Arterioureteral fistula after radical cystectomy and ureterocutaneostomy: two case reports and a systematic literature review

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Abstract

Background: Arterioureteral fistula (AUF) is a rare, life-threatening condition wherein communication occurs between a ureter and the common, internal, or external iliac artery. The sensitivity of common clinical imaging examination for AUF is low, which leads to a delayed diagnosis and increased mortality. In addition, the increased use of ureteral stents contributes to the growing frequency of AUF.

Case presentation: Our two patients were 74 and 65 years old males respectively. They both had a medical history of bladder cancer and underwent radical cystectomy with ureterocutaneostomy. The patients underwent routine catheter exchange during over 1 year postradical cystectomy and subsequently experienced intermittent gross pulsatile haematuria. After a series of imaging examinations failed to identify the cause, the patients were ultimately diagnosed with AUF and treated with interventional radiotherapy, followed by broad-spectrum antibiotics. Positive effects were found.

Conclusions: The incidence of AUF is increased with the prolongation of survival in patients with related risk factors. This case report aims to highlight early diagnosis and management of AUF to lower the mortality.

Keywords: Arterioureteral fistula, Literature review, Bladder cancer, Ureterocutaneostomy

Background

Arterioureteral fistula (AUF) is a rare but potentially life-threatening condition that was first reported in 1908 by Moschcowitz [1]. The pathophysiology of AUF involves the development of communication between a ureter and the common, internal, or external iliac artery. The causes of AUF can be divided into primary (15%) and secondary (85%) types [2]. Pelvic radiotherapy, genitourinary surgery, chronic ureteral stenting, and peripheral arterial disease are the most common secondary causes [3]. While haematuria is the most common symptom of AUF, flank pain, urinary retention, and infection have been described in the clinical as well [4]. Although AUF is uncommon, the mortality rate can reach 10% to 20% and increases in cases where the preoperative diagnosis is delayed [5]. We herein report two cases of AUF patients manifesting gross haematuria after radical cystectomy with ureterocutaneostomy.

Case presentation

Case 1

A 74-year-old male with persistent gross haematuria and flank pain was admitted to our department. He had a medical history of bladder cancer and asthma. In addition, he had severe obstructive pulmonary disease.

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for many years. Bladder cancer was treated with radical
cystectomy and ureterocutaneostomy in another hospi-
tal two years ago and the final pathology report revealed
high-grade urothelial carcinoma of the bladder, stage
unknown. A single-J polymeric stent was inserted and
replaced every 3 months after surgery. However, a few
days after the last replacement, the patient began to suffer
from persistent gross haematuria and flank pain, without
other significant symptoms. There was deep-red liquid
and blood clots in the fistula bag. Contrast-enhanced
computed tomography (CT) showed a low-density fill-
ing in the left renal pelvis. After admission, he developed
haemodynamic instability and received 4 U red blood cell
and 2 U haemocoagulase. After supportive treatment,
the patient’s symptoms were relieved significantly. The
patient’s urine became clear, and his vital signs gradually
stabilized.

In the early morning of the third day of hospitaliza-
tion, bright-red liquid and blood clots were noticed in
the patient’s fistula bag. As the blood pressure (BP) is
90/60 mmHg and the heart rate is 90, his haemodynamic
status was instable. Timely support treatment was given
to maintain hemodynamic stability. Nonetheless he con-
tinued to experience intermittent haematuria. The Inter-
ventional Radiology Department was urgently contacted,
and emergent diagnostic catheter angiography was per-
formed for suspected arterioureteral fistula. With the
movement of contrast medium, a fistula was observed at
the intersection of left ureter and common ipsilateral iliac
artery. The patient was diagnosed with AUF (Fig. 1A–B);
placement of a covered stent by endovascular treatment
during interventional radiotherapy was immediately
requested (Fig. 1C–D). The degree of haematuria gradu-
ally improved until disappearing and the patient was dis-
charged 5 days after the operation with good diuresis and
haemodynamic stability and remained free of gross ha-
ematuria during the 1-month follow-up. The patient was
satisfied with the treatment results.

Case 2
A 65-year-old male with intermittent haematuria was
admitted to our department. He had a medical history
of bladder cancer and accepted radical cystectomy with
ureterocutaneostomy 15 months ago. Besides, He had a
medical history of myocardial infarction and obstinate
cardiac insufficiency. The patient’s final pathology report
revealed high-grade urothelial carcinoma of the blad-
ner, stage pT2N0M0. The patient exhibited no other dis-
comfort except the haematuria in left single-J polymeric
stent. His haemodynamic status was stable. Enhanced CT
and magnetic resonance imaging (MRI) were performed,
but there were no findings capable of explaining the
patient’s clinical symptoms. Combined with the patient’s
medical history of pelvic surgery and long-term ureteral
stent implantation, AUF was suspected. Ureteroscopy
and angiography were performed to assess fistula after
the correction of anaemia. However, no bleeding point
was identified clearly on angiography. Rough mucosa
was found 15 cm from the ureteral orifice on ureteros-
copy. Then, ureteral stent implantation was performed
for urine drainage. No haematuria was detected during
several days of hospitalization, and the urine drained by
the ureteral stent was clear. The patient was discharged
5 days after the operation and followed up regularly.

One month after returning home, the patient devel-
oped massive haematuria when the ureteral stent was
replaced and accepted angiography in a local hospital.
Fortunately, a fistula was found (Fig. 2A–B), and an iliac
artery stent was placed. The patient was finally diagnosed
with AUF. The patient’s haematuria symptoms did not
appear again during the 1 month of follow-up.

Discussion and conclusion
The occurrence of AUF is not common, yet in the pre-
sent era of increasing longevity and huge increases in
accessibility to endoscopic interventions of the urinary
tract, there is now a widespread recognition of AUF. In
recent years, more than 150 cases of AUF with various
causes have been reported [6]. Furthermore, AUF has
become easier to diagnose due to the prolonged survival
of patients with malignant tumours [7]. A review gave a
summary of literature reports of 139 case reports of AUF
from 1899 to 2008, in which gynaecologic cancer (28%),
bladder cancer (13%), colorectal cancer (11%), other can-
cers (5%), untreated aneurysm (4%) and prior vascular
surgery (18%) were mentioned [8]. Pregnancy-associated
AUF was discussed in 3 reports [9]. Moreover, a study
including 445 patients showed that 80% had chronic
indwelling ureteral stents while 70% with a history of pel-
vic oncology, and most AUFs occurred at the common
iliac artery ureteral crossing [10]. We reviewed 216 cases
of 92 studies in English from the past 10 years (2011–
2021) in PubMed and summarized them in Table 1. Risk
factors included oncology (173 patients), ureteral stent
placement (187 patients), radiotherapy (136 patients),
aneurysm or pseudoaneurysm of the iliac artery (19
patients), vascular surgery (21 patients) and others (25
patients). The 213 patients in 92 studies consisted of
131 females and 82 males, with a mean age of 65.1 years
(range 35–90 years). Details are provided in Table 2.

The pathophysiology of the formation of arterioureteral
fistula is still unclear. However, it can be divided into pri-
mary iliac AUF and secondary iliac AUF according to
medical history and the disease process. Primary AUF
is mainly caused by aneurysm or pseudoaneurysm rup-
ture and is associated with atherosclerosis or vascular
surgery history [11]. In secondary AUF, radiotherapy and chronic ureteral stents might be risk factors [6]. Changes in the media and adventitial layers of the large vessels are caused by prior radiation, rendering the tissues more prone to rupture, erosion and necrosis [12]. Besides long-term compression of the ureteral stent leads to tissue necrosis and fistula between the ureter and iliac vessels. Therefore, a ureteral stent replaced after the operation should be as soft and thin as possible. To prevent strong compression and abrasion of the ureteral tube wall, it is recommended that the stent be less than Fr8 [12]. If the stent tube is too hard, the ureter wall and the iliac artery, particularly the turning point of the ureter, will be under excessive pressure and forced close to the artery. In this way, a fistula can easily form under the erosion of the pulsating artery against the baseline mechanical friction caused by the pulsatile arterial flow [6]. Due to the limited fat support between the ureter and iliac vessels for patients with low BMI, this situation may also result in AUF. In patients undergoing lymph node dissection, the iliac vascular sheath is opened, exposing the vascular wall and further leading a lack of tough connective

**Fig. 1 A–B** Left arteriogram with contrast noted a exudation through the fistula tract from left iliac artery into the left ureter. **C–D** No contrast agent exudation was found in both arteriogram and nephrostogram after a heparinbonded stent-graft placed in left iliac artery.
tissue protection between the iliac vascular sheath and the left ureter. The combined action might lead to fistula formation.

The most common symptom is haematuria, occasionally with flank pain. The degree of haematuria can range from intermittent bleeding to life-threatening haemorrhagic shock. In some cases obstructed clot formation in the ureter causes flank pain [2].

Although the danger of AUF has been mentioned in many studies, some patients cannot receive prompt treatment because of the difficulty of diagnosis. The most effective diagnostic method is digital subtraction angiography, yielding a diagnosis of 69% of 139 cases [8]. Angiography with concurrent manipulation of a neophroureteral stent has been shown to improve the sensitivity to 100%, which can achieve the same effect as balloon stimulation. The sensitivity of provocative retrograde pyelogram may be as low as 63% [13, 14]. Enhanced CT has less sensitivity in identifying bleeding but can be highly beneficial if active haemorrhage or a pseudoaneurysm is exist. It can also be used to rule out renal haemorrhages and plan endovascular treatment [15]. Cystoscopy may contribute to localized bleeding of the ureter.

There are two main therapeutic approaches to AUF: open surgery and endovascular treatment. Since 1996, a stent graft has been used as treatment for AUF in most patients [16]. Because of its minimally invasion and outcomes similar to those of open surgical reconstruction, endovascular treatment has become an appealing alternative to open surgical reconstruction [17]. It is important to note that intravascular stents increase the possibility of infection, which is an main factor leading to the shortening of postoperative survival [18]. Accordingly, empiric broad-spectrum antibiotics with the ability to penetrate bacterial biofilms should be used [18]. When replacing the ureteral stent regularly, use of a guide wire and a balloon with an appropriate amount of water in replacement of the ureteral stent can reduce the occurrence of AUF.

Regarding to our two cases with history of chronic ureteral stenting after radical cystectomy and ureterocutaneostomy, the priority of diagnosing AUF needs to be emphasized for patients with a history of pelvic malignancy, chronic ureteral stenting, pelvic irradiation or symptoms that include haematuria, flank pain, or both. Thus, the interval between the onset of symptoms and rapid progression of AUF may be minimized, which makes it reasonable to carry out emergency intervention without definitive imaging evidence in patients with related risk factors. The delay in clinical diagnosis may lead to the deterioration of the condition, which cannot be treated [12]. Overall, treatment results may be improved by timely angiography.

AUF is a life-threatening condition that can occur in patients with long-term ureteral stents. Although rare, AUF should be highly suspected if a patient has a medical history of pelvic surgery or pelvic irradiation in the setting of ureteral stents and haematuria. Timely interventional radiotherapy can help lower mortality.
| Publication date | Title | DOI | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment |
|-----------------|-------|-----|-------|-----|--------|-------------------------|--------------------------|----------|-----------|-----------|
| 2021            | Ureteroarterial fistula embolization by transradial approach: A case report | 10.1016/j.radcr.2021.02.004 | 1     | 80  | Female | Uterine cancer           | U-stent, surgery, RT     | Hematuria | Angiography | Embolism   |
| 2021            | Ureteroarterial Fistula: A Diagnosis Which Is Not Always Black and White | 10.1155/2021/8165991 | 2     | 55  | Female | Cervical cancer          | U-stent, surgery, RT     | Hematuria | Retrograde Pyelography | Stent graft |
|                 |       |     |       | 73  | Female | Cervical cancer          | U-stent, surgery, RT, Chemo-therapy | Hematuria | No Clear Evidence | Open surgery |
| 2021            | Uretero-Arterial Fistula: A Case Report and Review of the Literature | 10.1177/1538574420976731 | 1     | 56  | Female | Ureteral stone           | VS, laser lithotripsy    | Hematuria | No Clear Evidence | Stent graft |
| 2021            | Oncology and complications | 10.4081/aiua.2021.1.71 | 2     | 61  | Male   | Colon cancer             | U-stent, surgery         | Hematuria | Retrograde Pyelography | Stent graft |
|                 |       |     |       | 63  | Male   | Retroperitoneal fibrosis | U-stent                 | Hematuria | No Clear Evidence | Stent graft |
| 2021            | A Bleeding Uretero-Arterial Fistula: Open Repair After Unsuccessful Endovascular Treatment | 10.1177/1538574420953964 | 1     | 76  | Female | Abdominal aneurysm       | U-stent, VS, History of surgical injury to ureter | Hematuria | Angiography | Open surgery |
| 2021            | Management and endovascular therapy of ureteroarterial fistulas: experience from a single center and review of the literature | :10.1186/s42155-021-00,226-6 | 16    | 69.8| Male(12) Female(4) | Colorectal cancer (10) Uterine/cervical cancer (3) Bladder cancer (1) Testicular cancer (1) Prostate cancer (1) | U-stent (16) RT(14) Chemotherapy (14) Surgery (13) | Hematuria (16) Flank pain (5) | Enhanced CT (2) Angiography (3) No Clear Evidence (11) | Stent graft (10) Embolism (6) |
| 2021            | Endovascular therapy of arteroureteral fistulas | 10.1024/0301-1526/a000922 | 5     | 64  | Male(2) Female(3) | Pelvic malignancy (4) Peripheral arterial disease (1) | U-stent (4) RT (4) Surgery (4) | Hematuria (5) | Enhanced CT (2) Angiography (5) | Embolism (5) |
| Publication date | Title                                                                 | DOI                          | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment       |
|-----------------|----------------------------------------------------------------------|------------------------------|-------|-----|--------|------------------------|--------------------------|----------|-----------|----------------|
| 2021            | Asynchronous Bilateral Ureteric-Arterial Fistula: Diagnosis and Treatment | 10.1155/2021/5590432         | 1     | 48  | Female | Cervical cancer         | U-branch, surgery, RT, Chemotherapy | Hematuria | Enhanced CT Angiography | Stent graft |
| 2021            | Midterm Results after Open Surgical and Endovascular Management of Arterioureteral Fistula | 10.1016/j.avsg.2020.11.014  | 9     | 69.1| Male(6) Female(3) | Pelvic malignancy(6) Arterial disease(2) Aneurysm(1) | U-branch(7) RT(4) Surgery(9) VS(3) | Hematuria | Ureteroscopy(3) Angiography(6) Stent graft (4) Embolism (2) Open surgery(3) |
| 2020            | Ureteroiliac artery fistula caused by full-length metallic ureteral stenting in a malignant ureteral obstruction: a case report | 10.1186/s13256-020-02,532-4 | 1     | 57  | Female | Cervical cancer         | U-branch, surgery, RT, Chemotherapy | Hematuria | No Clear Evidence | Stent graft |
| 2020            | Case Report of a Ureteroiliac Artery Fistula                          | 10.1016/j.avsg.2020.09.026  | 1     | 63  | Male   | Rectal cancer           | U-branch, surgery, RT, Chemotherapy | Hematuria | Angiography | Open surgery |
| 2020            | Ureteroarterial fistula treated by endovascular stent placement       | 10.1016/j.radct.2020.05.044 | 1     | 69  | Female | Cervical cancer         | U-branch, surgery, RT | Hematuria | Angiography | Stent graft   |
| 2020            | Ureteroarterial fistula: imaging diagnosis and endovascular management | 10.1136/bcr-2020–236,011     | 1     | 65  | Female | Cervical cancer         | U-branch, surgery, RT, Chemotherapy, PA | Hematuria | Angiography | Stent graft   |
| 2020            | Uretero-iliac artery fistula a rare cause of haematuria               | 10.1136/bcr-2019–232,189     | 1     | 45  | Female | Cervical cancer         | U-branch, surgery, RT, Chemotherapy | Hematuria | Retrograde Pyelography | Open surgery |
| Publication date | Title                                                                 | DOI                             | Cases | Age | Gender | Primary Disease (cases)                                                                 | UAF Risk Factors (cases) | Symptoms | Diagnosis       | Treatment  |
|-----------------|-----------------------------------------------------------------------|---------------------------------|-------|-----|--------|----------------------------------------------------------------------------------------|--------------------------|----------|-----------------|------------|
| 2020            | Arterioureteral Fistula in the Setting of an Indwelling Ureteral Stent, Ileal Conduit and History of Pelvic Radiation. Urology | 10.1016/j.urology.2020.03.013  | 1     | 75  | Female | Bladder cancer                                                                        | U-stant, Cystectomy, RT, Chemotherapy | Hematuria | Retrograde Pyelography | Open surgery |
| 2020            | Uretero-arterial fistula treated with endovascular stent graft following multiple interventions | 10.1002/iju5.12216              | 1     | 64  | Male   | Rectal cancer                                                                         | U-stant, surgery, RT, Chemotherapy | Hematuria | Angiography     | Embolism   |
| 2020            | Successful Endovascular Management of an Arterioureteral Fistula Presenting with Massive Hematuria in a Failed Renal Transplant | 10.1089/cren.2019.0095         | 1     | 68  | Female | Allograft renal Transplant secondary to chronic pyelonephritis                        | Allograft renal Transplant surgery | Hematuria | Angiography     | Stent graft |
| 2020            | Endovascular treatment of arterio-ureteral fistula with new-generation balloon-expandable stent graft using a 7-French system | 10.1177/2050313X20959219        | 1     | 82  | Female | Cervical cancer                                                                       | U-stant, surgery, RT, Chemotherapy | Hematuria | Enhanced CT     | Embolism   |
| Publication date | Title                                                                 | DOI                                      | Cases | Age  | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms              | Diagnosis | Treatment               |
|-----------------|----------------------------------------------------------------------|------------------------------------------|-------|------|--------|------------------------|--------------------------|-----------------------|-----------|-------------------------|
| 2020            | Endoleak and Pseudaneurysm Formation in the Setting of Stent Graft Infection Following Endovascular Uretero-Arterial Fistula Repair: The Dreaded Complication | 10.7759/cureus.8830                      | 1     | 71   | Female | Cervical cancer         | U-stant, surgery, RT, Chemotherapy | Hematuria             | Angiography | Stent graft              |
| 2020            | Endovascular and open surgical options in the treatment of uretero-arterial                                          | 10.1177/1708538120970823                  | 25    | 61   | Male(8) Female(17)    | Endometrial adenocarcinoma (3) Cervical cancer (10) Prostate cancer (2) Bladder cancer (3) Aneurysm (2) Peripheral arterial disease (2) Colorectal cancer (2) Anal cancer (1) | Hematuria (25) Flank pain (10) Enhanced CT (7) Angiography (4) No Clear Evidence (14) | Stent graft (20) Open surgery (5) |
| 2020            | Ureterococcal Fistula: Bleeding of Unknown Origin- Case Report and Review of the Literature                            | 10.1089/cren.2020.0122                    | 1     | 62   | Male   | Uncontrollable bladder bleeding | U-stant, surgery,RT | Hematuria             | Ureteroscopy | Stent graft              |
| 2020            | Clinics in diagnostic imaging                                          | 10.11622/smedj.20200089                   | 1     | 69   | Female | Cervical cancer         | U-stant, surgery, RT, Chemotherapy | Hematuria             | Angiography | Stent graft              |
| 2020            | Ureterococcal artery fistula in idiopathic retroperitoneal fibrosis: A case report                                      | 10.4081/aiua.2020.2.107                    | 1     | 73   | Male   | Retropertoneal fibrosis  | U-stant | Hematuria             | Flank pain    | No Clear Evidence         | Stent graft |
| Publication date | Title                                                                 | DOI                                      | Cases | Age  | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms          | Diagnosis          | Treatment          |
|-----------------|----------------------------------------------------------------------|------------------------------------------|-------|------|--------|-------------------------|-------------------------|-------------------|-------------------|-------------------|
| 2020            | Arterioureteral fistula: overview of clinical characteristics, endovascular management, and outcomes | 10.1080/13645706.2020.1782939           | 8     | 62.4 | Male(2) Female(6)       | Pelvic malignancy (6)   | Hematuria         | Enhanced CT       | Stent graft        |
| 2020            | Aorto-ureteric fistula post endovascular stent graft management of ruptured abdominal aortic aneurysm: a case report | 10.1111/ans.15065                       | 1     | 79   | Male   | Aneurysm                | VS                      | Hematuria         | Enhanced CT       | Ureteric stent     |
| 2020            | Life-threatening arterioureteral fistula treatment by endovascular complete anatomic iliac artery bifurcation reconstruction | 10.1016/j.jvscit.2020.01.012            | 5     | 55   | Male(1) Female(4)       | Cervical cancer (4)     | Hematuria         | Angiography (5)   | Stent graft (5)    |
| 2019            | Endovascular treatment of ureteroarterial fistula using a covered stent, evaluated by intravascular ultrasound: a case report | 10.1186/s42155-019-0060-6                | 1     | 84   | Female | Retroperitoneal fibrosis | U-stent               | Hematuria         | Angiography (5)   | Embolism + Stent graft |
| 2019            | A Case of Ureteroarterial Fistula Successfully Treated with Endovascular Stent Graft | 10.14989/ActaUrolJap-65-7-299            | 1     | 46   | Female | Ovarian cancer        | U-stent, surgery       | Hematuria         | Angiography (5)   | Stent graft        |
| Publication date | Title                                                                 | DOI                          | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment            |
|-----------------|------------------------------------------------------------------------|------------------------------|-------|-----|--------|--------------------------|--------------------------|----------|-----------|----------------------|
| 2019            | Ureteroarterial Fistula in a Patient with an Ileal Conduit and Chronic Nephroureteral Catheter | 10.1089/cien.2019.0004      | 1     | 64  | Male   | Bladder cancer           | U-plant, Cystectomy      | Hematuria | Angiography | Stent graft           |
| 2019            | Endovascular management of arterio-ureteral fistula in a patient with a challenging hematuria. Minim Invasive Ther Allied Technol | 10.1080/13645706.2018.1534742 | 1     | 43  | Female | Cervical cancer          | surgery, RT             | Hematuria | Angiography | Embolism Stent graft |
| 2019            | Endovascular management and the risk of late failure in the treatment of ureteroarterial fistulas | 10.1016/j.jsct.201906.010   | 2     | 70  | Female | Cervical cancer          | U-plant, surgery, RT    | Hematuria | Angiography | Stent graft           |
|                 |                                                                        |                              | 77    |     | Female | Cervical cancer          | U-plant, surgery, RT    | Hematuria | Angiography | Stent graft           |
| 2019            | Sudden fatal bleeding from a uretero-arterial fistula combined with pre-existing ureterocolic and ureterovaginal fistulas 7 years after a cervical cancer surgery: a case report | 10.1186/s40792-019-0642-5    | 1     | 52  | Female | Cervical cancer          | U-plant, surgery, RT, Chemotherapy, Ureterocolic fistula and ureterocolic fistula | Perineal hemorrhage | No Clear Evidence Post-mortem | Cannot accept intervention |
| 2019            | Ureteral-Arterial Fistula—A Role for Open Operation in the 21st Century | 10.1016/j.jvs.2019.08.186    | 1     | 78  | Male   | Bladder cancer           | U-plant, surgery        | Hematuria | No Clear Evidence | Open surgery           |
| Publication date | Title                                                                 | DOI                                           | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment     |
|-----------------|----------------------------------------------------------------------|-----------------------------------------------|-------|-----|--------|------------------------|-------------------------|----------|-----------|---------------|
| 2019            | Endovascular management of arterio-ureteral fistula in a patient with a challenging hematuria | 10.1080/13645706.2018.1534742               | 1     | 43  | Female | Cervical carcinoma     | U-stent, surgery, RT    | Hematuria | Angiography | Embolism, Stent graft |
| 2019            | The DACRON Ureter: A Case of Ureter to Aorto-Femoral Dacron Graft Fistulization | 10.1016/j.urology.2018.11.005               | 1     | 65  | Male   | Peripheral artery disease | U-stent, VS            | Hematuria | Angiography | Open surgery |
| 2019            | Ureteroureteral Fistula in a Patient with an Ileal Conduit and Chronic Nephroureteral Catheter | 10.1089/cien.2019.0004                      | 1     | 64  | Male   | Bladder cancer         | U-stent, surgery        | Hematuria | Angiography | Stent graft |
| 2019            | Uretero-iliac artery fistula: a challenge diagnosis for a life-threatening condition: monocentric experience and review of the literature | 10.1007/s11255-019-02097-2                  | 3     | 66  | Male(0) Female(3)     | Cervical cancer         | U-stent, surgery, RT    | Hematuria | Angiography | Stent graft |
| 2018            | Iliac Artery-Uretero-Colonic Fistula Presenting as Gastrointestinal Hemorrhage and Hematuria: A Case Report | 10.1089/cien.2017.0066                      | 1     | 67  | Female | Colon cancer           | U-stent, surgery, RT, Chemotherapy | Hematuria | Enhanced CT | Embolism |
| 2018            | A rare complication of ureteral stenting: Case report of a uretero-arterial fistula and revision of the literature | 10.4081/aiua.2018.3.215                     | 1     | 79  | Female | Endometrial carcinoma  | U-stent, surgery        | Hematuria | Angiography | Stent graft |
| Publication date | Title                                                                 | DOI                          | Cases | Age  | Gender  | Primary Disease | UAF Risk Factors | Symptoms  | Diagnosis              | Treatment               |
|-----------------|----------------------------------------------------------------------|------------------------------|-------|------|----------|-----------------|------------------|-----------|-------------------------|-------------------------|
| 2018            | Uretero-arterial fistula due to a hypogastric aneurysm               | 10.1016/j.aju.2018.05.001   | 1     | 84   | Female  | Aneurysm      | Aneurysm         | Hematuria  | Enhanced CT            | Embolism, Stent graft   |
| 2018            | Two Cases of Arterio-ureteral Fistula in the Setting of Previous Radiation Therapy and Indwelling Ureteral Stents: Results of Endovascular Management | 10.1016/j.clgc.2018.04.003  | 2     | 73   | Female  | Anal cancer   | U-stant, PA, RT, Chemotherapy | Hematuria  | Angiography             | Embolism, Stent graft   |
| 2018            | Diagnosis, Treatment, and Outcome of Arterio-ureteral Fistula: The Urologist’s Perspective | 10.1089/end.2017.0819       | 26    | 67.9 | Male(1) Female(13) | Endometrial adenocarcinoma (3) Cervical cancer (5) Vaginal cancer (2) Oophoroma (1) Peripheral arterial disease (2) Colorectal cancer (11) Metastatic carcinoma (2) | U-stant (26) Surgery (26) RT (21) Aneurysm (2) Pelvic vascular bypass (2) | Hematuria (24) Flank pain (11) | Enhanced CT (5) Angiography (9) No Clear Evidence (11) | Stent graft (23) Open surgery (3) |
| 2018            | Arterio-ureteric fistula: a rare but important cause of haematuria   | 10.1111/ans.14316           | 1     | 61   | Female  | Anal cancer   | U-stant, surgery, RT, Chemotherapy | Hematuria  | Angiography             | Embolism                |
| 2018            | Minimally invasive treatment of vascular complications after neo-aortoiliac system reconstruction using autologous vein grafts | 10.1016/j.vscit.2018.08.013 | 1     | 54   | Male    | Aneurysm      | U-stant, VS       | Hematuria  | No Clear Evidence       | Stent graft             |
| Publication date | Title                                                                 | DOI                          | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms     | Diagnosis       | Treatment        |
|-----------------|-----------------------------------------------------------------------|------------------------------|-------|-----|--------|------------------------|--------------------------|--------------|-----------------|-----------------|
| 2018            | Case—Uretero-internal iliac artery fistula presenting with multiple negative angiographic studies | 10.5489/cuaj.4758            | 1     | 66  | Female | Cervical cancer         | U-stant, surgery, RT, Chemo-therapy | Hematuria    | No Clear Evidence | Embolism, Stent graft |
| 2018            | Successful Endovascular Management of a Transplant Renal Artery Pseudoaneurysm Complicated With Arterioureteral Fistula | 10.1177/1526924817746913     | 1     | 57  | —      | Post kidney transplantation | U-stant, surgery, Hematuria | Angiography  | Stent graft      |                 |
| 2017            | Arterioureteral Fistula: Treatment of a Hemorrhagic Shock with Massive Hematuria by Placing a Balloon Catheter | 10.1155/2017/9453618         | 1     | 52  | Female | Colon cancer             | U-stant, surgery, Chemotherapy | Hematuria, Flank Pain | Enhanced CT     | Stent graft      |
| 2017            | Uretero-Arterio-Enteric Fistula Formation and Stent Thrombosis After Endovascular Treatment of Ureteroarterial Fistula: A Case Report and Review of Literature | 10.1089/cien.2017.0108       | 1     | 51  | Female | Cervical cancer          | U-stant, surgery, RT, Chemotherapy | Hematuria    | No Clear Evidence | Stent graft      |
| 2017            | Uretero-iliac artery fistula eight years after open abdominal aneurysm repair: A diagnostic and therapeutic challenge | 10.1177/2051415816677502     | 1     | 79  | Male   | Aneurysm                 | U-stant, surgery, PA | Hematuria Flank pain | Enhanced CT     | Stent graft      |
| Publication date | Title | DOI | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment |
|------------------|-------|-----|-------|-----|--------|------------------------|------------------------|----------|-----------|----------|
| 2017             | Endoureteral coil embolization of an ureteral arterial fistula | 10.1177/1708538117704522 | 1     | 38   | Female | Postnephrectomy | U-stand, surgery | Hematuria | Abdominal pain | No Clear Evidence | Embolism of ureter |
| 2017             | Iliac Artery-Uretero-Colonic Fistula Presenting as Gastrointestinal Hemorrhage and Hematuria: A Case Report | 10.1089/cren.2017.0066 | 1     | 67   | Female | Colon cancer | U-stand, surgery, Chemotherapy | Hematuria | Angiography | Embolism |
| 2017             | Ureteroaerterial Fistulas: Diagnosis, Management, and Clinical Evolution | 10.1016/j.avsg.2017.05.001 | 5     | 68   | Male(3) Female(2) | Aneurysm (1) Aorto-iliac bypass (1) Bladder cancer (1) Rectal cancer (1) Ovarian cancer (1) | U-stand (4) Surgery (3) VS (2) Chemotherapy (2) | Hematuria (5) | Enhanced CT (3) Angiography (1) No Clear Evidence (1) | Stent graft (1) Embolism (2) Open surgery (2) |
| 2017             | Balloon-Expandable Stent Graft for Treating Ureteroiliac Artery Fistula | 10.1007/s00270-017-1586-4 | 8     | 64.5 | Male(3) Female(5) | Pelvic malignancy (8) | U-stand (7) Surgery (6) RT (5) | Hematuria (8) | Enhanced CT (2) Angiography (8) | Stent graft (8) |
| 2016             | Ureteroiliac Artery Fistula Caused by a Metallic Memokath Ureteral Stent in a Radiation-Induced Ureteral Stricture | 10.1089/cren.2016.0097 | 1     | 71   | Male | Colon cancer | U-stand, surgery, RT, Chemotherapy | Hematuria | Abdominal Pain | Angiography | Stent graft |
| 2016             | Bilateral ureteroarterial fistula: a case report and review of literature. Urologia | 10.5301/uro.5000164 | 1     | 50   | Female | Endometrial carcinoma | U-stand, surgery, RT, Chemotherapy | Hematuria | Angiography | Embolism |
| 2016             | Unique Presentation of Hematuria in a Patient with Arterioureteral Fistula | 10.1155/2016/8682040 | 1     | 54   | Female | Cervical cancer | surgery, RT | Hematuria | Angiography | Embolism |
Table 1 (continued)

| Publication date | Title                                                                 | DOI                                 | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment |
|------------------|----------------------------------------------------------------------|-------------------------------------|-------|-----|--------|-------------------------|--------------------------|----------|-----------|-----------|
| 2016             | Arterioureteral fistula: an unusual clinical case                     | 10.1136/bcr-2016–214,400           | 1     | 66  | Male   | Infection of the vascular graft | VS, Graft infection      | Hematuria | Angiography | Open surgery |
| 2016             | Diagnosis and Management of a Challenging Patient: Ureteroarterial Fistula | 10.1016/jurology.2016.07.017       | 1     | 62  | Female | Cervical cancer          | U-stant, surgery, RT, VS | Hematuria | Retrograde Pyelography | Stent graft |
| 2016             | Ureteroarterial Fistulas After Robotic and Open Radical Cystectomy    | 10.1089/cem.2015.0034              | 2     | 82  | Male   | Bladder cancer           | U-stant, Cystectomy      | Hematuria | Angiography | Stent graft |
|                  |                                                                      |                                     | 88    |     | Male   | Bladder cancer           | U-stant, Cystectomy      | Hematuria | Angiography | Stent graft |
|                  |                                                                      |                                     |       |     |        |                         |                          |          |           |           |
| 2016             | Management Strategy for Ureteral-Iliac Artery Fistula                 | 10.1016/javsg.2016.02.033          | 6     | 61.7| Male(2) Female(4) | Rectal cancer (2) Cervical cancer (2) Bladder cancer (1) Ureteral stricture (1) | U-stent (6) Surgery (5) RT (3) | Hematuria | Enhanced CT | Angiography (2) Open surgery (4) |
|                  |                                                                      |                                     |       |     |        |                         |                          |          |           |           |
| 2016             | Endovascular Repair of an Iliac Ureteroarterial Fistula with Late Stent Thrombosis and Migration into the Bladder | 10.1016/javsg.2016.01.026          | 1     | 37  | Female | Cervical cancer          | U-stant, RT, Chemotherapy | Hematuria | Angiography | Stent graft |
| 2016             | Ilio-ureteric Fistula: A Rare Cause of Haematuria                     | 10.1016/jevs.2016.05.021           | 1     | 76  | Female | Aneurysm                | VS, PA                  | Hematuria | Enhanced CT | Embolism Stent graft |
| 2016             | Uretero-arteral fistula due to a hypogastric aneurysm                 | 10.1016/jaju.2018.05.001           | 1     | 84  | Female | —                      | Aneurysm                | Hematuria | Enhanced CT | Embolism Stent graft |
| Publication date | Title                                                                 | DOI                          | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment   |
|-----------------|----------------------------------------------------------------------|------------------------------|-------|-----|--------|-------------------------|--------------------------|----------|-----------|-------------|
| 2015            | Ureteroarterial fistula following retrograde ureteral stenting in a patient with a double-barreled wet colostomy for cervical cancer | 10.1016/j.gore.2015.06.007  | 1     | 64  | Female | Cervical cancer         | U-stant, surgery, RT, Chemotherapy | Hematuria | No Clear Evidence | Embolism Stent graft |
| 2015            | Successful endovascular treatment using a covered stent for artery—artery-ureteral fistula after surgery for abdominal aortic aneurysm | 10.4103/0970–1591.159668    | 1     | 63  | Male   | Aneurysm                | U-stant, VS               | Hematuria | No Clear Evidence | Embolism Stent graft |
| 2015            | Bilateral Ureteral-Iliac Artery Fistula in a Patient with Chronic Indwelling Ureteral Stents: A Case Report and Review | 10.1155/2015/826760         | 1     | 58  | Female | Cervical cancer         | U-stant, surgery, RT       | Hematuria | Angiography | Stent graft |
| 2015            | A rare cause of massive haematuria: Internal iliac artery-ureteric fistula | 10.1177/170853814538623      | 1     | 82  | Male   | Aneurysm                | Aneurysm                 | Hematuria | Enhanced CT | Embolism Stent graft |
| 2015            | Complications after polymeric and metallic ureteral stent placements including three types of fistula | 10.1089/endo.2014.0394      | 3     | 64.7| Male(2) Female(1) | Cervical cancer(2) Rectal cancer(1) | U-stant, surgery, RT       | Hematuria | Enhanced CT (1) Angiography (2) | Open surgery (3) |
### Table 1 (continued)

| Publication date | Title | DOI                          | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms                  | Diagnosis       | Treatment       |
|------------------|-------|------------------------------|-------|-----|--------|-------------------------|--------------------------|---------------------------|----------------|----------------|
| 2015             | Iliac Artery-Uretero-Colonic Fistula Presenting as Severe Gastrointestinal Hemorrhage and Hematuria: A Case Report and Review of the Literature | 10.1016/j.avsg.2015.07.006 | 1     | 35   | Male   | Aneurysm                | VS                       | Hematuria, Hematochezia | No Clear Evidence | Stent graft, Open surgery |
| 2014             | Ureteroarterial fistula from ureteral stump: a challenging case | 10.1155/2014/514625 | 1     | 43   | Female | Cervical cancer         | U-stant, surgery, RT, Chemo-therapy | Hematuria, Hematochezia | Angiography | Embolism, Stent graft |
| 2014             | Endovascular management of ureteroarterial fistula: a rare potentially life threatening cause of hematuria | 10.3941/jccr.v8i7.1879 | 1     | 70   | Female | Uterine cancer          | U-stant, surgery, RT, Chemo-therapy | Hematuria | Angiography, Stent graft |
| 2014             | Lessons learned from endovascular management of ureteroarterial fistula. Vasc Endovascular Surg | 10.1177/1538574413510620 | 1     | 76   | Female | Uterine cancer          | U-stant, surgery, RT | Hematuria | Angiography, Embolism, Stent graft |
| 2014             | Endovascular treatment of arterio-ureteral fistulae with covered stents: Case series and review of the literature | 10.1177/2050313X14548094 | 2     | 44   | Female | Cervical cancer         | Surgery, RT, Chemotherapy | Hematuria | Angiography | Stent graft |
|                  |       |                              |       | 71   | Female | Cervical cancer         | U-stant, surgery, RT, Chemotherapy | Hematuria | Angiography | Stent graft |
| 2014             | Ureteroarterial fistula from ureteral stump: a challenging case | 10.1155/2014/514625 | 1     | 43   | Female | Cervical cancer         | U-stant, surgery, RT, Chemo-therapy | Hematuria | Angiography | Stent graft |
| Publication date | Title                                                                 | DOI                              | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms          | Diagnosis       | Treatment     |
|-----------------|----------------------------------------------------------------------|----------------------------------|-------|-----|--------|------------------------|-------------------------|-------------------|----------------|--------------|
| 2014            | Diagnosis and treatment of arterial-ureteric fistula                  | 10.1016/j.jvs.2013.06.015        | 1     | 45  | Female | aorto-bi-iliac bypass  | U-stant, VS, PA          | Hematuria         | Angiography    | Stent graft  |
| 2014            | Lessons learned from endovascular management of ureteroarterial fistula | 10.1583/04–1496 1                | 1     | 76  | Female | Cervical cancer         | U-stant, surgery, RT    | Hematuria         | Angiography    | Stent graft  |
| 2013            | Ureteroarterial fistula                                              | 10.1016/j.jvs.2011.12.050        | 1     | 54  | Male   | Infection of the vascular graft | U-stant,VS               | Hematuria         | Angiography    | Stent graft  |
| 2013            | Delayed massive hemorrhage due to external iliac artery pseudo-aneurysm and uretero-iliac artery fistula following robotic radical cystectomy and intracorporeal Studer pouch reconstruction: Endovascular management of an unusual complication | 10.5489/cuaj.170                | 1     | 54  | Male   | Bladder cancer          | U-stant, PA, Cystectomy | Hematuria         | Angiography    | Stent graft  |
| 2013            | Uretero-iliac fistula: modern treatment via the endovascular route | 10.1016/j.diii.2012.10.005       | 2     | 56  | Female | Cervical cancer         | Surgery, RT, Chemotherapy | Hematuria         | Angiography    | Stent graft  |
|                 |                                                                      |                                  |       | 59  | Male   | Colon cancer            | U-stant, surgery, RT, Chemotherapy | Hematuria         | Enhanced CT    | Embolism, Stent graft |
| 2013            | Successful endovascular treatment of iliac arteriovesical fistula with secondary stent-graft infection | 10.1016/j.jvir.2013.05.047      | 1     | 58  | Female | Uterine cancer          | U-stant, surgery, RT, PA  | Hematuria         | Enhanced CT    | Angiography  |
| Publication date | Title                                                                 | DOI                                      | Cases | Age  | Gender | Primary Disease (cases)                                      | UAF Risk Factors (cases) | Symptoms                     | Diagnosis                | Treatment                |
|------------------|----------------------------------------------------------------------|------------------------------------------|-------|------|--------|-------------------------------------------------------------|--------------------------|-------------------------------|--------------------------|--------------------------|
| 2013             | Long-term results of endovascular stent graft placement of ureteroarterial fistula. Cardiovasc Intervent Radiol | 10.1007/s00270-012-0534-6               | 11    | 72.8 | Male(4) Female(7) | Pelvic malignancy (9) Retroperitoneal fibrosis (1) Aneurysm (1) | U-stent (10) Surgery (8) RT (5) Aneurysm (1) | Hematuria                     | Enhanced CT (3) Angiography (5) No Clear Evidence (5) | Stent graft               |
| 2013             | Massive haematuria and shock caused by ilio-ureteral fistula in a patient with an isolated internal iliac artery aneurysm | 10.3400/avd.cr.1.200066                 | 1     | 73   | Female | Aneurysm                                            | Aneurysm                  | Hematuria                     | No Clear Evidence          | Open surgery             |
| 2013             | A primary arterial-ureteral fistula after an aortic-bifemoral bypass | 10.1016/j.jiscrt.2012.09.010             | 1     | 74   | Male   | Aortic-bifemoral bypass                                  | VS                                      | Hematuria                     | Angiography              | Open surgery             |
| 2013             | Ureteroiliac fistula secondary to radiotherapy in a patient with single renal metastasis of colon adenocarcinoma | 10.5489/cuat.259                        | 1     | 61   | Male   | Rectal cancer                                           | Surgery, RT, Chemotherapy        | Abdominal pain               | Enhanced CT              | Open surgery             |
| 2013             | Endovascular approach in a secondary arterial fistula                | 10.1024/0301–1526/a000237               | 1     | 67   | Male   | Peripheral arterial disease                             | U-stent, VS, PA                | Hematuria                     | Enhanced CT              | Stent graft              |
| 2013             | A case of gross haematuria due to an ureterocolic artery fistula     | —                                        | 1     | 75   | Male   | Aneurysm                                              | U-stent, VS                 | Hematuria                     | Enhanced CT              | Stent graft              |
| 2012             | Ureteroarterial fistula                                            | 10.3109/01443615.2012.690788            | 1     | 42   | Female | Cervical cancer                                         | U-stent, surgery, RT, Chemotherapy | Hematuria                     | Angiography              | Embolism                 |
Table 1 (continued)

| Publication date | Title                                                                 | DOI                                      | Cases | Age | Gender | Primary Disease (cases) | UAF Risk Factors (cases) | Symptoms | Diagnosis | Treatment          |
|------------------|----------------------------------------------------------------------|------------------------------------------|-------|-----|--------|-------------------------|--------------------------|----------|-----------|-------------------|
| 2012             | An unusual cause of aortofemoral bypass infection                    | 10.1080/000015458.2012.11680799         | 1     | 70  | Female | PA                       | U-stant, VS              | Hematuria | Introoperative finding | Open surgery       |
| 2012             | Uretero-iliac artery aneurysm fistula: A rare but fatal cause of haematuria | 10.1093/jscr/2012.8.16                   | 1     | 90  | Male   | Colon cancer             | Bilateral iliac aneurysms | Hematuria pain | Postmortem | Cannot accept surgery |
| 2012             | Treatment of ureteroaerterial fistula with an endoureteral stent graft | 10.1016/j.jvir.2012.06.020               | 1     | 76  | Female | Bladder cancer           | U-stant, RT, Cystectomy  | Hematuria | Angiography | Stent graft         |
| 2012             | Uretero-internal pudendal artery fistula with longterm indwelling of ureteral stent: a case report | 10.1155/2012/817942                     | 1     | 74  | Female | Cervical cancer          | Surgery, RT, U-stent     | Hematuria | Angiography | Embolism            |
| 2011             | Endovascular treatment of a right-sided ureterolical fistula in a patient with a simultaneous left-sided ureter-oileal fistula | 10.1155/2011/284505                     | 1     | 80  | Female | Liver metastasis         | U-stant, surgery, RT, Chemo-therapy | Hematuria | No Clear Evidence | Stent graft         |

CT, computed tomography; U-stant, ureteral stent; RT, radiotherapy; PA, pseudoaneurysm; VS, vascular surgery
### Table 2  Study group characteristics and risk factors for AUF

| Characteristics                     | Value |
|-------------------------------------|-------|
| Patients (n)                        | 213   |
| Publication date                    | 2011–2021 |
| Male sex (%)                        | 38.5  |
| Age                                 | 65.1  |
| Range                               | 35–90 |
| **Medical history**                 |       |
| Oncology (radiotherapy/surgery/both)| 173   |
| Ureteral stent                      | 187   |
| Radiotherapy                        | 136   |
| Aneurysm or pseudo-aneurysm of iliac artery | 19   |
| Vascular surgery                    | 21    |
| Others                              | 25    |

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### Abbreviations
AUF: Arterio-ureteral fistula; CT: Contrast enhanced computed tomography.

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### Author contributions
ZJ and JC wrote the initial draft of the manuscript. YZ, JW and BS made substantial efforts to the diagnosis and to determine the therapy. SC and SQ designed the tables. WW and HG revised the manuscript. Final approval of the manuscript was gained from all authors, and all authors agree to be accountable for the content of the work. All authors read and approved the final manuscript.

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### Declarations

#### Ethics approval and consent to participate
Not applicable.

#### Consent for publication
A written informed consent was obtained from both patients for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal.

#### Competing interests
The authors have no conflicts of interest to declare.

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