Systematic Review of the Management of Ureteroarterial Fistulas After Ileal Conduit Urinary Diversion

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OBJECTIVE. No studies or guidelines exist to direct management of ureteroarterial fistula (UAF) after ileal conduit urinary diversion in which the possible risks and complications associated with stent-graft infection from the conduit flora must be reconciled with those of open surgical repair. This study seeks to characterize the clinical presentation, pathogenesis, and optimal diagnostic and therapeutic management of this entity through a systematic review of the literature.

MATERIALS AND METHODS. A systematic search of the English-language literature using the PubMed, Scopus, and ScienceDirect databases was performed: 264 abstracts were identified. From those abstracts, 32 studies comprising 40 patients with 43 UAFs were selected for analysis. Data points including demographics, clinical presentation, UAF specifications, procedural details, postprocedural complications, and clinical outcomes were reviewed.

RESULTS. Predisposing factors included female sex, chronic ureteral stent placement, and past surgical intervention and irradiation for pelvic malignancy. Fistulization was overwhelmingly unilateral (95.0% of patients) and included the common iliac artery (90.7% of UAFs). Combined endovascular and endoureteral modalities presented similar outcomes compared with surgical approaches in terms of UAF-related mortality (7.1% vs 13.3%, respectively) and complication rates (28.6% vs 26.7%) during a similar median follow-up period (9.5 vs 14.0 months). Endovascular stent-graft infections were present in 14.3% of cases and represented a leading indication for reintervention after endovascular management (50.0%).

CONCLUSION. Short- and intermediate-term outcomes of combined endovascular and endoureteral techniques compare favorably with those of surgical approaches in the treatment of UAF after ileal conduit urinary diversion. Although there is a relatively low stent-graft infection rate, close follow-up within the first year after the procedure is required given the propensity of complications to develop during this window. The use of postprocedural antibiotics is uncertain but is likely prudent.

Ureteroarterial fistula (UAF) is a potentially life-threatening but uncommon clinical entity that has been increasing in incidence because of the improved efficacy of oncologic therapies and subsequent increase in chronic ureteral stenting in patients with a history of irradiation and surgery for pelvic malignancy [1–3]. Although prompt treatment is associated with improved clinical outcomes, the diagnosis is often delayed or is unrecognized because of the relative obscurity of the entity as a cause of hematuria and the difficulty in obtaining endoscopic or imaging confirmation of the diagnosis [1]. Thus, the morbidity and mortality rates have been historically high, with the latter reaching as high as 13% [4].

Traditional open surgical management involved repair of both the vascular and ureteral defects with either primary repair or extraanatomic bypass for the former and urinary diversion for the latter. With the advent of endoluminal stent-grafts, modern management has shifted to combined endovascular and endoureteral approaches because of the prohibitively high risks associated with open surgical intervention. However, the management of UAF in select clinical situations, such as in the setting of ileal conduit urinary diversion, presents a clinical conundrum because the risks and complications associated with possible stent-graft infection from the conduit flora must be reconciled with those

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of open surgical repair. No studies or society guidelines exist to direct management of this specific but relevant clinical scenario. Thus, this systematic review aims to characterize the clinical presentation, pathogenesis, and optimal diagnostic studies and therapeutic interventions for the management of UAF in the setting of an ileal conduit urinary diversion. Definitive combined endovascular and endoureteral approaches are hypothesized to be noninferior to open surgical repair given their increasing prevalence and minimally invasive nature.

Materials and Methods

This systematic review was conducted in accordance with a protocol adhering to the guidelines set forth by the PRISMA Statement [5]. Institutional review board approval was not required for this systematic review.

Eligibility Criteria

The inclusion criteria for publications were as follows: works published in the English-language literature, human subjects, confirmed presence of UAF requiring an invasive procedural intervention or interventions, and confirmed presence of ileal conduit urinary diversion. UAF was defined as an abnormal communication between a ureter and an arterial structure or an inserted arterial vascular graft. Prospective and retrospective studies as well as case series and case reports were eligible for inclusion. Exclusion criteria were as follows: pooled studies lacking individualized patient data and conference or meeting abstracts. The eligibility of each work was reviewed by two authors.

Systematic Search Strategy

Primary systematic searches of publications were performed from the earliest date available to February 1, 2020, in the PubMed (National Library of Medicine), Scopus (Elsevier), and ScienceDirect (Elsevier) databases by two authors. The primary systematic searches were completed on February 1, 2020. Free-text keywords used for the systematic search were the following: ureteroarterial, ureteroarterial, ureteral-arterial, arterioureteric, ureteroiliac, ureteroiliac, ureteral-iliac, arterioureteral, arterioureteral, arterial-ureteral, and iliac-ureteral. A secondary systematic search assessing the bibliographies of primary studies and review articles to identify additional articles for inclusion was conducted by two authors. Database lists were created and duplicate publications were excluded using software (EndNote, version 9.3, Clarivate Analytics).

Study Selection and Quality Assessment

Two reviewers independently assessed the quality of each included study using a 6-point scoring system derived from the modified Newcastle-Ottawa Scale, a validated tool for risk-of-bias assessment in observational studies [6]. Disagreements were resolved by a third reviewer. For each study, the entire article was read by all reviewers to accurately assign points. Studies with scores equal to or greater than 4 were deemed moderate to high in quality and were included for analysis. Pooled results and analyses from 16 of the included publications were previously reported [3].

Data Extraction and Statistical Analyses

Multiple data points including patient demographics (age, sex, oncologic diagnosis, and medical and surgical history), clinical presentation, UAF specifications, procedural details, postprocedural complications, and clinical outcomes were recorded in a standardized spreadsheet (Excel 2016, Microsoft). The data were reviewed in conjunction with an experienced biostatistician, and descriptive statistical analysis was performed using software (SAS, version 9.4, SAS Institute). Tests for statistical significance were not performed because of the small sample size.

Results

Literature Search

Primary and secondary systematic searches yielded 264 abstracts, after which 96 were excluded and 168 subsequently underwent full-text review. Publication year of the reviewed texts ranged from 1908 to 2020 with 305 patients with UAF identified. Of these 305 patients, 48 patients were identified to have UAF after ileal conduit diversion. After full-text review, 32 studies comprising 40 patients with 43 UAFs were eligible for inclusion and selected for further analysis [7–38]. The PRISMA flow diagram outlines the number of studies screened, included, and excluded (Fig. 1). Quality assessment scores for each included study using the modified Newcastle-Ottawa Scale are provided in Table 1.

Patient Demographics

The majority of UAFs after ileal conduit urinary diversion occurred in women (27/43 UAFs, 62.8%) who had a history of extensive prior surgical intervention for pelvic malignancy (43/43, 100%), pelvic irradiation (29/43, 67.4%), and chronic ureteral stent placement (39/43, 90.7%). The leading indications for stent placement were ureteral stricture or stenosis (30/39, 76.9%) and ureteroileal anastomotic dehiscence (5/39, 12.8%). Median duration of ureteral stent placement before presentation was 7.0 months (interquartile range [IQR], 3.0–10.5 months).

In addition to ileal conduit diversion, the most common pelvic surgical interventions were cystectomy (20/43 UAFs, 46.5%) and pelvic exenteration (17/43, 39.5%). Squamous cell carcinoma and endometrioid adenocarcinoma of the cervix (18/43, 41.9%) and transitional cell carcinoma of the bladder (14/43, 32.6%) were the most frequent oncologic diagnoses. Individualized data are provided in Table 1. Demographics are summarized in Table 2.

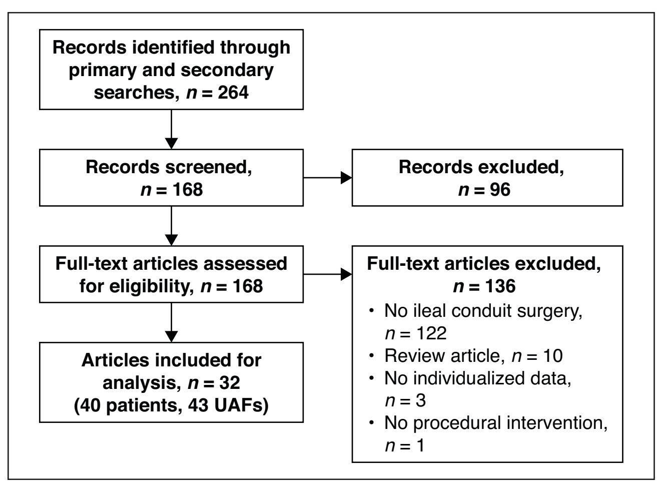

Fig. 1—Flowchart shows publication review process. UAF = ureteroarterial fistula.

TABLE 1: Demographics of 40 Patients With Ureteroarterial Fistula Stratified by Patient

Study Type, Reference	Year, Study Score	Age (y), Sex	Oncologic Diagnosis	Pelvic Surgery	Ureteral Stent: Duration (mo)	Ureteral Stent: Indication	Fistula Location	Intervention: Arterial	Intervention: Ureteral	Complication; Treatment (Time Since Intervention)	Outcome	Follow-Up
Case report												
[7]	1975, 5	57, F	Cer (SCC)	PE	1	Deh	LU to LCIA	PR	Lig, US	Bowel obstruction, septicemia, pelvic abscess	D	1 mo
[8]	1984, 5	67, M	MRF	Cys	7	Str	LU to LCIA	PR	Lig, NP	None	D (Prog)	3 mo
[9]	1984, 5	61, F	Cer (SCC)	PE	2	Deh	RU to RCIA	RAE, CIAE	Stent	None	S	None
[10]	1984, 5	66, F	Bl (TCC)	Cys[a]	2	Str	LU to LCIA	RAE	NU	D during intervention	D	None
[11]	1986, 5	73, M	Bl (TCC)	Cys[a]	15	Deh	LU to LCIA	Lig, Byp	UN	None	S	5 mo
[12]	1990, 4	53, F	Cer (SCC)	PE	5	Str	RU to RCIA	CE, Byp	Stent	None	S	10 mo
[13]	1993, 6	43, F	Cer (SCC)	PE	10	Str	RU to RCIA	CE, Byp	Stent	None	S	1 wk
[13]	1993, 6	53, F	Cer (SCC)	PE	5	Deh	RU to RCIA	CE, Byp	Stent	None	S	38 mo
[13]	1993, 6	43, F	Cer (SCC)	TAH, BS	10	Str	LU to LCIA	CE, Byp	Stent	None	S	32 mo
[14]	1993, 5	59, F	CR (AC)	PE	NS	Str	RU to RCIA	BO, Byp	Stent	None	D (Prog)	6 mo
[16]	1996, 5	67, F	Cer (SCC)	TAH, BS, Cys	2	Ind stent	LU to LCIA	AVC stent	Stent	None	S	12 mo
[18]	1998, 6	74, F	Bl (TCC)	Cys	0.5	Str	RU to RCIA	VS	Stent	None	S	8 mo
[19]	2000, 6	78, M	Pros (AC)	CP, DC	NS	Str	LU to LCIA	VS	Stent	Recurrent UAF; Byp (1.5 mo)	S	8 mo
[20]	2001, 6	38, F	Cer (SCC)	PE	6	Str	RU to RCIA	CE	Stent	D	D	8 h
[21]	2002, 5	49, M	CR (AC)	PE[a]	3	Str	LU to LCIA	VS	Stent	None	S	12 mo
[22]	2002, 6	57, F	Pelvic AC[b]	PE	8	Str	LU to LCIA	VS	Stent	None	S	2 mo
[23]	2004, 6	40, F	Cer (EC)	Anterior PV	1	Deh	RU to RCIA	CE, fem-fem Byp	NP	None	S	84 mo
[24]	2005, 5	54, F	Cer (SCC)	PE	Not used	None	LU to LCIA	VS	Stent	Stent occlusion, cyanotic foot; Byp (0.5 mo)	S	NS
[26]	2007, 5	55, M	CR (AC)	PE[a]	NS	Str	RU to RCIA	Lig, Byp	Cut US	Lig stump-ileal conduit fistula; stent (7 mo)	S	21 mo
[27]	2008, 5	58, F	Cer (SCC)	Hys, Cys	NS	Str	RU to REIA	VS	Stent	None	S	6 mo
[29]	2013, 5	35, F	OMC	PE[a]	24	Str	LU to REIA	VS	Stent	None	S	2 mo
[31]	2015, 6	58, F	Cer (SCC)	Cys	3	Str	Ureter to CIA[c]	VS	Stent	None	S	62 mo
[32]	2016, 5	82, M	Bl (TCC)	Cys	8	Str	LU to LCIA	VS	Stent	None	S	12 mo
[32]	2016, 5	88, M	Bl (TCC)	Cys[a]	3	Str	LU to LCIA	VS	Stent	Persistent UAF; stent (3 wk)	S	NS
[33]	2017, 5	61, M	Bl (TCC)	CP[d]	34	Str	LU to LCIA	VS	Stent	Stent thrombosis, infection, LC; explantation, open PR (25 mo)	S	52 mo
[34]	2018, 6	62, M	Bl (TCC)	Cys[a]	NS	NS	LU to LCIA	VS	Stent	None	S	8 mo

(Table 1 continues on next page)

TABLE 1: Demographics of 40 Patients With Ureteroarterial Fistula Stratified by Patient (continued)

Study Type, Reference	Year, Study Score	Age (y), Sex	Oncologic Diagnosis	Pelvic Surgery	Ureteral Stent		Fistula Location	Intervention		Complication; Treatment (Time Since Intervention)	Outcome	Follow-Up
					Duration (mo)	Indication		Arterial	Ureteral			
[34]	2018, 6	80, M	Bl (TCC)	Cys[a]	NS	NS	LU to LCIA	VS	Stent	Persistent UAF; stent (3 wk)	S	11 mo
[35]	2018, 6	55, M	CR (AC)	PE	48	Str	LU to LCIA	VS	Stent	PA, abscess; CE, Byp (3 mo)	S	15 mo
[38]	2019, 4	64, M	Bl (TCC)	CP[a]	NS	Str	LU to LCIA	VS	Stent	None	S	NS
Case series												
[15]	1994, 6	74, F	Bl (TCC)	PE	96	Str	LU to LCIA	PR	Stent	None	S	18 mo
[15]	1994, 6	64, F	Bl (TCC)	Cys	120	Str	LU to LCIA	CE, Byp	Stent	Thrombosis; Byp revisions	S	36 mo
[17]	1997, 4	53, F	Cer (SCC)	PE	4	Str	RU to RCIA	CE, Byp	Stent	None	S	10 mo
[17]	1997, 4	43, F	Cer (SCC)	PE	10	Str	LU to LCIA	CE, Byp	Stent	None	S	NS
[25]	2005, 6	54, F	Vag (SCC)	Cys	12	Str	RU to RCIA	VS	CE, NP	None	S	5 mo
[25]	2005, 6	74, M	Bl (TCC)	Cys[a]	60	Str	RU to REIA	VS	CE, NP	Renal infections; NPE (6 mo)	S	11 mo
[36]	2019, 6	66, F	Cer (SCC)	Hys, Cys	NS	Str	RU to RCIA	VS	NP	None	S	66 mo
[36]	2019, 6	68, F	Cer (SCC)	Hys, Cys	NS	Str	LU to LCIA	VS	NP	None	S	42 mo
[36]	2019, 6	73, F	Cer (SCC)	Hys, Cys	NS	Str	RU to RCIA	VS	NP	None	S	25 mo
[37]	2019, 6	56, M	CR (AC)	CRR, Cys	Not used	None	LU to LCIA	VS	NS	Stent infection; Lig, Byp (2 mo)	D[e]	5 mo
Retrospective												
[28]	2012, 6	82, F	Bl (TCC)	Cys	Not used	NS	LU to LCIA, RU to REIA	Bif VS	Stent	None	S	5 mo
[30]	2013, 6	72, M	CR (AC)	PE[a]	12	Str	Ureter to CIA[f]	VS	Stent	None	D (Prog)	33 mo

Note—Unless otherwise specified, all patients underwent radiation. Cer = cervical, SCC = squamous cell carcinoma, PE = pelvic exenteration, Deh = dehiscence, LU = left ureter, LCIA = left common iliac artery, PR = primary repair, Lig = ligation, US = ureterostomy, Abs = abscess, D = died, MRF = malignant retroperitoneal fibrosis, Cys = cystectomy, Str = stricture, NP = nephrostomy, Prog = progression, RU = right ureter, RCIA = right common iliac artery, RAE = renal artery embolization, CIAE = common iliac artery embolization, S = survived, Bl = bladder, TCC = transitional cell carcinoma, NU = nephroureterectomy, Byp = bypass, UN = ureteronephrectomy, CE = coil embolization, TAH = total abdominal hysterectomy, BS = bilateral salpingo-oophorectomy, CR = colorectal, AC = adenocarcinoma, NS = not specified, BO = balloon occlusion, Ind = indwelling, AVC = autologous vein covered, VS = vascular stenting, Pros = prostate, CP = cystoprostatectomy, DC = diverting colostomy, UAF = ureteroarterial fistula, EC = endometrioid adenocarcinoma, PV = pelvectomy, fem = femoral, Cut = cutaneous, Hys = hysterectomy, REIA = right external iliac artery, OMC = ovarian mucinous cystadenoma, LC = leg claudication, CIA = common iliac artery, PA = pseudoaneurysm, Vag = vaginal, NPE = nephrectomy, CRR = colorectal resection, Bif = bifurcated.
[a]Patient did not undergo radiation.
[b]Origin unknown.
[c]Bilateral.
[d]Report did not specify whether patient underwent radiation.
[e]Death caused by ligation stump blowout.
[f]Side not specified.

TABLE 2: Demographic Characteristics of Study Group

Characteristic	Value
Age (y)	
Median	61.0
IQR	53.5–72.5
Sex	
Female	27 (62.8)
Male	16 (37.3)
Primary malignancy site	
Cervix	18 (41.9)
Bladder	14 (32.6)
Colorectum	6 (14.0)
Other site	5 (11.6)
Abdominopelvic surgery	
Cystectomy	20 (46.5)
Pelvic exenteration	17 (39.5)
Hysterectomy	6 (14.0)
Other	3 (7.0)
Ureteral stent placement	39 (90.7)
Stricture	30 (76.9)
Anastomotic dehiscence	5 (12.8)
Median duration (mo)	7.0
IQR	3.0–10.5
Pelvic irradiation	29 (67.4)

Note—Unless indicated otherwise, values are reported as number with percentage in parentheses. Percentages may not add up to 100 because of rounding. IQR = interquartile range.

TABLE 3: Clinical Presentation and Diagnosis of Ureteroarterial Fistulas

Characteristic	Value
Clinical presentation	
Hematuria via urostomy	42/43 (97.7)
Gross hematuria during stent exchange	21/43 (48.8)
Hypotension and/or transfusion requirement	21/43 (48.8)
Pyelonephritis or bacteremia	7/43 (16.3)
Diagnostic sensitivity	
Angiography (provoked)	13/14 (92.9)
Laparotomy	4/4 (100)
Angiography (unprovoked)	15/27 (55.6)
Pyelography	4/11 (36.4)
CT with angiography	3/13 (23.1)
Ureteroscopy	1/6 (16.7)
Arterial site	
Ipsilateral CIA	39/43 (90.7)
Ipsilateral EIA	3/43 (7.0)
Contralateral EIA	1/43 (2.3)
Arterial laterality	
Unilateral	38/40 (95.0)
Bilateral	2/40 (5.0)
Right-sided vessel	24/43 (55.8)
Left-sided vessel	18/43 (41.9)

Note—Values are reported as raw numbers with percentages in parentheses. CIA = common iliac artery, EIA = external iliac artery.

Clinical Presentation and Diagnosis

Median age at presentation was 61.0 years (IQR, 53.5–72.5 years). Intermittent or gross hematuria via the urostomy during initial presentation was observed nearly universally (42/43 UAFs, 97.7%). In a sizable proportion of cases, intermittent hematuria through the urostomy presaged massive or pulsatile hematuria during ureteral stent exchange or manipulation (21/43, 48.8%). Hypotension and/or transfusion was likewise associated with a significant proportion of cases (21/43, 48.8%) (Table 3). Infection in the form of pyelonephritis or bacteremia was present in a minority of cases (7/43, 16.3%) and was treated before the intervention for UAF.

The median number of diagnostic examinations required to yield a diagnosis—including CT, pyelography, angiography, exploratory laparotomy, and repeat examinations thereof—was two studies (IQR, 1–3 studies). Angiography performed after provocative maneuvers such as ureteral stent removal or balloon- or catheter-directed endoureteral mechanical friction was nearly universally diagnostic (13/14, 92.9%) (Table 3). Laparotomy was diagnostic in all instances (4/4, 100%). Lower diagnostic rates were observed with unprovoked angiography (15/27, 55.6%), pyelography (4/11, 36.4%), CT with or without angiography (3/13, 23.1%), and ureteroscopy (1/6, 16.7%). Positive CT findings were defined as the presence of contrast extravasation, a pseudoaneurysm, or an arterial abnormality in the vicinity of a ureter. There were two cases of misdiagnosis (2/43, 4.6%) that resulted in renal artery embolization [9, 10] due to presumed tumor erosion before the correct diagnosis.

On initial presentation, ureteroarterial fistulization was almost exclusively unilateral (38/40 patients, 95.0%) with the exceptions being two bilateral presentations [28, 31] (Table 3). An additional patient with a treated unilateral UAF later presented with a contralateral UAF [36]. The ipsilateral common iliac artery was most commonly involved (39/43 UAFs, 90.7%), with the remaining vessels including the ipsilateral external iliac artery (3/43, 7.0%) and the contralateral external iliac artery (1/43, 2.3%). The right-sided vessels were more commonly affected (24/43, 55.8%) than the left-sided vessels (18/43, 41.9%).

Interventions and Outcomes

Individual data on interventions and outcomes are summarized in Table 4. Definitive single-step surgical management was performed in a minority of cases (15/43 UAFs, 34.9%), predominantly in studies published before 2004. The UAF-related mortality rate for surgical management was 13.3% (2/15) with a median follow-up of 14 months (IQR, 5.3–35.0 months). The complication

TABLE 4: Interventions and Outcomes

Characteristic	Intervention	
	Surgical	Combined Endovascular and Endoureteral
Interventions	15 (34.9)	28 (65.1)
UAF-related mortality	2 (13.3)	2 (7.1)
Complications	4 (26.7)	8 (28.6)
Follow-up (mo)		
Median	14	9.5
IQR	5.3–35.0	5.0–22.5
Time to reintervention (mo)		
Median	7.0	2.5
IQR	7.0	0.9–5.1
Reinterventions	2 (13.3)	8 (28.6)
Recurrence	1 (50.0)	4 (50.0)
Stent-graft thrombosis	1 (50.0)	2 (25.0)
Stent infection	0 (0)	4 (50.0)

Note—Unless indicated otherwise, results are reported as number (percentage). UAF = ureteroarterial fistula, IQR = interquartile range.

rate was 26.7% (4/15) and included two cases requiring reintervention in addition to the aforementioned UAF-related deaths.

Further subgroup analysis was performed on two broad categories of definitive surgical management (single-step open surgical repair and staged endovascular bridging to open surgical repair). Single-step open surgery was performed in 14.0% (6/43) of total cases and involved vascular repair with either oversewing the vascular defect (4/6, 66.7%) or arterial ligation with concomitant femoral-femoral bypass (2/6, 33.3%). The ureteral defects were addressed with continued ureteral stenting (1/6, 16.7%) or ureteral ligation followed by either ureterostomy creation (3/6, 50.0%) or ureteronephrectomy (2/6, 33.3%). The UAF-related mortality rate was 33.3% (2/6) with a median follow-up of 11.5 months (IQR, 3.5–20.3 months) of the four surviving patients. The complication rate was 16.7% (1/6), and the complication consisted of ligation stump–ileal conduit fistulization requiring endovascular stenting 7 months after the original intervention.

A hybrid approach using endovascular modalities as a bridge to open surgical repair was performed in 20.9% (9/43) of the cases. In all instances, vascular repair was achieved via common iliac artery embolization followed by femoral-femoral bypass (9/9, 100%). All ureteral defects were managed with continued stent placement (9/9, 100%). No UAF-related deaths were reported, and the median follow-up was 21.0 months (IQR, 7.0–37.5 months). The complication rate was 11.1% (1/9) and consisted of one case requiring multiple graft revisions due to repeated episodes of graft thrombosis [15].

Combined endovascular and endoureteral management was performed in a majority of cases (28/43, 65.1%), primarily from 2000 onward. Endovascular approaches included the use of balloon- and self-expandable stent-grafts (26/28, 92.9%) as well as common iliac artery coil embolization alone (2/28, 7.1%). In one case, coil embolization alone was performed before the advent of vascular stents and after the detection of ample collateralization to the lower extremity on angiography [9]. In the other case, coil embolization was performed emergently in a hemodynamically unstable patient as a temporizing, although ultimately unsuccessful, measure [20]. Endoureteral approaches predominantly involved the continued use of ureteral stents (23/28, 82.1%) or percutaneous nephrostomy with or without endoureteral coil embolization (5/28, 17.9%). The UAF-related mortality rate was 7.1% (2/28) and included one case each from coil embolization (discussed earlier) and endovascular stenting. Median follow-up was 9.5 months (IQR, 5.0–22.5 months). The complication rate for the combined endovascular and endoureteral approaches was 28.6% (8/28) and included six cases necessitating open surgical reintervention and an additional two requiring further endovascular stenting. Stent-graft infections were present in 14.3% (4/28) of cases and represented a leading indication of reintervention (50.0%). The remaining overlapping indications included ipsilateral fistula recurrence or pseudoaneurysm (4/8, 50.0%) and in-stent occlusion (2/8, 25.0%). Median time to reintervention was 2.5 months (IQR, 0.9–5.1 months). Two cases required reintervention within 1 month of the original intervention (2/8, 25.0%). The majority of reinterventions occurred within 6 months of the original intervention (7/8, 87.5%).

Preprocedural infection in the form of pyelonephritis or bacteremia was present in a minority of cases (8/43, 18.6%). Of these patients, 50.0% (4/8) proceeded to definitive surgical repair, and the remaining 50.0% (4/8) underwent definite endovascular and endoureteral management. A single case of preprocedural infection (14.3%) was associated with fistula recurrence 6 weeks after endovascular repair [19].

Discussion

The incidence of UAF has been steadily increasing since the first published report by Moschcowitz in 1908 [39]. Since then, cases involving 305 patients with UAF—including 48 patients with UAF after ileal conduit urinary diversion—have been published in the English-language literature. Although the increasing incidence is in part because of greater awareness of the entity, the true prevalence is likely higher when accounting for publications in other languages and general underreporting. However, despite this, no studies or society guidelines exist to direct diagnostic and therapeutic management of UAF.

Risk factors for the development of UAF after ileal conduit urinary diversion identified in this study include the clinical tetrad of prior surgical intervention for pelvic malignancy, chronic ureteral stent placement, pelvic irradiation, and female sex. The high incidence of cervical cancer as an oncologic diagnosis underlies the aforementioned female sex predisposition. The increased efficacy of oncologic therapies and therefore long-term survivorship likely underlies the rising incidence of this clinical entity because it lengthens the duration of chronic ureteral stent placement, another strong risk factor for UAF development. The impact of stent diameter—a logical parameter for assessment—could not be analyzed because the pertinent information was not available in the majority of the included studies.

A significant proportion of cases were characterized by sentinel bleeding in the form of intermittent hematuria that presaged massive or pulsatile hematuria during ureteral stent exchange or manipulation. An equally sizable number of cases was also associated with hypotension and/or transfusion requirements. Thus, given the increasing frequency of UAF, association of UAF with ureteral stent placement, and nature of presentation during stent exchanges, it therefore becomes important for interventional radiologists to diagnose and immediately manage UAF because they may be the first to encounter this entity.

Diagnosis of UAF remains problematic because of the entity's relative obscurity; thus, UAF rarely features high on the differential diagnosis for hematuria after treatment of pelvic malignancy. Rather, other considered causes include recurrent malignancy, urinary tract infection, radiation necrosis, nephroureterolithiasis, or ureteral stent–related arterial injury or pseudoaneurysm. Difficulty in obtaining imaging confirmation of UAF compounds this problem as evidenced by the necessity of multiple diagnostic examinations (median, 2; IQR, 1–3) and cases of misdiagnosis leading to unnecessary interventions (renal artery embolization). CT, pyelography, ureteroscopy, and unprovoked angiography show relatively low diagnostic yields with observed sensitivities of 16.7–55.6%, which corresponds with sensitivities for all types of UAF in published reports [4, 28, 30, 40]. However, despite this, initial evaluation with multiphase CTA in a hemodynamically stable patient may add value by excluding the other aforementioned causes and assessing for findings suggestive of UAF such as pseudoaneurysm, aneurysmal dilatation, and thrombus in the collecting system [35]. Provocative angiography with manipulation or removal of the indwelling ureteral stents or balloon- or catheter-directed endoureteral mechanical friction provides the best diagnostic yield, with the observed 92.9% sensitivity corroborating previously reported rates [15, 41]. This likely relates to mechanical disruption of thrombus tamponading the fistula. Torrential contrast extravasation and hematuria typically follow this highly diagnostic yet potentially dangerous maneuver and thus careful preparation with a prepositioned balloon catheter in either the ureter or artery is necessary.

The strong predilection for the common iliac arteries as the site of fistulization likely relates to the fact that the base of the ileal conduit and the proximal ureters overlie these vessels. The pulsation from the underlying artery in conjunction with chronic compression from ureteral stents and the compromised vascular supply to the ureters and arteries from prior irradiation combines to induce pressure necrosis that ultimately results in fistulization [1, 15]. Although not supported by the presented data, ureteral stents with a large diameter may confer an increased risk for fistulization given that their increased rigidity may further promote the transmission of arterial pulsations to the ureter [42]. It is not surprising that this unique anatomic configuration also lends to fistulization between the iliac arteries and the ileal conduit itself as previously reported [43–47]. Thus, ileal conduit urinary diversion performed with current surgical techniques is also an independent risk factor for UAF. Bolstering this notion is the fact that experimental omental interposition between the ileal conduit or ureters and the underlying vascular structures during the original surgery prevents fistulization [48].

Management of UAF has evolved from open repair to minimally invasive modalities owing to the development of stent-grafts and the higher morbidity and mortality associated with definitive surgical repair in a hostile anatomic environment. Accordingly, endovascular and endoureteral modalities compare favorably with surgical approaches in terms of UAF-related mortality (7.1% vs 13.3%) and complication rates (28.6% vs 26.7%). These findings mirror results from smaller prior studies analyzing treatment of all forms of UAF and suggest the noninferiority of endovascular treatment compared with surgical approaches [1, 4]. Reinterventions for the endovascular and endoureteral approaches were largely secondary to fistula recurrence or hemorrhage or to stent occlusion or infection within the first 6 months. Although recurrence or hemorrhage and stent occlusion may be managed with repeat endovascular reintervention, stent infection has historically required explantation and conversion to an extraanatomic bypass to definitively remove the infectious nidus and prevent additional complications.

The presence of preprocedural infection does not appear to preclude successful intervention, as evidenced by the association of a single postprocedural complication from the seven cases of preprocedural infection. In addition, the relatively low rate of stent-graft infection requiring reintervention (14.3%) mitigates the prevailing concern for this postprocedural complication and thereby provides further justification for the use of definitive endovascular rather than staged or surgical management.

The continued presence of a fistulous connection between the artery and ureter, albeit excluded, likely provides the mechanism for stent-graft infection through bacterial translocation and therefore explains the higher stent-graft infection rate associated with endovascular approaches when compared with the reported rate for abdominopelvic prosthetic vascular grafts placed in nonfistulous conditions (1–5%) [49, 50]. Microbial cultures from the cases involving infected stent-grafts, however, were not available for analysis to corroborate this hypothesis. The onset of all stent infections within the first 6 postprocedural months correlates with observations that partial stent-graft endothelialization decreases the risk of stent-graft infection over time [51, 52]. The use of postprocedural chronic suppressive antibiotics was

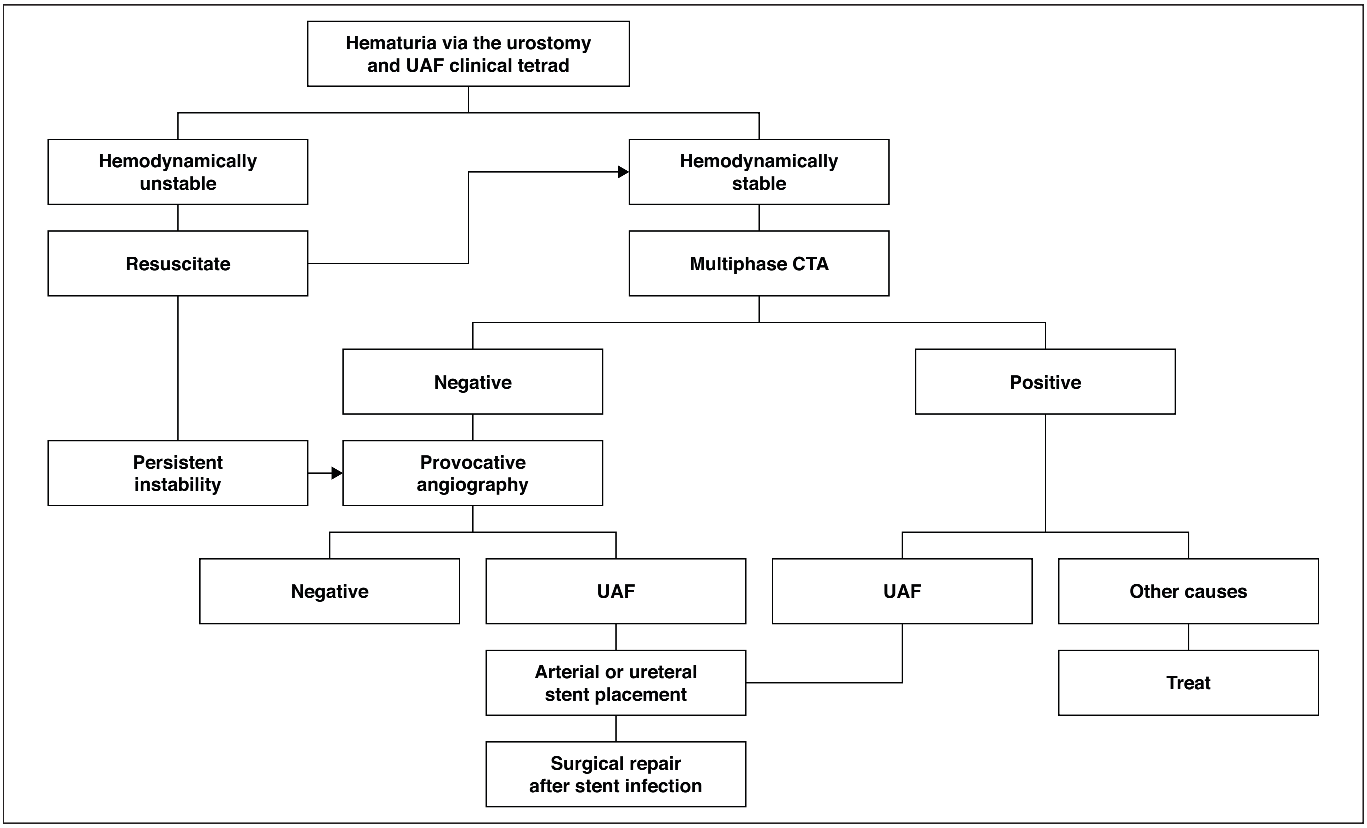

Fig. 2—Proposed algorithm for diagnostic and therapeutic management of ureteroarterial fistula (UAF) in setting of ileal conduit urinary diversion. UAF clinical tetrad is prior to surgical intervention for pelvic malignancy, chronic ureteral stent placement, pelvic irradiation, and female sex. Positive CTA findings for UAF include presence of contrast extravasation, pseudoaneurysm, or arterial abnormality in vicinity of ureter.

not reported in the analyzed cases, and thus no evidence-based recommendations can be extrapolated. However, a brief course of postprocedural antibiotic prophylaxis during the endothelialization process may be prudent given the presence of microbial flora in the ileal conduit.

UAF in the setting of ileal conduit diversion is a clinically challenging entity for which management may be facilitated by the diagnostic and therapeutic algorithmic approach shown in Figure 2. The clinical suspicion for UAF should be heightened when encountering hematuria in a patient fulfilling the clinical tetrad of prior surgical intervention for pelvic malignancy, chronic ureteral stent placement, pelvic irradiation, and female sex and should prompt coordination among the urology, vascular surgery, and interventional radiology services. In a hemodynamically stable patient, multiphase CTA is an appropriate initial study to primarily exclude other alternative causes of hematuria, although CTA may occasionally prove diagnostic for an UAF. Positive CTA findings for UAF include the presence of contrast extravasation, pseudoaneurysm, or arterial abnormality in the vicinity of a ureter. In patients who are not hemodynamically stable or who have negative CTA findings for UAF, further angiographic evaluation with provocative maneuvers and examination of the bilateral iliac arteries is recommended.

After the angiographic diagnosis of UAF, definitive ureteral and arterial stent placement should be performed given the suggestion of its noninferiority to surgical management. The latter should ideally be reserved as salvage therapy after endovascular failure secondary to stent-graft infection. The role of postprocedural antibiotic prophylaxis is uncertain, but postprocedural antibiotic prophylaxis is likely prudent. Close clinical follow-up within the 1st year after the procedure is required because of complications such as stent-graft infection or occlusion and fistula recurrence or pseudoaneurysm during this window. Postprocedural follow-up at 1, 3, 6, and 12 months would provide sufficiently close surveillance given that the median time to reintervention was 2.5 months and that the majority of complications (7/8, 87.5%) occurred within the first 6 months. Surveillance should incorporate the following: physical examination focused on the detection of hematuria and ischemia, biochemical workup evaluating the hematocrit level and WBC count, and CTA or MRA for the detection of pseudoaneurysms or stent occlusion.

The limitations of the current systematic review include its small and heterogeneous sample size derived predominantly from retrospective case reports. However, the small sample size is an expected limitation when investigating uncommon and underreported entities such as UAF after ileal conduit urinary diversion. In addition, the lack of long-term data and incomplete details regarding postprocedural antibiotic usage limit the generalizability of the findings. However, despite these limitations, inferences derived from systematic reviews of case reports and case series are recognized as valid and useful decision-making aids, particularly with uncommon entities such as UAF after ileal conduit urinary diversion for which there is an absence of strong evidenced-based recommendations and guidelines [6].

Conclusion

UAF after ileal conduit urinary diversion is an uncommon entity with a characteristic clinical presentation. A systematic review of the available literature suggests that endovascular and endoureteral modalities afford clinical outcomes comparable with those of surgical approaches but that close postprocedural follow-up is required. Although the stent-graft infection rate is relatively low, the role of postprocedural antibiotic prophylaxis remains uncertain and their use may be prudent. Management of this challenging clinical entity may be facilitated by using the aforementioned diagnostic and therapeutic algorithmic approach in a multidisciplinary manner with the interventional radiology, urology, and vascular surgery services.

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