 (57.5%) had left ureter avulsion. Demographic data, stone characteristics, operational characteristics, and equipment used are summarized in Table 1. While

**Table 1.** Demographic and clinical features of the patients

Variables	
Number of patients	33
Age, years	39.5±12.1
Gender, n (%)	
Male	25 (75.7)
Female	8 (24.3)
Side, n (%)	
Right	14 (42.4)
Left	19 (57.5)
Stone size, mm	8.8±3.3
Stone location, n (%)	
Proximal	23 (69.6)
Middle	6 (18.1)
Distal	4 (12.1)
Impacted stone, n (%)	15 (45.4)
Hydronephrosis degree, n (%)	
Grade 1	9 (27.3)
Grade 2	13 (39.4)
Grade 3	9 (27.3)
Grade 4	2 (6.1)
SWL history, n (%)	21 (63.6)
Lithotripsy technique, n (%)	
Pneumatic	19 (57.5)
Laser	14 (42.5)
Usage of stone basket, n (%)	16 (48.4)
Anesthesia technique, n (%)	
Spinal	17 (51.5)
General	14 (42.4)
Sedation	2 (6.2)
Ureteroscope diameter, Fr, n (%)	
4.5/6.5	5 (15.1)
6/7.5	5 (15.1)
6.4/7.8	6 (18.1)
6.5/7	5 (15.1)
7/8	4 (12.1)
8/9.5	4 (12.1)
8/9.8	4 (12.1)

SWL: Shock wave lithotripsy; Fr: French.

20 (60.6%) patients with ureteral avulsion were referred to another center, 13 (39.3%) underwent an immediate intervention in the center where avulsion developed. Nephrectomy was performed in 25% (n=5) of the referred patients and 69.2% (n=9) of those that immediately underwent nephrectomy. For the patients who did not undergo nephrectomy in both groups, autotransplantation, ileal interposition, and ureteroneocystostomy (UNC) were the treatments applied in order of frequency (Table 2). It was determined that the rate of proximal stone localization was statistically significantly higher in Group 1 compared

**Table 2.** Type and time of intervention

	Referred	Immediate
Number of patients	20	13
Nephrectomy, n (%)	5 (25.0)	9 (69.2)
UNC, n (%)	2 (10.0)	3 (23.0)
Ileal interposition, n (%)	6 (30.0)	0 (0.0)
Autotransplantation, n (%)	7 (35.0)	1 (7.6)

UNC: Ureteroneocystostomy.

to Group 2 (p=0.034). In addition, the patients in Group 1 had a higher degree of hydronephrosis than those in Group 2 (p=0.007). Complete avulsion developed in 71.4% (n=10) of the patients in Group 1 and 31.6% (n=6) of those in Group 2 (p=0.024). After the development of avulsion, 78.6% (n=11) of the patients in Group 1 and 36.8% (n=7) of those in Group 2 were treated at a state hospital, while 21.4% (n=3) of the patients in Group 1 and 63.2% (n=12) of those in Group 2 were treated at a tertiary referral hospital (university/training hospital) (p=0.017). In Group 1, 64.3% (n=9) of the patients received an immediate intervention, while 35.7% (n=5) were referred to another center after nephrostomy tube placement, and in Group 2, 21.1% (n=5) of the patients were treated immediately and 78.9% (n=15) were referred to another center after a nephrostomy tube placement (p=0.029) (Table 3). Table 4 shows the results of the multivariate analysis of nephrectomy-related factors. Increased degree of hydronephrosis (odds ratio [OR]: 3.376, 95% confidence interval [CI]: 1.053–10.823), presence of complete avulsion (OR: 11.651, 95 CI%: 1.029–131.985), and intervention at a state hospital (OR: 21.821, 95 CI%: 1.144–416.309) were determined as independent predictive factors for nephrectomy (Table 4).

## Discussion

As a result of the rarity of ureteral avulsion and presence of mostly case reports in the literature, there are only limited data on this subject. In addition, studies conducted to date have generally focused on factors that predict ureteral avulsion, and there are a only limited number of studies addressing post-avulsion interventions. Therefore, our study can be considered as the single most comprehensive study in the literature, in which patients that developed ureteral avulsion after URS were handled medicolegally.

The management of ureteral avulsion can be difficult because the surgeon must decide on the surgical repair method by making an intraoperative diagnosis and intervene immediately.<sup>[9]</sup> The selection of the optimal surgical procedure should be based on the patient's age and condition, functional status of the renal unit, location and se-

**Table 3.** Comparison of the patients' characteristics according to the study groups

Variables	Group 1	Group 2	p <sup>^</sup>
Number of patients	14	19	
Age, years	35.3±9.2	42.7±13.2	0.081
Gender, n (%)			0.098#
Male	13 (92.9)	12 (63.2)	
Female	1 (7.1)	7 (36.8)	
Side, n (%)			
Right	7 (50.0)	7 (36.8)	0.450
Left	7 (50.0)	12 (63.2)	
Stone size, mm	8 (6-10.5)	9 (7-10)	0.627
Stone location, n (%)			
Proximal	13 (92.9)	10 (52.6)	0.034#
Middle	0 (0.0)	6 (31.6)	
Distal	1 (7.1)	3 (15.8)	
Impacted stone, n (%)	9 (64.3)	6 (31.6)	0.062
Hydronephrosis degree, n (%)			0.007*
Grade 1	0 b	9 (47.4)a	
Grade 2	6 (42.9) a	7 (36.8) a	
Grade 3	6 (42.9) a	3 (15.8) a	
Grade 4	2 (14.3) a	0 a	
SWL history, n (%)	9 (64.3)	12 (63.2)	0.947
Lithotripsy technique, n (%)			
Pneumatic	9 (64.3)	10 (52.6)	0.503
Laser	5 (35.7)	9 (47.4)	
Usage of stone basket, n (%)	9 (64.3)	7 (36.8)	0.119
Anesthesia technique, n (%)			
Spinal	7 (50.0)	10 (52.6)	1.000
General	6 (42.9)	8 (42.1)	
Sedation	1 (7.1)	1 (5.3)	
Avulsion location, n (%)			0.024
Partial	4 (28.6)	13 (68.4)	
Complete	10 (71.4)	6 (31.6)	
Type of hospital, n (%)			
State	11 (78.6)	7 (36.8)	0.017
University/training	3 (21.4)	12 (63.2)	
Time of intervention, n (%)			
Referred to another center after nephrostomy	5 (35.7)	15 (78.9)	0.029
Immediate intervention	9 (64.3)	4 (21.1)	
Right	7 (50.0)	7 (36.8)12 (63.2)	0.450
Left		10 (52.6)6 (31.6)3 (15.8)	0.034#
Laser		10 (52.6)9 (47.4)	0.503
Sedation	6 (42.9)1 (7.1)	8 (42.1)1 (5.3)	
Referred to another center after nephrostomy/Immediate intervention	7 (36.8)12 (63.2)	15 (78.9)4 (21.1)	

Group 1, nephrectomy; Group 2, reconstructive surgery; SD: standard deviation; SWL: shock wave lithotripsy; #Fisher's exact test; \*Pearson chi-square exact test; ^Pearson chi-square test.

verity of ureteral damage, bowel availability, and surgeon's experience. Although different methods are preferred in ureteral avulsion, the main purpose of treatment is to maintain ureteral continuity.<sup>[4]</sup> While methods such as end-

to-end anastomosis, calicostomy, replacement of the ureter with the ileum, and autotransplantation of the kidney are recommended for proximal ureter avulsion, the Boari flap and psoas hitch methods are recommended for mid-

**Table 4.** Results of the multivariate logistic regression analysis of possible predictive factors for nephrectomy

Variables	Multivariate		
	OR	95% CI	p
Proximal stone	2.985	0.082–108.483	0.551
Hydronephrosis grade	3.376	1.053–10.823	0.041
Impacted stone	1.590	0.207–12.225	0.656
Avulsion			
Partial	ref		
Complete	11.651	1.029–131.985	0.047
Type of hospital			
University/training	ref		
State	21.821	1.144–416.309	0.040
Time of intervention, n (%)			
Referred to another center after a nephrostomy	ref		
Immediate intervention	1.290	0.128–13.027	0.829

OD: odds ratio; CI: confidence interval; SWL: shock wave lithotripsy.

ureteral avulsion cases.<sup>[4]</sup> Success can be achieved with UNC in the presence of distal ureteral injuries. However, if the diagnosis of avulsion is made in the post-operative period, a percutaneous nephrostomy tube should be inserted for urinary drainage, and definitive treatment should be postponed until the patient has been stabilized.<sup>[5,9]</sup>

Although various ureteral reimplantation techniques have been described, the success rates of these techniques are low because they generally result in the loss of ureteral blood supply due to complete avulsion at the ureteropelvic junction level or extensive injuries presenting with high tissue loss.<sup>[10]</sup> Therefore, an urgent simple nephrectomy can also be applied after discussing this situation with patients or their relatives and re-evaluating viable reconstruction methods.<sup>[9,10]</sup> The reason why ureter avulsion is one of the most feared complications of URS is the possible subsequent renal loss. Nephrectomy is another method that can be applied if it is necessary to manage the complication.<sup>[11]</sup> Our study revealed factors predicting nephrectomy after ureteral avulsion.

Treatment methods that require advanced surgical experience, for example, autotransplantation and ileal interposition are used, especially among young patients, in most challenging circumstances, such as complete ureter avulsion, in which there is severe tissue loss and only little or no ureter remains.<sup>[4]</sup> The upper third of the ureter is more prone to complete avulsion due to relatively less muscle tissue support. In addition, large impacted stones at this location lead to the formation of a weak or unhealthy ureter, causing avulsion to develop more easily in the proximal ureter where muscle support is weak, and the absence of little or no remaining ureter further reduces the success of end-to-end anastomosis.<sup>[2,10]</sup>

In a study by Taie et al.<sup>[12]</sup>, five patients developed complete ureteral avulsion, and nephrectomy was performed in two of these patients, while the remaining three underwent ureteral reimplantation, Boari flap, and ileal interposition. In our study, it was observed that 71.4% of the patients who underwent nephrectomy and only 31.6% of those who underwent reconstruction had complete ureteral avulsion. We also determined that the presence of complete ureteral avulsion was a predictive factor for nephrectomy and increased the risk of requiring this surgery by 11.6 times.

The repair of ureteral avulsions should preferably be undertaken immediately in stable cases because delayed repair may result in the loss of ureteral length due to fibrosis.<sup>[2]</sup> However, considering surgical experience, hospital conditions, or general state of the patient, s/he can be referred to a more experienced higher center after providing proper urinary drainage and discussing this option with the patient.<sup>[13]</sup> While delayed repair is recommended after approximately four to 8 weeks in experienced clinics, it has also been suggested that repair performed within the week of injury may cause fewer complications.<sup>[8]</sup> In our study, it was determined that immediate repair was performed in 64.3% of the patients who underwent nephrectomy, and delayed repair was performed in 78.9% of those who underwent successful reconstruction. Chengguo et al. reported that all patients who developed ureteral avulsion were referred to a more experienced higher-level center and successfully treated. The authors noted that these patients underwent autotransplantation and ureteropelvic anastomosis, which requires expert experience and includes many different challenging procedures, and anastomosis was successfully provided.<sup>[5]</sup> The classical ileal replacement of the ureter for



complete ureteral avulsion is another rescue option with high reliability, especially in case of emergency repair performed in experienced centers.<sup>[2]</sup>

In the present study, while 78.6% of the patients treated at a state hospital required nephrectomy, only 21.4% of those treated at a university/training hospital underwent this surgery. In addition, autotransplantation was successfully applied to 35% of the patients referred to another center, ileal interposition in 30%, and UNC in 10%. In Turkey, similar to other countries, standard surgical procedures rather than advanced surgical methods are applied in state hospitals in daily life, and higher-level surgical techniques are mostly offered to patients at university/training hospitals. Furthermore, after ureteral avulsion, the possibility of subsequent renal loss may cause anxiety and discomfort in the surgeon performing the procedure. This reduces the success rate of state hospitals in cases requiring urgent and advanced-stage surgical interventions, such as patients with ureteral avulsion. In our study, we determined that intervention at a state hospital was a predictive factor for nephrectomy and increased the risk of requiring this surgery by 21.8 times.

In cases of chronic hydronephrosis, it is generally observed that the epithelium around the stone in the proximal avulsed ureter becomes inflamed, thinner, and necrotic during open reconstructive surgery.<sup>[14]</sup> This prevents successful reconstruction or may lead to a non-functional kidney in the post-operative follow-up despite successful reconstruction.<sup>[7]</sup> Cindolo et al. performed immediate open reconstructive surgery after ureteral avulsion in two patients with impacted stones and hydronephrotic kidneys, but this resulted in the loss of kidney function, leading to more difficult management in follow-up. In these patients, due to devascularization in the ureter, a stricture developed in the ureter and loss of kidney function occurred during the follow-up. In complete ureteral avulsion, strictures due to devascularization and loss of renal function in advanced stages are frequently seen.<sup>[7]</sup>

In a study evaluating ureteral injuries, Al-Awad et al.<sup>[8]</sup> reported that the rate of nephrectomy was 2.4%. In that study, nephrectomy was performed in two of the three patients who developed ureteral avulsion due to low renal function. Alapont et al.<sup>[4]</sup> preferred nephrectomy in case of avulsion in patients with loss of kidney function associated with severe hydronephrosis. Although there is no pre-operative separate function evaluation in kidneys in the presence of severe hydronephrosis, surgeons may decide on nephrectomy to prevent possible complications after planned reconstruction operations or because they do not consider it sensible to perform advanced operations.<sup>[5]</sup> All the cases

evaluated in our study constituted medicolegal issues, and the surgeons may have made the surgical decision considering the presence of severe hydronephrosis. Therefore, in our study, the presence of advanced hydronephrosis was found to be a predictive factor for nephrectomy and increased the risk of requiring this surgery by 3 times.

This study had a number of strengths. The sample of the study represents the largest cohort evaluated medicolegally in the literature. In addition, our study is the first to investigate factors predicting nephrectomy after ureteral avulsion. However, it also had certain limitations. We were able to obtain the data of only a limited number of cases from the Institution of Forensic Medicine, and the retrospective design did not allow recording further data during the follow-up of the patients. Furthermore, the pre-operative renal function evaluation of the patients who underwent nephrectomy was not included, which led to the absence of an important criterion for the nephrectomy decision.

## Conclusion

The examination of the patient data in the present study demonstrates that catheterization of the relevant kidney and immediate referral of patients to a higher level of care is critical to allow for renal protection surgery. In the event of complications, it is clear that the success of surgical manipulations performed with haste will not be similar to those performed by a calmer and more experienced surgical team. Patients should be informed about the possibility of various complications after reconstruction, including loss of renal function. Although each patient should be treated with different methods in the presence of ureteral avulsion, which constitutes a medicolegal issue, our study aimed to provide a common approach to this catastrophic complication. However, multicenter prospective studies with larger patient numbers are needed to define and validate risk factors described in our study.

## Disclosures

**Ethics Committee Approval:** Ethics committee approval of the study was received on 08.04.2019 from Bakirkoy Dr Sadi Konuk Training and Research Hospital. The ethics committee approval number of the study is 2019/172.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

**Authorship Contributions:** Concept – A.I.T., Y.O.D., Y.A.; Design – A.I.T., Y.O.D., Y.A.; Supervision – Y.A., Y.O.D., F.A.; Materials – F.A., E.G., Y.O.D.; Data collection &/or processing – Y.B., Y.O.D., F.A.A., S.P.; Analysis and/or interpretation – Y.B., Y.O.D., F.A.A., S.P.; Literature search – Y.A., E.G., Y.O.D., F.A.; Writing – F.A., Y.A., Y.O.D.; Critical review – A.I.T., Y.O.D., Y.B., E.G.

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