

Evolution from open surgical to endovascular treatment of ureteral-iliac artery fistula

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Purpose: To review the indications and results of open surgical and endovascular treatment for ureteral-iliac artery fistula (UIAF).

Methods: We reviewed the clinical data of 20 consecutive patients treated for 21 UIAFs between 1996 and 2010. Since 2004, iliac artery stent grafts were the primary treatment except for complex fistulas with enteric contamination or abscess. Endpoints were early morbidity and mortality, patient survival, vessel or graft patency, freedom from vascular or stent graft/graft infection, and freedom from recurrent bleeding.

Results: There were 20 patients, 15 females, and five males, with mean age of 63 ± 13 years. Predisposing factors for UIAF were prior tumor resection in 18 patients, radiation in 15, ureteral stents in 15, ileal conduits in four, and ileofemoral grafts in three. All patients presented with hematuria, which was massive in 10. Treatment included iliac stent grafts in 11 patients/12 fistulas (55%), with internal iliac artery (IAA) exclusion in nine, femoral crossover graft with IAA exclusion in five, direct arterial repair in three, and ureteral exclusion with percutaneous nephrostomy and no arterial repair in one. There were no early deaths. Five of eight patients treated by open surgical repair developed complications, which included enterocutaneous fistula in three and superficial wound infection in two. Four patients (36%) treated by iliac stent grafts had complications, including pneumonia, non-ST segment elevation myocardial infarction, buttock claudication, and early stent occlusion in one each. After a median follow-up of 26 months, no one had recurrent massive hematuria, but minor bleeding was reported in three. Patient survival at 5 years was 42% compared with 93% for the general population ($P < .001$). Freedom from any recurrent bleeding at 3 years was 76%. In the stent graft group, primary and secondary patency rates and freedom from stent graft infection at 3 years were 81%, 92%, and 100%.

Conclusions: UIAF is a rare complication associated with prior tumor resection, radiation, and indwelling ureteral stents. In select patients without enteric communication or abscess, iliac artery stent grafts are safe and effective treatment, and carry a low risk of recurrent massive hematuria or stent graft infection on early follow-up. Direct surgical repair carries a high risk of enterocutaneous fistula. (J Vasc Surg 2012;55:1072-80.)

The ureter crosses over the common or proximal external iliac artery at the pelvic rim. Ureteral erosion or fistula into the iliac artery or adjacent organs is a rare but recognized complication in patients with prior pelvic operations, radiation, indwelling ureteral stents, or arterial prosthetic grafts. Although the communication typically involves only the ureter and the iliac artery, complex fistulas can affect the small bowel, colon, bone, or skin.

Conventional treatment of ureteral-iliac artery fistula (UIAF) involves extra-anatomic reconstruction with exclusion of the iliac artery; or less frequently, direct arterial reconstruction with in situ bypass or primary arterial repair. Ureteral diversion and exclusion without arterial repair is a palliative measure and does not prevent recurrent bleeding.

Endovascular treatment with stent grafts is a minimally invasive alternative, immediately controls bleeding, avoids dissection in a scarred field, and has clear advantages for patients with hostile anatomy. However, stent grafts fail to address the communication between the ureter and the artery, which remains a potential nidus for infection of the vessel and stent graft. Although some reports of endovascular treatment for UIAF suggest this approach is safe and effective in select cases, the risk of stent graft infection and recurrent bleeding has not been determined. The purpose of this study was to review changes in treatment strategies and outcomes of open surgical repair, hybrid approaches, and endovascular treatment of UIAF in a single-center.

METHODS

The study was approved by the Institutional Review Board of the Mayo Clinic. We identified 20 consecutive patients treated for 21 UIAFs by open surgical repair, hybrid, or endovascular techniques between 1996 and 2010. Demographics, cardiovascular risk factors, clinical presentation, imaging, and operative details were collected from the patients' records. Early and late medical and surgical morbidity and mortality were recorded. Early outcome was defined as the period occurring in the hospital stay or within ≤ 30 postoperative days. Late mortality data

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Competition of interest: none.

Presented at the Thirty-fourth Annual Spring Meeting of the Peripheral Vascular Surgery Society, Denver, Colo, June 11-14, 2009.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/\$36.00

Published by Elsevier Inc. on behalf of the Society for Vascular Surgery.

doi:10.1016/j.jvs.2011.11.043

included the use of the Social Security death index search (<http://ssdi.rootsweb.ancestry.com/>).

Treatment of UIAF evolved at our institution during the study period. Treatment in the 1990s was extra-anatomic reconstruction with a femoral crossover graft and iliac artery exclusion by coil embolization or direct arterial ligation. This remains the treatment of choice in patients with local sepsis requiring surgical drainage. Direct arterial repair was used in patients with inadvertent bleeding encountered during open urologic procedures, or in the rare patient with concomitant aneurysmal disease in whom it was important to maintain pelvic flow into the internal iliac artery. During the last decade, iliac stent grafts have been preferentially used to exclude the fistulous communication, except for patients with abscess or enteric communication.

Statistical analysis. Survival curves were analyzed using Kaplan-Meier estimates and differences were determined by Log-rank test. Continuous variables were reported as mean and standard deviation, and categorical variables as frequency and percentages. A *P* value less than .05 was considered statistically significant and all statistical analyses were performed by JMP 7.01 SAS (SAS Institute, Cary, NC).

RESULTS

Clinical presentation

There were 15 female and five male patients with the mean age of 63 ± 13 years (range, 42-88). All patients had frank hematuria (Table I), which was associated with massive bleeding, defined by bleeding with severe hypotension (systolic blood pressure <80 mm Hg) present in 10 patients (50%). The remaining five patients had intermittent hematuria requiring transfusion (Table II). Renal insufficiency was noted in 10 patients (50%) and was chronic in eight and acute in three.

Predisposing factors for UIAF were present in all patients and included pelvic operations for malignancy in 18, pelvic irradiation in 15, indwelling ureteral stents in 15, and iliofemoral prosthetic grafts in three. The average time from the previous pelvic operation to presentation was 80 ± 8 months. All patients with indwelling ureteral stents had a history of hydronephrosis with ureteral strictures caused by prior irradiation or local operation. Ureteral stents were placed an average of 4.8 ± 6.1 months prior to presentation. Eight patients (40%) had recurrent urinary tract infections treated with chronic oral antibiotic suppression.

Diagnostic investigation

All patients underwent diagnostic studies to identify the source of bleeding. Cystoscopy was performed in 14 patients (70%) and showed pulsatile flow into the bladder or fresh thrombus within the ureteral stent in 11 (79%). Three patients (21%) developed massive bleeding precipitated by intentional cystoscopic manipulation of the ureteral stent. Contrast-enhanced computed tomography (CT) was obtained in eight patients and showed active bleeding in three. Conventional angiography was utilized in 14

Table I. Demographics and cardiovascular risk factors in 20 patients treated for ureteral-iliac artery fistulas (UIAFs)

	UIAF (N = 20 patients)	
Demographics		
Age, years	63 ± 13	
Female/male	15/5	
Symptoms		
Hematuria	20	100%
Massive	10	50%
Dysuria	9	45%
Flank pain	4	20%
Cardiovascular risk factors		
Coronary artery disease	10	50%
Chronic renal failure	8	40%
Hypertension	9	45%
Smoking	7	35%
Peripheral arterial disease	7	35%
Hyperlipidemia	4	20%
Diabetes mellitus	4	20%
Dialysis	0	0
Medications		
Beta-blocker	3	15%
ACEi	3	15%
Immunosuppressors (prednisone, chemotherapy)	3	15%
Coumadin	1	5%
ASA classification		
ASA 3-4 class	15	75%

ACEi, Angiotensin converting-enzyme inhibitor; ASA, American Society of Anesthesiology.

patients (70%), most often at the time of endovascular treatment (Fig 1). In two patients, angiography did not identify active bleeding into the ureter, but a UIAF was suspected because of hematuria, the presence of ureteral stent, prior pelvic radiation, and no other identifiable source of bleeding.

The location of 19 UIAFs were confirmed in 18 patients (85%). The fistula affected the left side in 10 patients, right side in seven patients, and both sides in one. The fistula involved the common iliac artery in nine patients, the external iliac artery in six, and iliac bifurcation or internal iliac in three. One patient had a complex UIAF fistula, which also involved the sigmoid colon, psoas muscle, and the skin.

Treatment

Patients were treated by one of the following approaches described below and summarized in Table III.

Ureteral diversion and interruption without arterial intervention. An 87-year-old male patient with advanced metastatic colon cancer, myelodysplastic syndrome, prior aortic reconstruction, sigmoid colectomy, and indwelling ureteral stents developed left UIAF involving the aortoiliac graft limb. The patient underwent diverting nephrostomy tube placement, left ureteral embolization, and no arterial intervention because of advanced metastatic disease. The hematuria resolved and the patient expired at 8 months of follow-up.

Direct iliac artery repair. Three patients had direct iliac artery repair. In two, bleeding occurred during

Table II. Clinical presentation, underlying diagnosis, and predisposing factors in 20 patients treated for ureteral-iliac artery fistulas (UIAFs)

Pt (year)	Age, gender	Hematuria/flank pain (Y/N)	Diagnosis	Ureteral stent	Radiation dose (cGy)	Interval from index diagnosis (months)
1 (1996)	77F	Massive, Y	Endometrial cancer	Bilateral	0	168
2 (1996)	45F	Intermittent, N	R Ao-iliac + fem-fem crossover	No	0	30
3 (1998)	51F	Massive, Y	Pelvic myxoid liposarcoma	Unilateral	4500	65
4 (1998)	71F	Massive, N	Vulvar cancer	Unilateral	6000	102
5 (1998)	76M	Massive, N	Rectum cancer	No	Unk	111
6 (1999)	64F	Massive, Y	Colon cancer	Unilateral	1500	113
7 (2001)	63F	Intermittent, Y	Ovarian cancer	No	0	1
8 (2003)	87F	Massive, N	Rectum cancer + ABI	Unilateral	0	33
9 (2004)	88M	Massive, Y	Bladder cancer	Unilateral	5400	305
10 (2004)	75F	Intermittent, N	ABI	Unilateral	0	68
11 (2006)	60F	Massive, N	Endometrial cancer	Unilateral	6120	80
12 (2006)	80M	Intermittent, N	Rectum cancer	Unilateral	Unk	181
13 (2007)	42M	Intermittent, N	Colon cancer	Unilateral	Unk	65
14 (2007)	56F	Intermittent, N	Retroperitoneal sarcoma	Unilateral	1250	37
15 (2008)	82M	Intermittent, N	Bladder cancer (ileal conduit)	No	Unk	39
16 (2008)	65F	Intermittent, N	Endometrial cancer	No	0	3
17 (2008)	65F	Massive, N	Recurrent cervical cancer	Unilateral	Unk	30
18 (2008)	52F	Intermittent, Y	Cervical cancer	Unilateral	1344	12
19 (2010)	72F	Massive, Y	Cervical cancer	Unilateral	3000	144
20 (2010)	68F	Intermittent, N	Rectum cancer	Unilateral	Unk	96

ABI, Aorto-bi-iliac grafts; Ao-iliac, aortoiliac graft; cGy, centigray; fem-fem, femoral-femoral crossover graft; R, right.

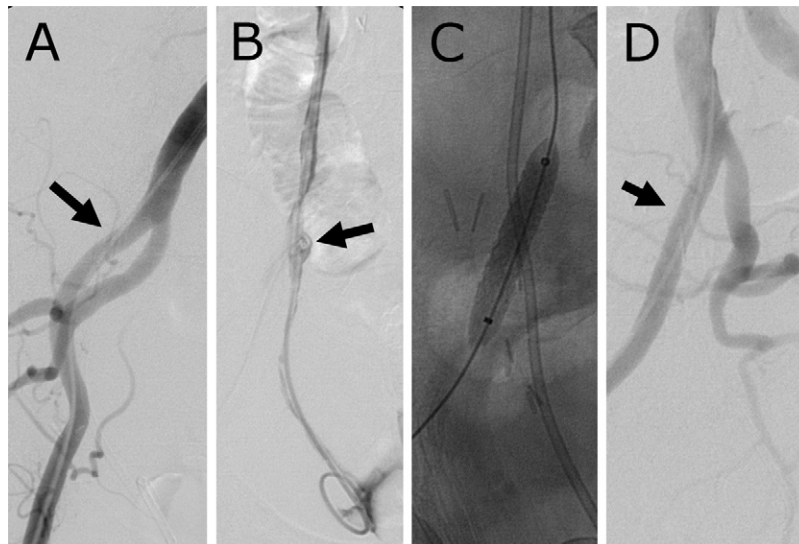


Fig 1. Technique of endovascular treatment of ureteral-iliac artery fistula (UIAF). Right iliac angiography reveals no obvious extravasation of contrast in the crossing point of the ureteral stent (A, black arrow), but selective catheterization of the fistulous communication demonstrates contrast extravasation into the right ureter and ureteral stent (B, black arrow). The patient was treated with covered balloon-expandable stent (C), which was deployed in the external iliac artery (D, black arrow) preserving flow into the internal iliac artery.

dissection of the ureter and iliac artery, revealing the fistulous communication to the iliac artery uncovering the fistula. In both patients, the arterial defect was repaired by pledged sutures and covered with omentum. A third patient developed an UIAF from a pseudoaneurysm at the distal anastomosis of an aortoiliac graft limb.

This was reconstructed with an in situ rifampin-soaked polyester graft so that the internal iliac artery could be preserved, since the contralateral internal iliac artery was chronically occluded.

Femoral crossover bypass and iliac exclusion. Five patients had a femoral crossover bypass graft with iliac

Table III. Fistulous location, treatment and outcomes in 20 patients treated for ureteral-iliac artery fistulas (UIAFs)

Pt (year)	UIAF location	Type of treatment	Nephrostomy tube (Y/N)	Early complications	Late complications/follow-up (months)
1 (1996)	L IIA	DIR + omental patch	Yes	None	None at 3 months
2 (1996)	R iliac graft	In situ R iliac graft	Prior nephrectomy	EC fistula	Graft infection at 1 month/died at 30 months
3 (1998)	R EIA	Fem-fem + CIA embo	Yes	Wound infection	Died at 101 months
4 (1998)	L CIA	Fem-fem + CIA embo	No	None	Died at 2 months
5 (1998)	L CIA	Fem-fem + CIA embo crossover	Yes	None	Died at 98 months
6 (1999)	R IIA	DIR + omental patch	No	EC fistula	None at 115 months
7 (2001)	L CIA	Fem-fem + CIA ligation	No	EC fistula	Died at 2 months
8 (2003)	L iliac graft	L endoureteral embo	Yes	None	Died at 8 months
9 (2004)	R EIA	R iliac SG	Yes	None	Died at 6 months
10 (2004)	L iliac graft	L iliac SG	Yes	NSTEMI	Died at 42 months
11 (2006)	L CIA	L iliac SG	No	None	Died at 3 months
12 (2006)	L CIA	Aortic endograft limb	Yes	None	None at 2 months
13 (2007)	L EIA	L iliac SG	Yes	Stent thrombosis	None at 3 months
14 (2007)	R EIA	R iliac SG	No	None	Thrombosis at 32 months
15 (2008)	L CIA; R EIA	Bif endograft	No	None	None at 5 months
16 (2008)	R CIA	R iliac SG	No	None	None at 13 months
17 (2008)	R IIA	R iliac SG	No	Pneumonia	Died at 5 months
18 (2008)	R CIA	R iliac SG	No	Buttock claudication	None at 14 months
19 (2010)	L EIA	L iliac SG Fem-fem + EIA ligation	No	Wound infection	None at 3 months
20 (2010)	L CIA	L iliac SG	No	None	None at 3 months

Bif, Bifurcated; *CIA*, common iliac artery; *DIR*, direct iliac repair; *EC*, enterocutaneous fistula; *EIA*, external iliac artery; *embo*, embolization; *Fem-fem*, femorofemoral crossover graft; *F/U*, follow-up; *IIA*, internal iliac artery; *L*, left; *NSTEMI*, non-ST elevation myocardial infarction; *pseudoan*, pseudoaneurysm; *PTC*, percutaneous; *R*, right; *SG*, stent graft.

artery exclusion using coil embolization in three, or direct arterial ligation in two. Direct arterial ligation was done because of a large iliac artery pseudoaneurysm in one, and a complex fistula with enteric communication and overt infection. The femoral crossover grafts were externally supported polytetrafluoroethylene (PTFE) graft in three patients, and polyester or rifampin-soaked polyester graft in one patient each. One patient with a complex fistula involving the sigmoid colon and ureter presented in extremis with hemorrhagic shock 3 months after placement of an external iliac artery stent graft in another institution (Fig 2). This patient underwent emergent angiography, which confirmed complete disruption of the midportion of the iliac stent graft and iliac artery. The patient was treated with a new iliac stent graft as a “bridge” to definitive repair, which included staged femoral crossover graft followed by laparotomy, sigmoid colectomy, colostomy, ureteral conduit, and ligation and excision of the infected external iliac artery and stent graft.

Endovascular iliac artery stent graft. Endovascular iliac artery stent grafts were used first in 2004. Since then, this technique was applied as the definitive method of

treatment in 11 of the 12 patients treated for UIAFs (Table IV). One patient described above had iliac stent graft as a “bridge” to control massive bleeding prior to definitive treatment by femoral crossover graft and iliac artery exclusion. Of the 11 patients treated definitively by iliac stent grafts, six presented with massive hematuria and severe hypotension. A transfemoral percutaneous approach was used in all patients with closure devices if sheath diameter exceeded 8F. Self-expandable stent grafts were used in nine iliac segments, and balloon-expandable stent grafts in two (Table IV). The internal iliac artery was excluded in nine patients, by the stent graft coverage in five or by coil embolization in four. Eight of the 11 patients treated with stent grafts received chronic oral antibiotic suppression.

Early outcomes

There were no operative deaths. Of the eight patients treated by direct artery repair or femoral crossover reconstruction, five (63%) developed complications (Table III). These included three (60%) enterocutaneous fistulas, which developed because of inadvertent enterotomies among five patients who had laparotomy or flank incisions

Fig 2. Patient with complex ureteral-iliac artery fistula (UIAF) with erosion into the rectum presented with massive hematuria and exsanguinating hemorrhage 3 months after endovascular treatment by self-expandable stent graft at other institution. Left iliac angiography (A) demonstrates disruption of the left iliac artery and stent graft with extravasation of contrast into the retroperitoneum. A catheter was used to traverse the disrupted stent (A, black arrow). The patient was treated by placement of a self-expandable stent graft (B) as a bridge to definitive repair. Contrast enema (C) also confirmed communication of the rectum with the complex abscess in the retroperitoneum space. The patient subsequently underwent staged right-to-left femoral crossover bypass, followed by abdominal exploration, resection of the left external iliac artery, ureteral conduit, colectomy, and colostomy.

Table IV. Procedural details in 12 patients treated by endovascular iliac stent grafts for ureteral-iliac artery fistulas (UIAFs)

Pt	Type of stent	Diameter (mm)	Embolization of the IIA
9 (2004) ^a	Wallgraft ^a	10 × 50	No
10 (2004)	Wallgraft	12 × 50	No
11 (2006)	Viabahn ^b	10 × 50	No
12 (2006)	Excluder ^b (limb)	16 × 100	No
13 (2007)	iCast ^c	7 × 38	No
14 (2007)	iCast	7 × 38	No
15 (2008)	Bifurcated Excluder ^b	23 × 16	Yes
16 (2008)	Viabahn	10 × 50	No
17 (2008)	Viabahn	6 × 100	Yes
18 (2008)	Fluency ^d	10 × 60	Yes
20 (2010)	Fluency	10 × 60	Yes

IIA, Internal iliac artery.

^aBoston Scientific, Bloomington, Minn.

^bW. L. Gore, Flagstaff, Ariz.

^cAtrium, Hudson, NH.

^dBard, Convington, Ga.

for direct arterial repair or direct iliac ligation. Two patients developed superficial wound infections and were treated with antibiotics. There were no early graft infections after open surgical reconstructions.

Early complications occurred in three of the 11 patients (27%) treated with iliac artery stent grafts, including minor

pneumonia, non-ST-segment myocardial infarction and early stent graft thrombosis in one patient each. The latter patient had peritoneal carcinomatosis from colon cancer, and presented with acute occlusion of a balloon-expandable iCAST stent graft (Atrium, Hudson) placed in the common and external iliac artery. This patient was not on any antiplatelet therapy and had a moderate kink of the stent graft at the transition from the common to the external iliac artery. He was treated successfully by thrombolysis, redo stent placement and antiplatelet therapy, and the iliac artery remains patent 20 months later. The mean length of hospital stay was 33.6 ± 10.4 days for patients treated by direct arterial repair, 12 ± 9 days for those who had femoral crossover graft, and 11 ± 7 days for iliac stent grafts ($P < .007$).

Late outcomes

All patients had clinical and imaging follow-up at a median of 14 months (range from 2 to 115 months). There were no recurrent episodes of massive hematuria. However, intermittent low grade bleeding or microscopic hematuria occurred in three patients (15%). Freedom from any hematuria at 3 years was $80 \pm 9\%$ (Fig 3). Fourteen patients had permanent indwelling ureteral J stents, which were present prior to treatment for the UIAF. These stents were exchanged every 3 to 4 months on average.

There were no stent graft infections among the 11 patients treated by iliac stent grafts. However, one patient

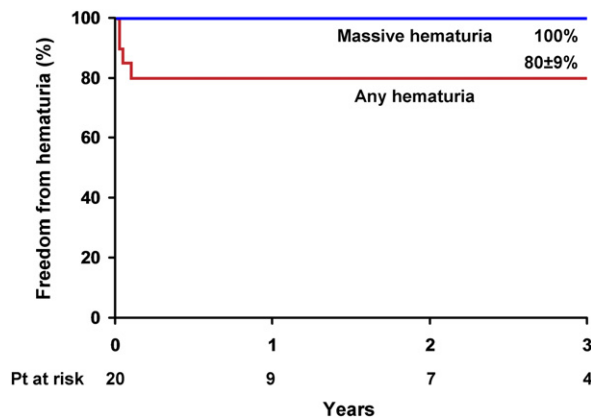


Fig 3. Kaplan-Meier survival estimates of freedom from hematuria in 20 patients treated for ureteral-iliac artery fistulas (UIAFs).

treated at other institution for a complex UIAF involving the sigmoid colon, developed overt infection and disruption of the external iliac artery and the stent graft (Fig 2). Another patient with history of chronic recurrent urinary tract infections had persistent fever and leukocytosis for one month after stent graft placement, but these problems resolved with antibiotic suppression. No patient required explantation of a stent graft or additional treatment because of periarterial fluid or abscess.

One patient developed late iliac stent graft occlusion at 32 months follow-up, which was likely related to tumor encasement of the stented iliac artery segment resulting in compression and then occlusion. This patient was not on any antiplatelet therapy. Treatment included femoral crossover bypass without other complications. Primary and secondary patency for iliac stent grafts at 2 years was $92\% \pm 9\%$ and 100% , respectively (Fig 4, A and B).

No patient developed stenosis or occlusion after femoral crossover bypass or direct arterial repair. However, one patient had revision of the femoral anastomosis because of a noninfected femoral anastomotic pseudoaneurysm. Another patient treated initially with in situ rifampin-soaked graft, developed an enterocutaneous fistula and graft infection 24 months later, which required complete graft excision and replacement using cryopreserved arterial allograft.

There were 10 (50%) late deaths, none related to the UIAF or the procedure. The most common cause of death was progression of underlying cancer in eight patients, and cardiac or unknown cause in one patient each. Patient survival at 1 and 5 years was $75\% \pm 10\%$ and $35\% \pm 15\%$, significantly less than the expected survival for the age- and gender-matched controls from the Minnesota general population ($P < .001$; Fig 5).

DISCUSSION

UIAFs are rare and difficult problems to treat. The only systematic review published by Bergqvist and associates analyzed 80 patients in 77 reports¹ that spanned seven decades. Erosion of the ureter into the iliac artery is

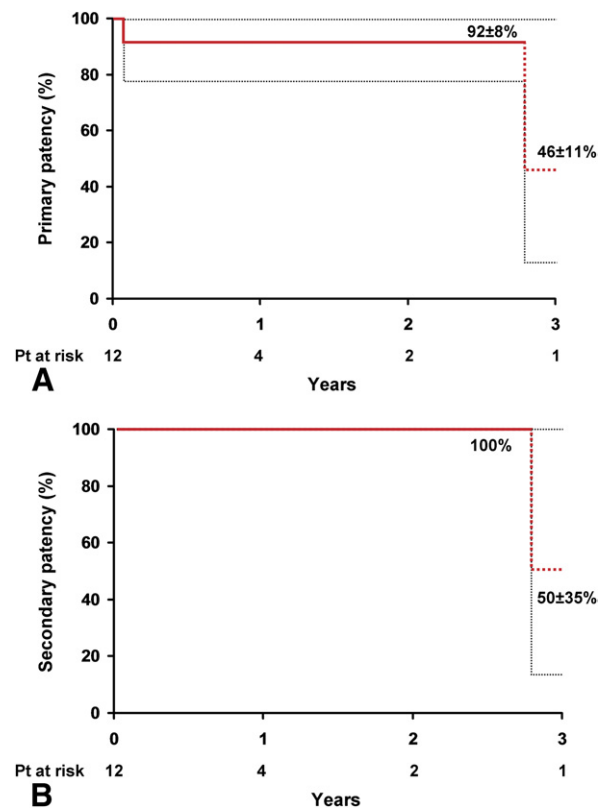


Fig 4. Kaplan-Meier survival estimates of primary (A) and secondary (B) patency rates in 20 patients treated for ureteral-iliac artery fistulas (UIAFs) with endovascular stent grafts.

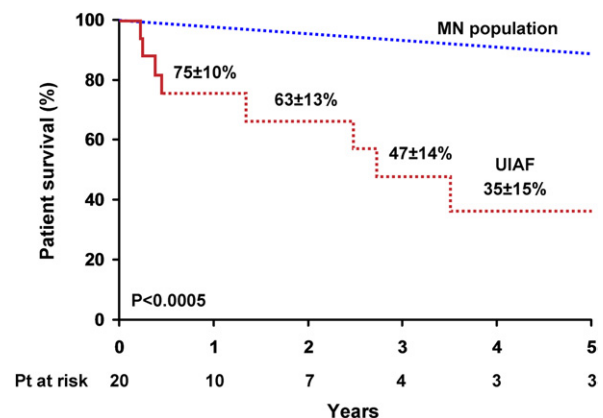
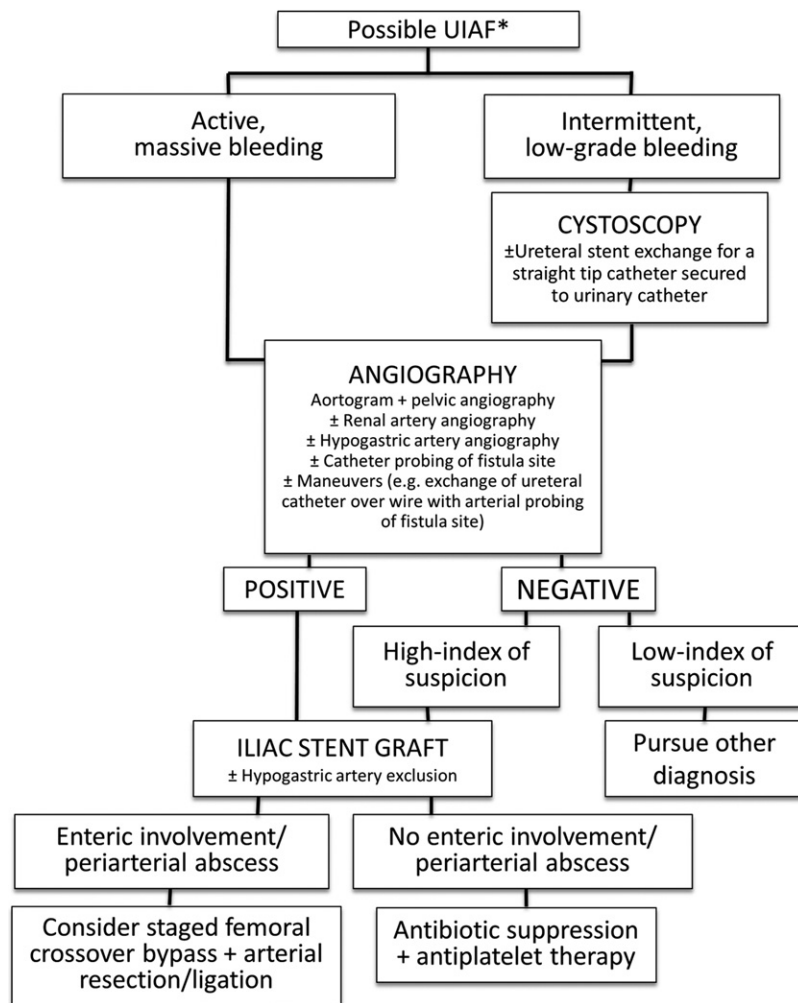


Fig 5. Kaplan-Meier patient survival estimates in patients treated for ureteral-iliac artery fistula (UIAF) and for control patients from the general population of the State of Minnesota (MN).

precipitated by local factors that promote chronic pressure or adherence between the ureter and the artery, or ureteral and arterial fragility from ischemia and radiation damage. Since most surgeons have treated isolated cases, treatment algorithms have not yet been defined. The time-honored method of reconstruction is femoral crossover



*UIAF, ureteral iliac artery fistula is suspected in patients with gross hematuria ± clots ± flank pain and predisposing factors such as prior surgery, radiation, aortofemoral grafts and ureteral stents

Fig 6. Proposed diagnostic and treatment algorithm for dealing with ureteral-iliac artery fistula (UIAF).

bypass through a noninfected field and iliac artery exclusion. This study shows promising results from endovascular stent graft coverage to effectively exclude the fistula.

The clinical features of UIAFs deserve comment. These predominantly affect women (72%) with a wide time range between the initial operative insult to the ureter and fistulization, ranging from 2 to 25 years in several reports.¹ Factors that should raise suspicion of an UIAF include hematuria in a patient with indwelling ureteral stents, prior pelvic operations, irradiation, or prior aortoiliac or aortofemoral grafts.²⁻⁶ In this series, massive hematuria was common (45%), but was typically associated with herald bleeding or gross hematuria during ureteral stent manipulations.^{1,6,7} Therefore, if an UIAF is suspected, manipulations of the ureter should be performed in the endovascular suite or operating room where immediate arterial control with percutaneous endovascular techniques is readily available. Nonetheless, ureteral stent manipulations are often a

necessary maneuver to confirm the diagnosis and demonstrate the exact location of the fistula.

The diagnostic goal is to identify the specific location of the fistula into the iliac artery, which is challenging in patients with intermittent bleeding, bilateral ureteral stents, or prior aortoiliac or aortofemoral grafts (Fig 6). Blood in one or both ureters on cystoscopy may help guide treatment, but is a nonspecific sign.^{1,2,7,8} A useful maneuver in preparation for angiography is to exchange the J ureteral stent for a straight catheter, so that this could be manipulated at time of angiography to induce bleeding and identify the side and location of the fistula. A straight catheter is usually able to stop or minimize any bleeding that occurs. However, while doing this maneuver, it is imperative that one does not lose access in the ureter, and that an endovascular suite and team is immediately available to deal with any massive bleeding. The accuracy of tests to locate a source of massive urinary bleeding has varied in previous

reports.^{1,2,7,8} Computed tomographic angiography (CTA) showed contrast extravasation in only three of eight patients (38%). However, CTA is useful because it identifies periaarterial fluid, an abscess, enteric communication, aneurysmal dilatation and arterial diameter, calcification and thrombus. Diagnostic angiography with selective iliac views remains the gold standard. A useful maneuver is to probe the location where the ureter (or stent) crosses the artery with a selective catheter, which often shows contrast extravasation into the ureter (Fig 1). Provocative maneuvers, including manipulation of the ureteral stent as described above, or administration of thrombolytics can be attempted, but one must be prepared to immediately deal with massive bleeding triggered by these maneuvers.⁷ Finally, a minority of patients (10%) in this report was treated empirically for UIAF without identification of the exact fistula location. These individuals had significant hematuria, predisposing factors for UIAF (ureteral stents, irradiation), and no other identifiable source of urinary bleeding.

The ideal treatment for UIAF is controversial and has changed with the advent of covered stents. This report provides important insight into a variety of methods. Treatment selection is based on patient comorbidities, clinical presentation, hostile anatomy, presence of overt infection or enteric contamination, and on the status of pelvic perfusion.⁹ The ideal treatment should address three primary goals: control of bleeding, control of sepsis, and repair of the fistulous communication. Ureteral diversion with percutaneous nephrostomy and endoureteral occlusion without arterial repair is possible, but has been associated with recurrent bleeding and has the shortcomings of external ureteral diversion. This technique was used in only one of our patients in 2003 as a palliative measure because of advanced cancer. We do not recommend its use when arterial repair can be performed using endovascular or open techniques. Traditionally, the most common reconstruction is a femoral crossover graft and iliac artery exclusion. Direct primary repair of the iliac artery or arterial ligation should be avoided because dissection through scarred and radiated field risks bowel injury and arterial complications. Our study shows an exceedingly high rate of enterocutaneous fistula with the latter approach, in which three of five (65%) patients developed enteric fistula.

Endovascular coverage of the fistula with stent grafts is a less-invasive alternative and can be performed percutaneously under local anesthesia in most patients. It provides rapid control of hemorrhage and avoids operating in hostile abdomen. This technique may decrease trauma, reduce physiologic stress, and avoids the complications of reoperative surgery in a radiated or scarred field. However, stent grafts fail to address the fistulous communication between the ureter and the artery, which remains a nidus for bacterial growth and infection. In this study, one patient with communication to the sigmoid colon failed treatment with stent grafts, and disrupted the external iliac artery and stent graft (Fig 2). This problem also has been described with treatment of aortoenteric erosions with stent grafts, where failure due to reinfection occurs in ~40% of patients and is

associated with high morbidity and mortality rates.¹⁰ For this reason, we avoid the use of stent grafts as a definitive method of repair in patients with enteric communications whenever possible. However, we use them in extreme situations as a “bridge” to open surgical repair under more controlled circumstances (Fig 2). Nevertheless, the use of iliac stent grafts is safe, effective, and has low arterial and stent graft infection rates at an average of 2-year follow-up in the absence of enteric communication. Late follow-up is needed to determine rates of secondary interventions and risk of infection.

Choice of the stent graft needs to take into consideration the location of the fistula (common vs external iliac artery), and whether there is a discrepancy in arterial diameters. Several stent graft options that are commercially available are shown in Table III. Our preference is to use a self-expandable stent graft in the external iliac artery position and a balloon-expandable stent if there is difference in diameter between the common and external iliac arteries. These can be dilated up to 14 mm. Other alternatives in these situations include flared stent grafts or aortic stent graft limbs.¹¹ Finally, in patients with large diameter vessels or aneurysms, iliac extension limbs or a bifurcated modular aortic stent graft may be required.

Patients treated with stent grafts probably warrant long-term prophylactic antibiotics, an adjunct used in eight (44%) of 11 patients in this study. While intuitively beneficial, there is no data in the literature to support its efficacy, dosing of suppressive antibiotics, nor the treatment duration to prevent stent graft infections. Chronic antibiotic suppression is often needed in patients with indwelling ureteral stents and/or recurrent urinary tract infections. One final observation from this report is the occurrence of two stent graft occlusions in patients who were not treated with antiplatelet therapy after intervention. Our protocol currently uses clopidogrel for the first 8 weeks, followed by aspirin indefinitely.

Several shortcomings of our study deserve comment. Some factors involved in decision-making may have been missed because of the retrospective design. Patients were treated by a variety of techniques, and the lack of a pre-defined treatment algorithm limits generalization of results. The relatively short follow-up period (median 26 months) does not allow us to accurately assess long-term reinfection rates, secondary interventions, and stent graft patency. However, given the rarity of the problem (<100 reported cases), this large single-center experience provides important insights about the treatment of UIAF.

CONCLUSIONS

The treatment of UIAF has evolved during the last decade. We currently recommend endovascular iliac artery stent graft coverage as the preferential treatment whenever possible. Indications for open reconstruction include enteric contamination, abscess, or the need to preserve pelvic flow because of contralateral occluded or diseased internal iliac artery.

For patients with local sepsis, femoral crossover reconstruction, and iliac artery exclusion is recommended. Direct

arterial repair or ligation is avoided because of risk of local complications, but still may be required in a patient who needs surgical debridement or preservation of pelvic flow. Early results of iliac stent grafts in select patients with UIAF is encouraging, but long-term follow-up is needed to determine rates of stent graft infection, patency, and secondary interventions.

AUTHOR CONTRIBUTIONS

Conception and design: RM, GO, JA, SM, MK, MM, PG, TB

Analysis and interpretation: RM, GO

Data collection: RM, GO, JA, SM, MK, MM, PG, TB

Writing the article: RM, GO

Critical revision of the article: RM, GO, JA, SM, MK, MM, PG, TB

Final approval of the article: RM, GO, JA, SM, MK, MM, PG, TB

Statistical analysis: RM, GO

Obtained funding: GO

Overall responsibility: GO

REFERENCES

1. Bergqvist D, Pärsson H, Sherif A. Arterio-ureteral fistula—a systematic review. *Eur J Vasc Endovasc Surg* 2001;22:191-6.
2. Dervanian P, Castaigne D, Travagli JP, Chapelier A, Tabet G, Parquin F, et al. Arterio-ureteral fistula after extended resection of pelvic tumors: report of three cases and review of the literature. *Ann Vasc Surg* 1992;6:362-9.
3. Gelder MS, Alvarez RD, Partridge EE. Ureteroarterial fistulae in exenteration patients with indwelling ureteral stents. *Gynecol Oncol* 1993;50:365-70.
4. Dyke CM, Fortenberry F, Katz PG, Sobel M. Arterial-ureteral fistula: case study with review of published reports. *Ann Vasc Surg* 1991;5:282-5.
5. Rennick JM, Link DP, Palmer JM. Spontaneous rupture of an iliac artery aneurysm into a ureter: a case report and review of the literature. *J Urol* 1976;116:1111-3.
6. Andreasen JJ, Fahrenkrug L, Madsen PV. Massive hematuria due to iliac artery-ureteral fistula. *Acta Chirurgica* 1991;157:223-4.
7. Krambeck AE, DiMarco DS, Gettman MT, Segura JW. Ureteroiliac artery fistula: diagnosis and treatment algorithm. *Urology* 2005;66:990-4.
8. Jafri SZ, Farah J, Hollander JB, Diokno AC. Urographic and computed tomographic demonstration of ureteroarterial fistula. *Urol Radiol* 1987;9:47-9.
9. Bilbao JJ, Cosin O, Bastarrika G, Rosell D, Zudaire J, Martinez-Cuesta A. Treatment of ureteroarterial fistulae with covered vascular endoprostheses and ureteral occlusion. *Cardiovasc Interv Radiol* 2005;28:159-63.
10. Antoniou GA, Koutsias S, Antoniou SA, Georgiakakis A, Lazarides MK, Giannoukas AD. Outcome after endovascular stent graft repair of aortoenteric fistula: a systematic review. *J Vasc Surg* 2009;49:782-9.
11. Leon LR Jr, Mills JL Sr. Successful endovascular exclusion of a common iliac artery aneurysm: off-label use of a reversed Cook Zenith extension limb stent graft. *Vasc Endovasc Surg* 2009;43:76-82.

Submitted Oct 19, 2011; accepted Nov 3, 2011.