Diagn Interv Radiol 2021; 27:762–767

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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Percutaneous transrenal ureteral plug embolization: is there a need for tissue adhesives?

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PURPOSE
We aimed to evaluate the feasibility, effectiveness, and safety of ureteral embolization exclusively using Amplatzer Vascular Plugs (AVPs) in the management of ureteral leakages.

METHODS
A retrospective analysis of 7 patients with ureteral leakages and fistulas having undergone transrenal ureteral embolization with AVPs was performed. In all cases, AVPs were deployed via a preexisting percutaneous transrenal nephrostomy tube. Technical and clinical success as well as complications were evaluated.

RESULTS
During a 4-year study period, 11 ureters in 7 patients were embolized using AVPs. In one case additional coil embolization was conducted. Technical success in terms of sufficient occlusion of the treated ureter was achieved in 100% of the procedures. Median size of used plugs was 16.0 mm (range, 12–18 mm). Number of deployed AVPs ranged between one and three. Median procedural time was 24 minutes, and a median dose area product of 58.92 Gy·cm^2 was documented. No procedure-related complications occurred. During a median follow-up period of 7 weeks, recurrence of the treated leak could not be observed.

CONCLUSION
Ureteric plug embolization in patients with ureteral leakages or fistulas is a feasible, effective, and safe technique, even without the addition of tissue adhesives. However, due to the often limited prognosis and life expectancy of the affected patients, long-term experiences are still lacking.

In general, ureteral leakages represent rare but severe complications of different origin. Frequent underlying conditions can include abdominal surgery, inflammation, malignancy, trauma, or iatrogenic causalities (1). As a potential consequence, ureteral internal fistulas, defined as pathological communications between the ureter and an adjacent hollow organ, may occur with an uretero-vaginal, uretero-uterine, or uretero-enteral manifestation. Due to their tendency to result in formation of abdominal urinoma or abscesses, ureteral leakages may be associated with significantly increased morbidity and mortality (2). In this context, the therapeutic management of this condition remains challenging. Due to a limited life expectancy, patients usually require an approach with palliative intent in terms of an improvement of quality of life. Irrespective of their invasiveness, surgical approaches may be complicated by the presence of difficult tissue conditions with frequently extensive scarring or post-radiogenic changes and thus, do not often represent the therapy of choice (2). Discussion of different therapeutic approaches should be carried out in an interdisciplinary setting considering patients´ general condition and prognosis, as well as the location, extension, and origin of the ureteral leak. In smaller fistulas, urinary diversion by percutaneous nephrostomy or ureteral stenting may decrease the urinal leakage and therefore enable the fistula to heal (3). In more extensive leakages, however, the persisting contact with urine often prevents the defect from healing and external drainage of urine might not be sufficient. In such a scenario, permanent ureteric occlusion can pose as a promising and definitive therapeutic concept, in which a minimally invasive percutaneous approach should be considered (4). Different endovascular embolic agents have been utilized for ureteral

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Received 27 August 2020; revision requested 22 October 2020; last revision received 30 October 2020; accepted 16 November 2020.

Published online 3 November 2021.

DOI 10.5152/dir.2021.20640

You may cite this article as: Augustin AM, Koneval L, Kalogirou C, Kocot A, Kickuth R. Percutaneous transrenal ureteral plug embolization: is there a need for tissue adhesives? Diagn Interv Radiol 2021; 27:762–767.

Table 1. Patients characteristics

Patient	Age (y)	Gender	Underlying pathology	Cause of leakage	Urinoma	Surgery	RT	Fistula	Clinical FU (weeks)	Death
1	51	M	Sigmoid diverticulitis	Iatrogenic	Yes	Yes	No	No	4	No
2	83	M	Rectal CA	Iatrogenic	Yes	Yes	No	No	6	Yes
3	68	F	Cervical CA	Insufficient conduit	No	Yes	No	No	240	No
4	26	F	Cervical CA	Local tumor progression	No	Yes	Yes	Uretero-vaginal	12	Yes
5	62	M	Prostate CA	Local tumor progression	No	Yes	Yes	No	3	Yes
6	30	F	Cervical CA	Local tumor progression	No	Yes	Yes	Vesico-vaginal	7	Yes
7	56	F	Vulvar CA	Local tumor progression	No	Yes	Yes	Tumor-vesical	7	No

RT, radiotherapy; FU, follow-up; CA, carcinoma.

embolization so far (2, 5). Common ground of this kind of therapy is the application of embolic material via a preexisting percutaneous nephrostomy access. Utilization of embolic devices in this setting constitutes an off-label use (6). As a consequence, a systematic analysis of procedure´s outcomes or guidelines concerning the choice of embolic agent do not exist in the literature.

Compared with the amount of information on the effects of coils, stents and liquid embolic agents, few data exist referring to ureteral plug embolization. In this context, the combination of plugs with cyanoacrylates have been mainly reported (6). Consequently, to address the need for more data, we evaluated our experiences with this technique, but without the supplemental use of tissue adhesives. Moreover, awareness of this kind of ureteric embolization approach among interventional radiologists still seems to be low.

Methods

Study cohort

A retrospective review of the archives of our interventional radiology division between April 2016 and March 2020 yielded the cases of 7 patients (4 women and 3 men; median age 56 years; range, 26–83 years) who had consecutively undergone ureteric plug embolization. The requirement for consent from patients to be included in this study was waived by our institutional review board (No. of waiver 20200608 01). In all patients, urinary external diversion had been previously conducted by percutaneous nephrostomy tubes prior to the intervention. In total, 11 ureters were embolized in 7 patients via the transrenal approach. In 4 cases, plug embolization was performed bilaterally during the same procedure. Most of the patients (85.71%; 6/7; patients 2–7) suffered from advanced malignancy. Underlying diseases and indications for plug embolization were heterogeneous: In one case (patient 4) of underlying uterine cervical carcinoma the patient developed a vesico-vaginal fistula due to local tumor progression. One patient (patient 5) with advanced prostate cancer suffered from recurrent macrohematuria and was repeatedly treated by evacuation of bladder tamponade and palliative transurethral prostate resection (TUR-P). Another patient with cervical carcinoma (patient 6) developed uretero-vaginal as well as recto-vaginal fistula. With the underlying disease being cervical carcinoma again, another patient (patient 3) that was treated with Wertheim-Meigs operation and ileal conduit urinary diversion presented with conduit insufficiency. Due to extensive postradiogenic and postsurgical intraabdominal scarring combined with peritoneal adhesions with consequent development of wound healing disorders, burst abdomen and abdominal abscess formations, the patient was a poor candidate for open surgical revision approaches. Additionally, despite urinary diversion, the patient suffered from urine flow beside the catheter, leading to significant discomfort. With a history of rectal carcinoma, one patient (patient 2) was treated with total mesorectal excision, mesometrial resection and coloanal anastomosis with occurrence of intraoperative iatrogenic injury of ureter and development of an extensive urinoma. One patient (patient 1) with complicated sigmoid diverticulitis and treatment with subtotal colectomy suffered from intraprocedural iatrogenic ureteral injury with urine leakage. Percutaneous ureteral embolization with simultaneous percutaneous nephrostomy was performed in order to achieve a bridging situation with termination of the urine leakage and a first consolidation of the abdominal inflammation. A secondary ureteral reconstruction was then performed subsequently. The last patient (patient 7) had vulvar carcinoma as underlying disease with development of tumor-vesical fistula due to local tumor progression.

Radiation therapy was previously performed in 4 cases (patients 4–7). In one case, formation of urinoma was treated by computed tomography (CT)-controlled puncture and drainage prior to the embolization procedure. A urinary diversion attempt had been previously performed in all patients. Five patients (patients 1–3, 5 and 7) had been treated with percutaneous nephrostomy, with a median period between the procedure and the ureteral embolization of 6 days, ranging between 2 and 662 days. In 2 patients (patients 4 and 6), former permanent ureteral stenting had been conducted, with a period between the first stenting and the ureteral embolization being 200 and 345 days, respectively.

Baseline demographic data of all patients are presented in Table 1. All patients gave their informed consent for the procedure. The local institutional review board waived its approval.

Main points

- Ureteric embolization using vascular plugs in patients with ureteral leakages and fistulas is feasible and effective and might be an attractive alternative to surgical strategies.
- Significant oversizing of the vascular plugs might have an impact on the technical outcome of the procedure.
- The additional usage of adhesive tissues seems not to be necessary.
- Due to the often short life-expectancy of the affected patients, long-term results are limited.

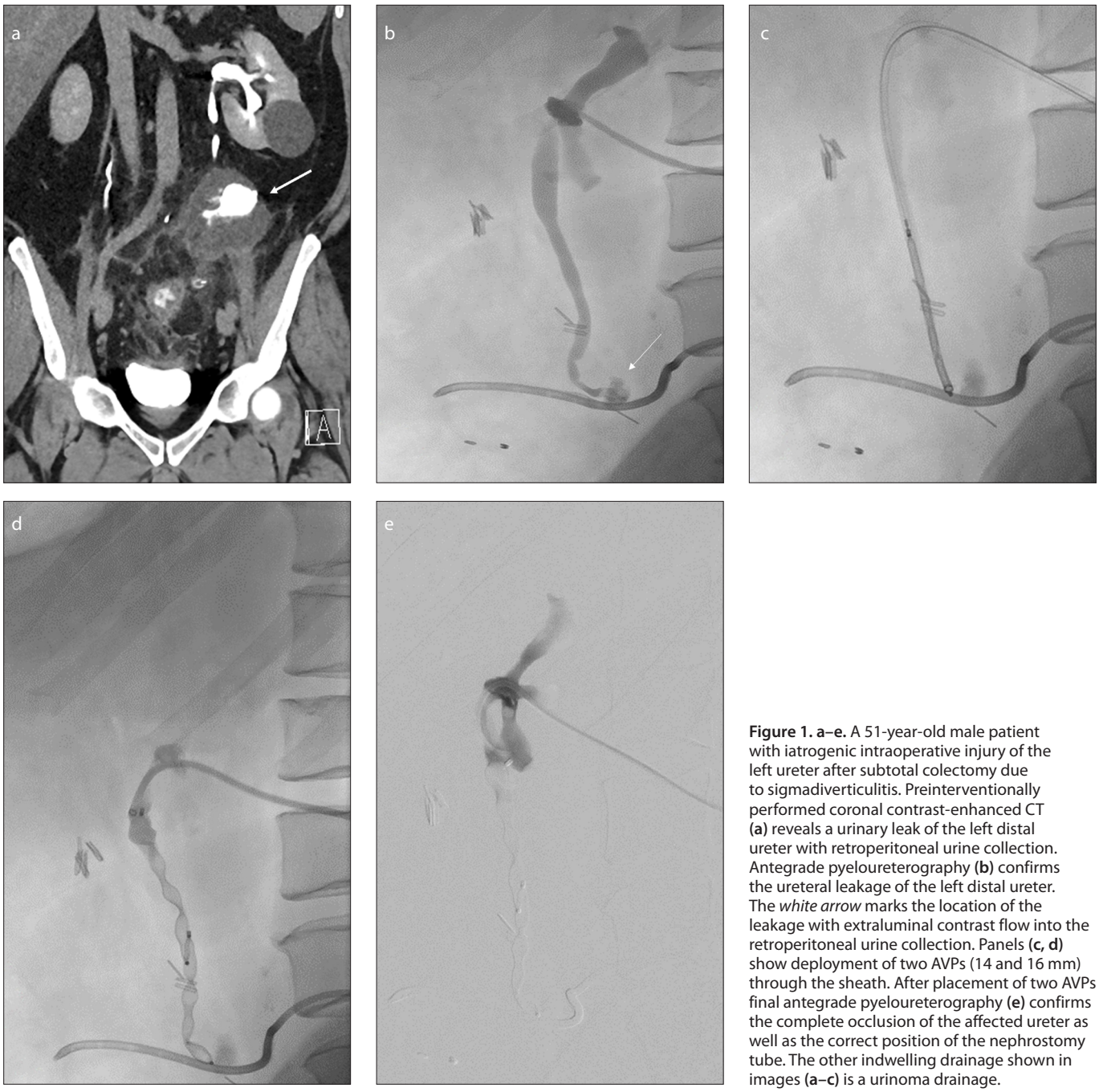

Figure 1. a–e. A 51-year-old male patient with iatrogenic intraoperative injury of the left ureter after subtotal colectomy due to sigmadiverticulitis. Preinterventionally performed coronal contrast-enhanced CT **(a)** reveals a urinary leak of the left distal ureter with retroperitoneal urine collection. Antegrade pyeloureterography **(b)** confirms the ureteral leakage of the left distal ureter. The *white arrow* marks the location of the leakage with extraluminal contrast flow into the retroperitoneal urine collection. Panels **(c, d)** show deployment of two AVPs (14 and 16 mm) through the sheath. After placement of two AVPs final antegrade pyeloureterography **(e)** confirms the complete occlusion of the affected ureter as well as the correct position of the nephrostomy tube. The other indwelling drainage shown in images **(a–c)** is a urinoma drainage.

Technique

All procedures were performed by the same operator in our local angiography suite (Siemens, Axiom Artis Zee). First, an ureterography was performed by contrast media application via the preexisting nephrostomy tube. With all patients under local anesthesia, a hydrophilic 0.035-inch guidewire (Radifocus, Terumo) was then used to cannulate the nephrostomy tube. A 7 F armed vascular sheath (Destination®RDC, Terumo or Flexor®, Cook Medical) was then exchanged for the nephrostomy tube and advanced to the distal segment of the ureter. After that, Amplatzer Vascular Plugs (AVPs, St. Jude Medical) type I or type II were selected approximately 400%–500% larger than the ureteral diameter (3–4 mm). The preference of the selected diameters was at the discretion of the interventional radiologist. The guidewire was removed and the AVPs were expelled into the sheaths and deployed into the ureter while carefully retracting the sheath. Plug embolization of the whole ureter was conducted from the distal to the proximal segment close to the proximity of the renal pelvis. In one case, additional coil embolization (MReye®, Cook Medical) had been coaxially performed via a Cobra shaped catheter in order to consolidate the technical outcome. Plug embolization ended with an antegrade pyeloureterogram via the sheath. After ureterographic verification of a technically successful procedure, the sheath was removed over the guidewire and a new nephrostomy tube was inserted into the renal pelvis for urinary drainage. A final ureterogram was performed via the nephrostomy tube in order to document sufficient ureteric occlusion as well as correct nephrostomy placement (Figs. 1 and 2).

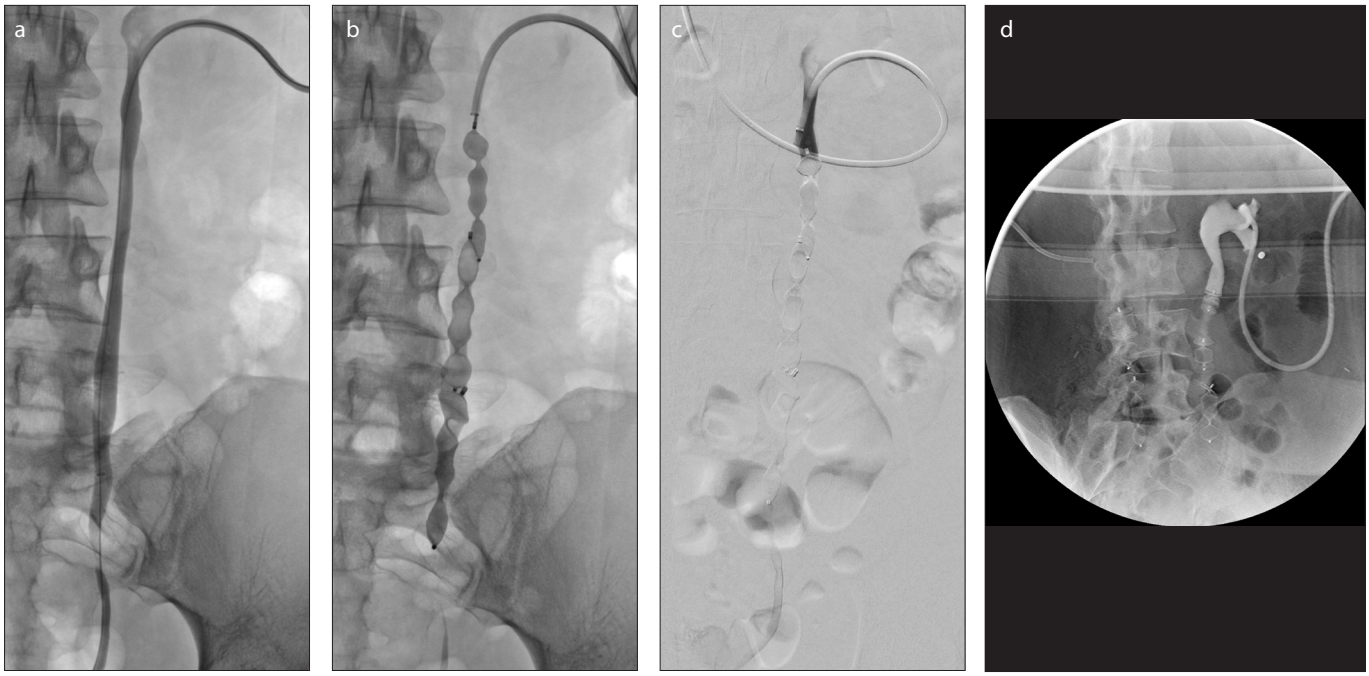

Figure 2. a–d. A 30-year-old female patient with extensive metastasis and local progression of uterine cervical carcinoma. Development of a vesico-vaginal fistula was the indication for bilaterally ureteral plug embolization. Intraprocedural antegrade pyeloureterography **(a)** shows that the preexisting nephrostomy tube has already been exchanged for a 7 F sheath. The vesico-vaginal fistula was not visible in the DSA, but had previously been verified by clinical examination. Image **(b)** shows placement of 3 AVPs while successively and gently retracting the sheath. Control antegrade pyeloureterogram **(c)** clearly demonstrates a technically successful procedure without leakage distal to the deployed AVP devices. Contralaterally placed AVPs are also depicted.

Endpoint definition

Medical records were evaluated by a urological surgeon to assign the cause of urologic injury in the subject population. Radiologic records and patient charts were jointly reviewed by two authors to gather information on the technical and clinical success of the interventions and their complications. This information was completed by means of telephone interviews with patients and their referral physicians. Technical success was designated as the complete cessation of ureteral urine leakage documented with antegrade pyeloureterography at the end of each intervention. Clinical success was determined as the sustained cessation of urine leakage or a significant decrease in fistula soiling after 24 hours and during the follow-up period (7, 8).

Secondary endpoints were procedure time, fluoroscopy time, and radiation exposure in terms of the dose area product (DAP).

As a safety endpoint, complications of treatment were classified on the basis of outcome according to the reporting standards of the Society of Interventional Radiology (9). Minor complications included those resulting in (A) no therapy and no consequence or (B) nominal therapy and no consequence including overnight admission for observation only. Major complications included (C) those requiring therapy, minor hospitalization (<48 hours), (D) those requiring major therapy, unplanned increase in level of care, prolonged hospitalization (>48 hours), (D) those resulting in permanent adverse sequelae, and (E) those resulting in treatment-related mortality.

Follow-up

All patients were closely monitored after ureteric plug embolization. Peri- and post interventional minor or major complications were documented for 24 hours. All patients who returned for routine follow-up control in the urologic outpatient clinic were assessed by clinical examination. These clinical findings were supplemented by radiologic examinations (magnetic resonance imaging and CT examinations in one case and fluoroscopic antegrade pyeloureterography controls in two cases). Patients were advised to immediately contact the outpatient clinic at the onset of new or worsening symptoms. Mean follow-up time was 7 weeks with a range between 3 weeks and 60 months.

Results

Details pertaining to the plug embolization approaches and the technical and clinical results of treatment are given in Table 2.

Technical success was achieved in 100% (11/11) of the procedures. A total of 28 AVPs were used, being assigned as AVP II in the majority of cases (20/21). Median size of the deployed AVPs was 15.6 mm and ranged between 12 and 18 mm. The most common used AVP size was 16 mm (n=12), followed by 18 mm (n=7), 14 mm (n=6), and 12 mm (n=3). In one case, seven embolization coils were additionally applied for bilateral ureteric occlusion as a consolidation. The other seven ureters were embolized by the exclusive use of AVPs.

Median procedure time was 24.00 minutes and ranged between 11.00 and 54.00 minutes. Evaluation of radiation exposure revealed a median DAP of 58.92 Gy·cm^2 (range, 20.65–84.10 Gy·cm^2). Median fluoroscopy time was 8.20 min (range, 3.78–21.70 min).

Reinterventions were not necessary, since clinical signs of recurrent formation of fistula or urinoma had not been documented. Major or minor complications were not observed. During the follow-up period four patients died due to their extensive underlying disease. Three patients were alive at time of data acquisition.

Discussion

Ureteral leakages and fistulas refractory to conservative therapy represent complex

Table 2. Procedural data

Patient	1	2	3	4	5	6	7
Side	Left	Right	Bilaterally	Bilaterally	Left	Bilaterally	Bilaterally
AVM I (mm)	-	16	-	-	-	-	-
AVM II (mm)							
Right		16 + 18	18	14 + 16		18 + 16 + 14	12 + 14 + 16
Left	14 + 16		18	14 + 16	16 + 16	16 + 14 + 12	12 + 16 + 18
Coils	No	No	Yes	No	No	No	No
PT (min)	24	11	51	54	15	21	34
DAP (Gy·cm^2)	76.7	20.6	79.5	84.1	58.9	55.2	37.3
FT (min)	6.5	3.8	17.9	21.7	6.9	8.2	10.7
Technical success	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clinical success	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nephrostomy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Complications	No	No	No	No	No	No	No
Reintervention	No	No	No	No	No	No	No

AVM, Amplatzer vascular plug; PT, procedure time; DAP, dose area product; FT, fluoroscopy time.

and severe disorders that frequently force the practitioner to consider unconventional therapeutic approaches (6). Affected patients often suffer from advanced pelvic malignancy and are characterized by both a poor prognosis and an unfeasibility for surgery due to a high perioperative risk. The offered therapeutic strategies in this situation should therefore aim to reduce the risk associated with those conditions on the one hand, while minimizing the procedural side-effects on the other hand. Because of their minimally invasive character, percutaneous approaches represent a valuable alternative instead of surgery (10). In this context, different methods for permanent ureteral occlusion have been reported in the literature so far. Many authors have already described the mechanism for an effective ureteral long-term occlusion using coils, plugs, or even metallic stents (7, 8, 11, 12). Pathologically, an irritation of the urothelium entails a reaction with hyperplastic tissue formation and/or ureteric strictures.

The use of tissue adhesives has been described utilizing different techniques and varying combinations with other endovascular materials like detachable balloons, coils and AVPs (10). Advantages of each embolization agent in terms of an extremely fast response time and of low costs must be weighed against its tendency to soften and devolve when in contact with urine, possibly leading to recanalization and thus necessitating reinterventions (10, 13).

Coils with or without additional use of gelatin sponge were shown to be very effective in ureteral occlusion (8, 11, 14). Reoccurrence of ureteral flow seems to be rare. Nevertheless, a relative risk of coil migration remains.

The AVP, an expandable composition of nitinol mesh that was introduced in 2004, is an established embolic device when occluding peripheral vessels (15). Its first application in ureteral embolization was reported by Schild et al. (12) in 2009. On this occasion, the AVP was inserted into a latex cover and then deployed into the ureter, leading to an immediate and complete occlusion. Another more recently reported technique is the combination of AVPs with cyanoacrylate in a "sandwich-technique" like manner. Preliminary results revealed high clinical success rates ranging between 90%–100% (7, 16, 17). However, in our study, the exclusive use of AVP is described for the first time without the conjunctive use of tissue adhesives. Our current hypothesis is that in comparison with other studies, an extreme oversizing of the plugs might have contributed to a relative impermeability to urine. As a consequence, a consolidation with coils had to be only performed in one patient. The underlying rationale of the intentional oversizing with diameters of 400%–500% was the ureter being a hollow, muscular and elastic organ that performs peristaltic contractions. In contrast to the utilization in the vascular system with selection of AVP diameters approximately 30%–50% larger than the target vessel being sufficient for vessel occlusion, the application of AVPs in the field of ureteral embolization is challenged by the absence of clot formation in urine. With our strategy, we aimed to a tighter packing of the nitinol wire mesh in order to achieve an acute and immediate occlusion of the ureter with complete cessation of the urine flow. In addition, we intended to induce a long-term effect of more intense urothelial scarring which is supposed to contribute to ureteral occlusion (7).

Huber et al. (17) reported the occurrence of bilateral iliac artery pseudoaneurysm in a case of larger AVP selection and therefore discussed the possibility of adverse effects due to oversizing. Nevertheless, such a complication had not been found in our cohort despite considerable oversizing. It remains speculative if preexisting arteriosclerosis might be predictive for the development of pseudoaneurysm due to the close anatomic vicinity of the ureter to smaller arterial vessels. Thus, future investigations should address the impact of different sizes of AVP on the procedure´s outcome.

With special regard to radiation exposure, comparable information has not been available so far. However, the DAPs documented in our study seem to be negligible taking the severity of diseases into account. A median procedure time of 24.00 min in our cohort suggests the procedure to be fast.

Nevertheless, further data are still missing here to make final conclusions.

In our small study cohort, no procedure-related complications were observed. Other studies reported rare cases of self-limiting minor complications like the occurrence of an ureteral tear (16). Due to the fast and minimally invasive character of the procedure with use of a preestablished percutaneous approach, major complications are not likely to appear.

There are three limitations to this study: First, the study sample is small and heterogeneous, a fact that must be attributed to the rarity of the underlying condition. Second, the study design is retrospective and lacks randomization. Furthermore, due to extensive pelvic malignancy in six of seven included patients, the clinical follow-up remains short. As a matter of fact, the described procedures were predominantly performed with the intention to prevent patients from inherent complications with further limitation of life expectancy and quality of life. Since palliation management had been already initiated in some patients, a detailed radiologic follow-up was not considered necessary. Consequently, the evaluation of clinical success could not be carried out in a standardized manner and the available parameters such as clinical condition, and absence of pain had to be considered instead. In order to generalize the results presented in our study and to evaluate their exact clinical value, a prospective multicenter trial would be beneficial in the future.

In conclusion, transrenal ureteral plug embolization in patients with ureteral leakages is a feasible, effective, and safe technique in urinary leakages that should be especially contemplated in patients with advanced malignancy refractory to conventional therapy approaches. Based on our preliminary results, the additional use of histoacryl does not seem to be necessary.

Conflict of interest disclosure

The authors declared no conflicts of interest.

References

1. Popuri R, Zuckerman DA. Ureteral interventions. Semin Intervent Radiol 2011; 28:392–395. [Crossref]
2. Avritscher R, Madoff DC, Ramirez PT, et al. Fistulas of the lower urinary tract: percutaneous approaches for the management of a difficult clinical entity. Radiographics 2004; 24 Suppl 1:217–236. [Crossref]
3. Al-Otaibi KM. Ureterovaginal fistulas: The role of endoscopy and a percutaneous approach. Urol Ann 2012; 4:102–105. [Crossref]
4. Titton RL, Gervais DA, Hahn PF, et al. Urine leaks and urinomas: diagnosis and imaging-guided intervention. Radiographics 2003; 23:1133–1147. [Crossref]
5. Kuetting D, Pieper CC. Percutaneous treatment options of lower urinary tract fistulas and leakages. Rofo 2018; 190:692–700. [Crossref]
6. Jin MX, Mohabir AD, Caplin DM, Lobko I, Siegel DN. Transrenal ureteral embolization utilizing amplatzer vascular plugs and N-butyl cyanoacrylate glue. J Endourol Case Rep 2018; 4:108–110. [Crossref]
7. Saad WE, Kalagher S, Turba UC, et al. Ureteric embolization for lower urinary tract fistulae: use of two amplatzer vascular plugs and N-butyl cyanoacrylate employing the "sandwich" technique. Cardiovasc Intervent Radiol 2013; 36:1068–1072. [Crossref]
8. Shindel AW, Zhu H, Hovsepian DM, Brandes SB. Ureteric embolization with stainless-steel coils for managing refractory lower urinary tract fistula: a 12-year experience. BJU Int 2007; 99:364–368. [Crossref]
9. Sacks D, McClenny TE, Cardella JF, Lewis CA. Society of Interventional Radiology clinical practice guidelines. J Vasc Interv Radiol 2003; 14:199–202. [Crossref]
10. Schild HH, Gunther R, Thelen M. Transrenal ureteral occlusion: results and problems. J Vasc Interv Radiol 1994; 5:321–325. [Crossref]
11. Gaylord GM, Johnsrude IS. Transrenal ureteral occlusion with Gianturco coils and gelatin sponge. Radiology 1989; 172:1047–1048. [Crossref]
12. Schild HH, Meyer C, Mohlenbroch M, et al. Transrenal ureter occlusion with an Amplatzer vascular plug. J Vasc Interv Radiol 2009; 20:1390–1392. [Crossref]
13. Stern JL, Maroney TP, Lacey CG. Management of incurable urinary fistulas by percutaneous ureteral occlusion. Obstet Gynecol 1987; 70:958–960.
14. Farrell TA, Wallace M, Hicks ME. Long-term results of transrenal ureteral occlusion with use of Gianturco coils and gelatin sponge pledgets. J Vasc Interv Radiol 1997; 8:449–452. [Crossref]
15. Wang W, Li H, Tam MD, et al. The amplatzer vascular plug: a review of the device and its clinical applications. Cardiovasc Intervent Radiol 2012; 35:725–740. [Crossref]
16. Pieper CC, Meyer C, Hauser S, Wilhelm KE, Schild HH. Transrenal ureteral occlusion using the Amplatzer vascular plug II: a new interventional treatment option for lower urinary tract fistulas. Cardiovasc Intervent Radiol 2014; 37:451–457. [Crossref]
17. Huber T, Wilkins LR, Sabri S, et al. Midterm follow-up of ureteral embolization using vascular plugs and N-butyl cyanoacrylate glue. J Vasc Interv Radiol 2017; 28:1123–1128. [Crossref]