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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Role of interventional radiology in the management of iatrogenic urinary tract injury: the factors affecting the outcome

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PURPOSE

To evaluate the efficacy of interventional radiological (IR) procedures in iatrogenic urinary tract injury and investigate the factors affecting the outcome.

METHODS

Fifty-eight patients (21 male) with a mean age of 50.3 ± 15.8 years referred for iatrogenic urinary tract injury were enrolled in this study. Technical success was defined as (i) successful placement of a nephrostomy catheter within the renal pelvis and/or (ii) successful antegrade ureteral stent placement (double J stent) between the renal pelvis and bladder lumen. Complete resolution was defined as maintained ureteral patency without an external drain and ureteral stent. The factors that may affect complete resolution [ureteral avulsion, ureterovaginal fistula (UVF), history of malignancy/radiotherapy, and time to IR management] were also investigated. The receiver operating characteristic analysis was performed to estimate the cut-off time point for the IR management timing affecting complete resolution.

RESULTS

The technical success rate for nephrostomy and ureteral stent placement was 100% (n = 58/58) and 78% (n = 28/36), respectively. In 14 patients, non-dilated pelvicalyceal systems were evident. In 18 patients, no further intervention after percutaneous nephrostomy was performed due to (i) poor performance status (n = 6) and (ii) reconstruction surgery upon clinicians' and/or patients' request (n = 12). Reconstruction surgery was required in 11 of the remaining 40 patients due to failure of percutaneous treatment (n = 11/40, 27.5%). In six of the patients, ureteral stents could not be removed due to the development of benign ureteral strictures (n = 6/40, 15%). Our complete resolution rate was 57.5% (n = 23/40). Age, gender, type of surgery (endoscopic or open), side and location of the injury did not statistically affect the complete resolution rate. The presence of ureteral avulsion, history of malignancy and radiotherapy individually or in combination significantly affected the complete resolution rate negatively. The presence of UVF also had a negative effect on the complete resolution rate; however, it did not reach statistical significance. Delayed intervention was also a significant factor related to lower complete resolution. The optimal cut-off point of the time interval for favorable clinical outcome was found to be 0–19th day following the surgery.

CONCLUSION

IR procedures are safe and effective in the management of iatrogenic urinary tract injuries. Antegrade ureteral stenting should be performed as soon as possible to establish ureteral integrity without the development of stricture.

KEYWORDS

Iatrogenic injury, urinary tract, urinary leak, percutaneous nephrostomy, ureteral stent

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Iatrogenic urinary tract injuries can be encountered following various abdominopelvic surgeries. Patients may present with fever, abdominal pain, and sepsis. Delayed diagnosis, particularly in asymptomatic patients, can lead to stricture, ureterovaginal fistula (UVF), or kidney failure.[1,2] Intraoperative detection is relatively rare, but it allows for immediate repair. The majority of cases are identified in the post-operative period, and delayed diagnosis is related to lower treatment success.[2-4]

The management of urinary tract injuries may vary depending on the location, severity, and recognition time of the injury.[5] Minimally invasive procedures are the commonly preferred methods of treatment due to the associated lower morbidity/mortality rates and shorter hospital stays.[3,6] Lask et al.[7] reported shorter hospital stay following interventional radiological (IR) procedures (3–5 days) compared with reconstructive surgery (14–35 days).

The European Association of Urology guideline on iatrogenic urinary trauma recommends initial urinary diversion via percutaneous nephrostomy.[8] Urinary diversion by percutaneous nephrostomy may serve as a bridging therapy prior to surgery or can be the definitive treatment. Although Lask et al.[7] reported a complete recovery rate of 80% with percutaneous nephrostomy, Borkowski et al.[9] reported a recovery rate of 28.6% in patients treated with percutaneous nephrostomy alone. Therefore, ureteral stent placement should be performed following nephrostomy to preserve ureteral integrity.[8,10]

This study aims to (i) investigate the efficacy of IR management in iatrogenic urinary tract injury and (ii) find out the factors affecting the outcome.

Methods

This retrospective study was approved by Hacettepe University, Faculty of Medicine Institutional Review Board (GO15/533-27). Informed consent for each procedure was provided by all patients.

Main points

- Ureteral avulsion, ureterovaginal fistula, history of malignancy and radiotherapy individually or in combination negatively affected interventional radiological treatment success.
- Delayed intervention was a significant factor related to a lower complete resolution rate.
- The optimal cut-off point of the time interval for favorable clinical outcome was found to be 0-19 day following the surgery.

Study population

Fifty-eight patients referred to our unit due to iatrogenic urinary tract injury over an 11-year period were enrolled in this study. The diagnosis of iatrogenic urinary tract injury was made by (i) contrast-enhanced abdominal computed tomography with a urography phase and (ii) laboratory analysis of samples obtained from intraabdominal collections. The patients' clinical data, laboratory results, and imaging findings were recorded individually. The factors that may affect the complete resolution rate (ureteral avulsion, UVF, malignancy, radiotherapy, and time to IR management) were also evaluated. Complications were classified according to the Society of Interventional Radiology classification system.[11]

Inclusion and exclusion criteria

The inclusion criteria were as follows: the presence of (i) urinary extravasation on cross-sectional imaging, (ii) urine leak via surgically or percutaneously placed drainage tubes (proven by laboratory analysis), or (iii) UVF. The exclusion criteria were as follows: (i) <18 years of age and (ii) urinary leak due to non-iatrogenic incidents.

Definitions

The results of the treatment were evaluated by reviewing the patients' electronic records. Technical success was defined as (i) the successful placement of a nephrostomy catheter within the renal pelvis and/or (ii) successful antegrade ureteral stent placement (double J stent) between the renal pelvis and bladder lumen. The data of the patients who underwent reconstruction surgery, upon clinicians' and/or patients' request, and in whom further management was not considered due to poor performance status were excluded from further analysis.

Complete resolution was defined as maintained ureteral patency without an external drain and ureteral stent. The location of injury was classified as (i) pelvicalyceal system, (ii) ureter, and (iii) bladder. Ureteral avulsion was recognized as complete discontinuity of the ureter.[12] Time to IR management was defined as the time interval between the surgery and percutaneous nephrostomy (n = 40, patients managed with IR procedures alone).

Technique

Routine hemogram, blood biochemistry, and the coagulation profile (international normalized ratio <1.5 and platelet >50,000/mL) were checked before each procedure. All patients received prophylactic broad-spectrum antibiotics (ceftriaxone or ciprofloxacin) prior to the procedure. All procedures were performed in an IR unit under conscious sedation.

Percutaneous nephrostomy

All procedures were performed under ultrasonographic and fluoroscopy guidance while patients were in the prone position. Lower or middle calyceal puncture was performed via an 18G needle in patients with severe hydronephrosis. Following contrast material administration under fluoroscopy, a 0.035-inch guidewire (Amplatz Super Stiff, Boston Scientific, Natick, MA, USA) insertion and tract dilatation were performed. Over the guidewire, a nephrostomy catheter was placed into the renal pelvis. In patients with a non-dilated pelvicalyceal system or mild hydronephrosis, a 21G needle was used for calyceal puncture. Then, the pelvicalyceal system was opacified under fluoroscopy, and a 0.018-inch guide wire was introduced through the renal pelvis, followed by the introducer set (AccuStick, Boston Scientific, USA). Finally, tract dilatation and catheter placement were performed over the 0.035-inch guidewire.

Antegrade ureteral stent placement

Ureteral stent placement was scheduled as a further intervention in a different session following nephrostomy. First, the nephrostomy catheter was removed with the support of a stiff guide wire (Amplatz Super Stiff, Boston Scientific, Natick, MA, USA). Then, a 0.035-inch hydrophilic wire (Terumo, Tokyo, Japan) was delivered through the ureter with the manipulation of a 5F guiding catheter (Imager II Angiographic Catheter, Bern, Boston Scientific, USA). Contrast material was given to reveal the bladder lumen, and the hydrophilic guide wire was exchanged for a stiff guide wire. A 9F vascular sheath was introduced, and a double J stent (8Fr, 20–26 cm, Flexima Ureteral Stent, Boston Scientific, USA) was placed with the support of pushers through the sheath. After obtaining the desired position of the ureteral stents, the nylon threads were removed under fluoroscopic guidance. All patients were evaluated at regular intervals and underwent stent exchange every four months.

Statistical analysis

The data were tested for normal distribution using the Kolmogorov–Smirnov and

Shapiro–Wilk tests. Descriptive statistics were presented as n (%) for categorical variables. If the continuous variables satisfied the normal distribution assumption, they were expressed as mean and standard deviation; otherwise, they were presented as median, first and third quartiles (Q1–Q3) or interquartile range (IQR). Pearson's chi-square test or Fisher's exact test was used to compare the difference association of two groups for categorical variables. For continuous variables, differences between the two groups were compared using the Mann–Whitney U test and t-test based on the normality assumption. The receiver operating characteristic (ROC) analysis was performed to estimate the cut-off time point for the IR management timing affecting complete resolution. The area under the curve (AUC) and 95% confidence interval (CI) were calculated. The optimal cut-off value for the time interval was specified with the maximizing metric in bootstrapped samples using the cutpointr package in R.[13] The maximizing metric is the sum of sensitivity and specificity. Moreover, in order to find the best discrimination point of the time interval for favorable clinical outcomes, the bootstrapped samples were preferred.

A *P* value of less than 0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics (version 23, IBM SPSS, Chicago, IL, USA).

Results

A total of 78 patients were referred for urinary diversion due to a urinary leak. In eight patients, the urinary leak occurred as UVF following radiotherapy, and in 12 of the patients, ureteral integrity was disrupted due to malignant ureteral invasion. These patients were excluded from the study. The final study group consisted of 58 patients (21 male, 36.2%) with a mean age of 50.3 ± 15.8 years (Figure 1).

Urinary tract injury was more frequently encountered following abdominal hysterectomy and bilateral salpingo-oophorectomy surgery (n = 23/58, 40%) and ureterorenoscopy (n=16/58, 28%). In men, the most common surgical indication was urinary stone disease (n = 12/21, 57%), and in women, the most common surgical indications were cervical carcinoma (n = 7/37, 19%) (Figure 2) and myoma uteri (n = 7/37, 19%). Patient and injury characteristics are given in detail in Table 1.

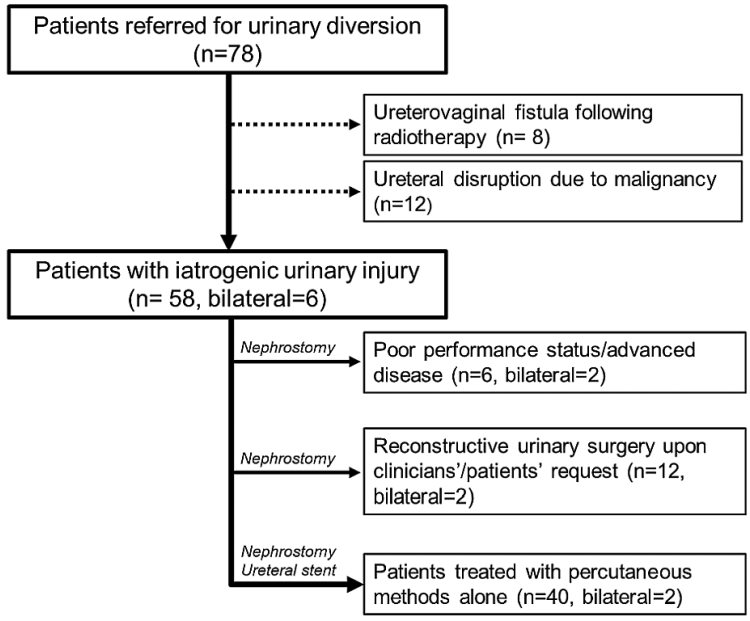

Figure 1. Flowchart of patient selection.

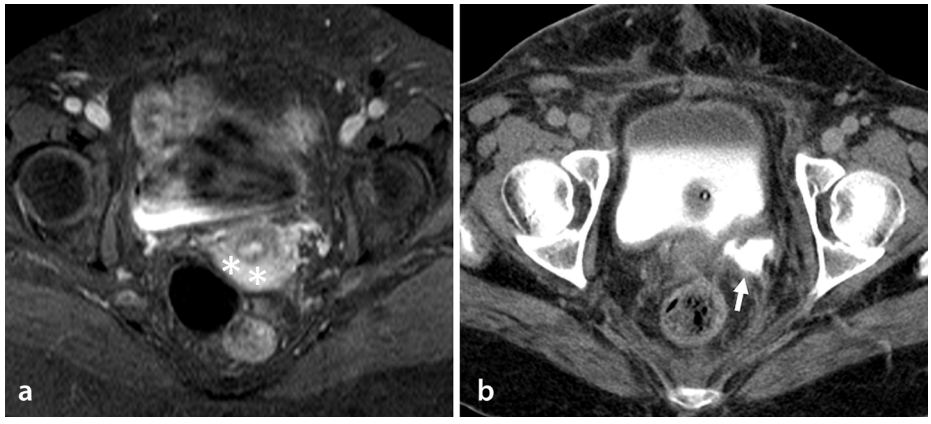

Figure 2. A 55-year-old woman with cervical carcinoma. Axial post-contrast fat-saturated T1 weighted magnetic resonance image shows carcinoma of the posterior cervical wall (a, asterisk). Post-surgical abdominal CT urography demonstrated distal ureteral contrast extravasation (b, arrow). CT, computed tomography.

Table 1. Data of patients with iatrogenic urinary tract injury (n = 58)

		n (%)
Gender (F)		37 (63.8)
Injury site	Ureter	43 (74) (n = 6 bilateral)
	Renal pelvicalyceal	11 (19)
	Bladder	4 (7)
Renal pelvicalyceal injury side	Right	6 (55)
	Left	5 (45)
Ureteric injury side	Right	16 (37)
	Left	21 (49)
	Bilateral	6 (14)
Ureteric injury localization	Proximal	7 (14)
	Middle	8 (16)
	Distal	34 (69)
Hydronephrosis		44 (76)
Pyonephrosis		13 (22)

In all cases, the initially performed procedure was percutaneous nephrostomy. A total of 64 percutaneous nephrostomy procedures were performed in 58 patients (bilateral: 6) with a technical success rate of 100%. In 12 patients (n = 12/58, 21%), percutaneous urinoma drainage was also necessary. Thirty-six patients had indwelling surgically placed drainage tubes. Further management was not considered in 6 patients (n = 6/58, 10%) (bilateral: 2) due to poor performance status and associated comorbid diseases, and these patients opted for permanent nephrostomy. In 21% of the patients (n = 12/58), surgeons performed reconstruction surgery following nephrostomy upon clinicians' and/or patients' request (mean 49.5 ± 33.3 days after nephrostomy). In these 12 patients, no further IR management after percutaneous nephrostomy was performed.

Finally, a total of 40 patients (bilateral: 2) were managed with IR procedures alone. Four out of these 40 patients (10%) were treated with nephrostomy, and no further intervention was required. In 36 patients (n = 36/40, 90%) (bilateral: 2), antegrade ureteral stent placement was attempted after a median of 12 days following nephrostomy (IQR: 18, range: 4–66 days). In 8 patients (n = 8/40, 20%) (bilateral: 1), antegrade stent placement could not be achieved due to the lack of ureteral continuity. The technical success rate for ureteral stent placement was 78% (n = 28/36). Percutaneous balloon dilatation was necessary in 5 patients due to associated benign ureteral stricture (n = 5/28, 18%). No major complications occurred during any of the procedures.[11]

In 68% (n = 19/28) of the patients with ureteral stents, the stents were removed after a median of 110.5 days (IQR: 149, range: 40–701) (Figure 3). The complete resolution rate was 57.5% [n = 23/40, (nephrostomy alone n = 4, ureteral stent n = 19)]. Six patients (n = 6/40, 15%) (bilateral: 1) are still under treatment with routine ureteral stent exchanges due to associated benign ureteral strictures. Eleven patients (n = 11/40, 27.5%) opted for nephrostomy due to (i) ureteral avulsion (n = 8, bilateral: 1) or (ii) refractory urinary leak despite functioning ureteral stent (n = 3). These patients underwent surgery due to failure of IR treatment (mean 47.6 ± 48 days). Moreover, the median follow-up period was 765 days (IQR: 1021).

A further analysis was carried out for patients treated with IR methods alone (n = 40). Age, gender, and the side and location of the injury did not statistically affect the complete resolution rate. There was no statistically significant difference regarding the complete resolution rate between endoscopic and open surgery (P = 0.117) (Table 2). However, the presence of ureteral avulsion, history of malignancy and radiotherapy individually or in combination significantly affected the complete resolution rate negatively. The presence of UVF also had a negative effect on the complete resolution rate, but it did not reach statistical significance (Table 3). Complete resolution was achieved in 25% (n = 2/8) of the patients with UVF (Figures 3, 4). In the complete resolution group, 74% (n = 17/23) of the patients had no malignancy. In addition, all patients with a history of radiotherapy (n = 4/40, 10%) opted for nephrostomy or ureteral stent.

The median time between surgery and diagnosis of iatrogenic injury by cross-sectional imaging was 10 days (IQR: 13.5, range: 0–75). After the diagnosis, percutaneous nephrostomy was performed after a median of 2 days (IQR: 2.5, range: 0–6). The median time between surgery and IR management

Table 2. Data of the patients managed with interventional radiological procedures alone (n = 40*)

		Complete resolution n = 23 (57.5%)	Nephrostomy/ ureteral stent n = 17 (42.5%)	*P* value
Gender (F)		12 (52.2)	12 (70.6)	0.240
Age		50 (33-60)	45 (40.5-64)	0.522
Injury site	Ureter	16 (69.5)	16 (94)	0.107
	Renal pelvis	7 (30.5)	1 (6)	
Injury side	Right	8 (35)	10 (59)	0.054
	Left	15 (65)	5 (29.5)	
	Bilateral	0 (0)	2 (12)	
Ureteric injury localization	Proximal	3 (19)	2 (12.5)	0.765
	Middle	3 (19)	2 (12.5)	
	Distal	10 (62)	12 (75)	
Type of surgery (endoscopic)		11 (48)	4 (24)	0.117

*In 18 of the patients, no further intervention after percutaneous nephrostomy was performed due to (i) poor performance status (n = 6) and (ii) reconstruction surgery upon clinicians' and/or patients' request (n = 12).

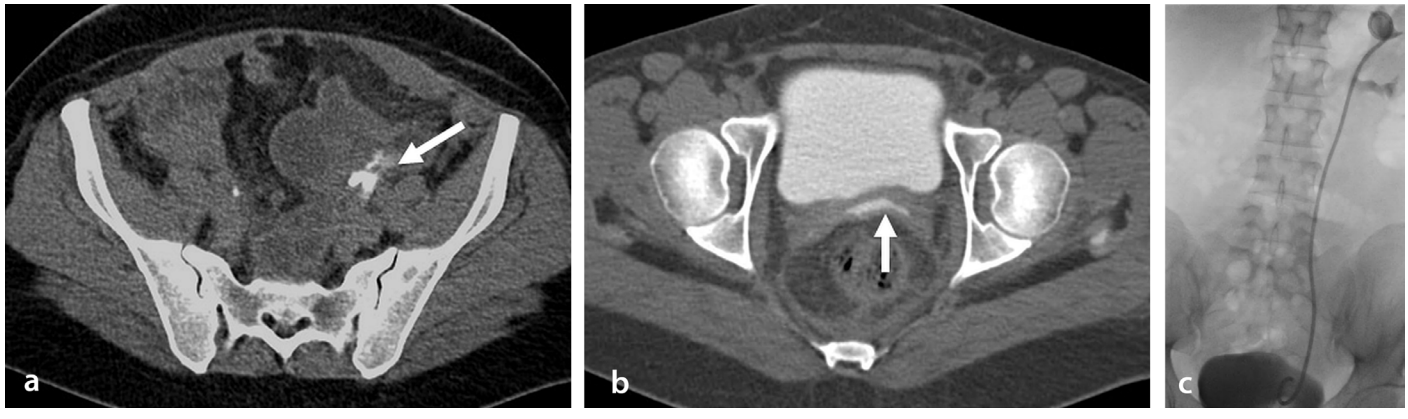

Figure 3. A 33-year-old woman underwent an emergency hysterectomy for postpartum hemorrhage. On follow-up, she developed left flank pain and fever. CT urography demonstrated contrast extravasation (**a**, arrow) and ureterovaginal fistula (**b**, arrow). Percutaneous nephrostomy was initially performed. Four days after nephrostomy, ureteral stent placement was performed **(c)**. During the procedure, ureteral stricture was evident at the level of the pelvic brim (not shown). The ureteral stent was removed on the second exchange period due to the absence of stricture or leak. CT, computed tomography.

was 13 days (IQR: 15, range: 0–78). Time to IR management had also a negative effect on the complete resolution rate. It was shorter in patients with complete recovery than in the remaining patients (a median of 10 days vs. 20 days, $P = 0.018$) (Table 3). According to the ROC analysis, the time to IR management was a significant predictor of clinical outcome (AUC: 0.729, 95% CI: 0.557–0.901, $P = 0.018$) (Figure 5). The optimal cut-off point of the time interval for favorable clinical outcome was found to be 0-19 day following the surgery with respect to the maximizing metric in bootstrapped samples (sensitivity: 0.714, specificity: 0.563).

Discussion

This study evaluated the effectiveness of IR procedures in the management of iatrogenic urinary tract injury. Percutaneous nephrostomy, ureteral stent placement, and collection drainage were the main percutaneous treatment options. The technical success rate for nephrostomy and ureteral stent placement was 100% and 78%, respectively. The lack of ureteral continuity was the major reason for failure of antegrade ureteral stent placement, and the complete resolution rate was 57.5%. The presence of ureteral avulsion, UVF, and history of malignancy and radiotherapy individually or in combination negatively affected the complete resolution rate. In addition, there was a statistically significant negative relation between delayed IR management and the complete resolution rate. The optimal cut-off point of the time interval for favorable clinical outcome was found to be 0-19 day following the surgery. The time prior to IR management was significantly longer in patients who opted for nephrostomy or ureteral stent.

In the management of iatrogenic urinary tract injury, clinical success is based on several conditions: (i) recovery from urosepsis, (ii) preserving renal function, (iii) cessation of urinary leak, and (iv) complete resolution without indwelling nephrostomy and/or ureteral stent. Percutaneous nephrostomy prior to any further management, including surgery, is recommended for urinary decompression and diversion.[6,14] Lask et al.[7] treated 20 patients with percutaneous nephrostomy alone and reported a complete recovery rate of 80%. However, percutaneous nephrostomy per se remains insufficient in most of the cases. Therefore, further management, primarily ureteral stent placement, is mandatory for complete resolution. Borkowski et al.[9] reported a complete recovery of 28.6% (6/21) with percutaneous nephrostomy alone, while this rate was 83% (5/6) for the ureteral stent group. Similarly, our complete resolution rate with percutaneous nephrostomy alone was relatively low (n = 4/12, 30%), while it was 68% (n = 19/28) for ureteral stent. In addition, nephroureteral stents can be used for both urinary diversion and maintaining ureteral patency in patients with urinary tract injury. Zilberman et al.[15] reported a complete resolution rate of 78.5% with nephroureteral stents in a patient population with iatrogenic urinary injury.

Ku et al.[3] reported a complete resolution rate of 65% in 17 patients with urinary leak treated with both antegrade and retrograde ureteral stent placement. Fontana et al.[16] performed ureteral stent placement in 15 patients with urinary leak and reported a complete resolution rate of 53.5%. However, Ustunsoz et al.[17] reported a complete resolution rate of 75% in 22 patients with 24 ureteral injuries. In this study, our complete resolution rate was 57.5%. This may be due to the heterogeneity and complexity of our study population. Ustunsoz et al.[17] reported a higher complete resolution rate in a study consisting of relatively young patients (postpartum urinary injury) without a history of malignancy or radiotherapy. The history of malignancy and/or radiotherapy were significant factors affecting complete resolution in our study. Furthermore, we found complete resolution rates of 71% and 37.5% in patients with benign and malignant diseases, respectively. In a different study, complete resolu-

Table 3. Factors affecting the outcome (n = 40)

	Complete resolution n = 23 (57.5%)	Nephrostomy/ureteral stent n = 17 (42.5%)	*P* value
Benign	17 (74)	7 (41)	0.037
Malignant	6 (26)	10 (59)	
Ureteral avulsion	0 (0)	8 (47)	<0.001
Ureterovaginal fistula	2 (9)	6 (35)	0.053
Radiotherapy	0 (0)	4 (23.5)	0.026
Combination of risk factors	0 (0)	7 (41)	0.001
Time to interventional radiological management (days)	10 (4.50–19.50)	20 (9.50–30.25)	0.018

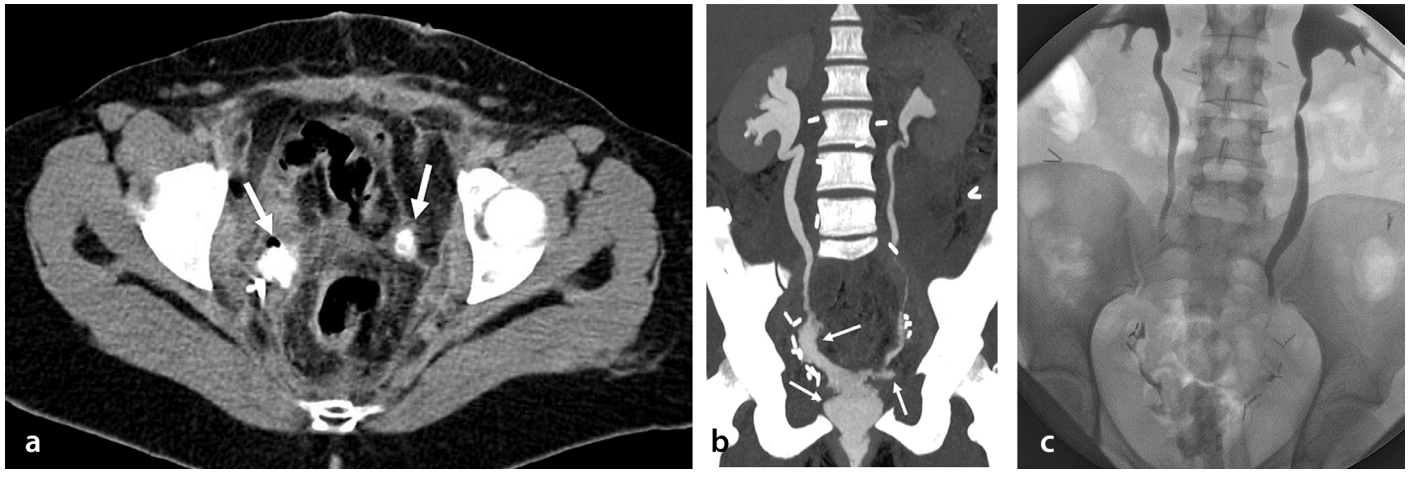

Figure 4. A 40-year-old woman presented with a vaginal urine leak following hysterectomy. CT urography demonstrated distal ureteral contrast extravasation and ureterovaginal fistula (arrows, **a** and **b**). Bilateral nephrostomy was performed **(c)**. The patient underwent bilateral ureteroneocystostomy due to failure of ureteral stent placement. CT, computed tomography.

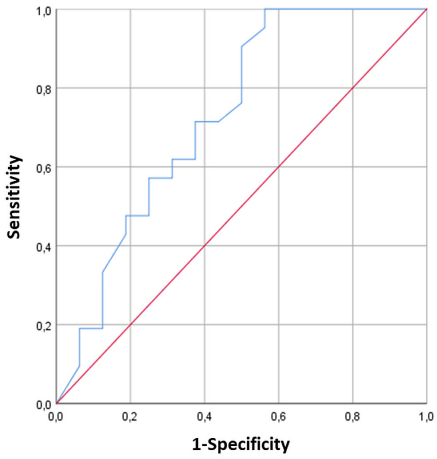

Figure 5. The receiver operating characteristics curve for the time to interventional radiological management (area under the curve: 0.729, 95% confidence interval: 0.557–0.901, $P = 0.018$).

tion was achieved in only 4 out of 19 cancer patients with postoperative ureteral injury.[18]

The presence of ureteral avulsion (loss of integrity) negatively affected the complete resolution rate. In this study, eight patients with ureteral avulsion opted for nephrostomy and ended up with reconstructive surgery. Ustunsoz et al.[17] also reported that 50% of the patients with failure of treatment had ureteral avulsion.

Delayed diagnosis of urinary tract injury is a major factor related to low treatment success.[3,4,9,17] Morrow et al.[19] reported that a longer median time to ureteral stent placement was associated with failure. We also found that time prior to IR management was a significant factor in determining complete resolution. The optimal cut-off point of the time interval for favorable clinical outcome was found to be 0–19th day following the surgery (sensitivity: 0.714, specificity: 0.563).

The presence of UVF also had a negative effect on the complete resolution rate; however, it did not reach statistical significance. This may be because of our small sample size. Chen et al.[20] reported a complete resolution rate of 83% in a series of 12 patients with UVF managed with ureteral stenting. In addition, Rajamaheswari et al.[21] reported successful ureteral stenting in 77% of patients with UVF. Our relatively low success rate in patients with UVF may be due to delayed intervention. Follow-up with nephrostomy alone is not recommended in the treatment of UVF due to an increased rate of failure.[20,22] Ureteral integrity should be established as soon as possible to avoid a mature fistula tract between the ureter and vagina.[20]

This study has several limitations. First, it is a retrospective study. Second, the study population was heterogeneous. Third, the time to IR management was relatively long; therefore, the complete resolution rate of this study might have been negatively affected. Finally, the sample size was small, and in several patients, antegrade ureteral stent placement could not be attempted due to clinicians' decisions.

In conclusion, IR procedures are safe and effective methods of treatment alternative to reconstruction surgery in the management of postoperatively detected iatrogenic urinary tract injury. Ureteral avulsion, UVF, history of malignancy and radiotherapy, and delayed intervention negatively affect treatment success. Antegrade ureteral stent placement should be performed as soon as possible to establish ureteral integrity without the development of stricture.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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