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INTERVENTIONAL RADIOLOGY

ORIGINAL ARTICLE

Intermittent quick-check CT fluoroscopy-guided percutaneous drainage placement in patients with infected renal and perirenal fluid collections: 11-year experience

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PURPOSE
We aimed to evaluate technical and clinical success and safety of computed tomography fluoroscopy (CTF)-guided percutaneous pigtail drainage (PPD) placement in patients with infected renal and perirenal fluid collections.

METHODS
This retrospective analysis comprised 44 patients (52.27% men; age, 57.1±18.5 years) undergoing low-milliampere (10–20 mA) CTF-guided PPD placement in 61 sessions under local anesthesia from August 2005 to November 2016. Infected fluid collections (n=71) included infected renal cysts (12.68%), renal and perirenal abscesses due to comorbidities (23.94%), or fluid collections after renal surgery or urological intervention (63.38%). Technical success was defined as PPD placement with consecutive fluid aspiration, clinical success as normalization or marked improvement of clinical symptoms (e.g., flank pain, fever) and inflammatory parameters (leukocyte count, C-reactive protein) after minimally invasive combination therapy (intravenous broad-spectrum antibiotics and drainage). Complications were classified according to the CIRSE classification.

RESULTS
Overall, 73 single lumen PPD (7.5–12 F) were utilized (1 PPD per session, 69.86%; 2 PPD per session, 15.07%). In 4 cases, PPD could not be inserted into the fluid collection (4.11%) or could not be aspirated (1.37%), yielding overall 94.5% primary technical success. Mean duration of functioning PPD before removal was 10.9 days. Adverse events within 30 days comprised PPD failure (2.27%) or secondary dislocation (Grade 3, 11.36%) and one death (Grade 6, unrelated to intervention, 2.27%). Additional invasive measures after primary CTF-guided PPD were required in 5 patients (nephrectomy 6.82%, partial nephrectomy 2.27%, surgical drainage 2.27%). Thus, clinical success using only minimally invasive measures was achieved in 39 of 44 patients (88.64%).

CONCLUSION
Given a minor proportion of patients requiring surgical revision, combined antibiotics and CTF-guided PPD of infected renal and perirenal fluid collections provides an excellent technical and clinical outcome.

Urinary tract infections (UTIs) are the most commonly observed bacterial infection, characterized by uncomplicated cystitis or pyelonephritis in most patients (1). While uncomplicated UTIs predominantly affect healthy and nonpregnant young women with good response to adequate antibiotic treatment and without further necessary diagnostic imaging, complicated UTIs comprise infections with an uncommon organism, symptoms suggesting obstruction (e.g., renal colic) or fever lasting more than 72 hours in spite of adequate antibiotics (2). Diabetic patients are particularly prone to upper tract UTIs, bilateral involvement and atypical underlying organisms (3). If severe clinical symptoms and altered laboratory parameters are found in a patient with suspected renal abscess, the first step is an ultrasound examination of the kidney. In some cases, the abscess may present as an echogenic mass, in which case the diagnosis with ultrasound is difficult and a contrast-enhanced computed tomography (CT) is essential for the diagnosis. Furthermore, ultrasound is less sensitive than CT or magnetic resonance imaging (MRI) for assessing spread to perirenal space (2, 4).

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Renal and perirenal abscesses are a comparatively rare complication of UTIs whose prognosis has been markedly improved during the last 20 years through earlier diagnosis by state-of-the-art cross-sectional imaging modalities on the one hand, and more widely available and earlier minimally invasive image-guided or surgical treatment on the other hand (2, 5–10). For instance, in superinfected renal cysts, CT fluoroscopy (CTF) facilitates a precise and near real-time targeting and drainage of the affected cyst. This may allow for a "nephron-sparing" preservation of renal parenchyma unaffected by the inflammation, microbiological sampling and potentially a faster patient recovery (11). Notably, infected renal cysts represent a particularly rare entity of infected renal fluid collections predominantly described in case reports.

For small renal abscesses (<3 cm diameter), antibiotic therapy should be sufficient for resolution. Otherwise, ultrasound- or CT-guided percutaneous aspiration and drainage is indicated for treatment in combination with antibiotics (2, 12, 13). Besides renal and perirenal abscesses due to UTIs, symptomatic infected and sterile retroperitoneal fluid collections are frequently observed after renal surgery such as nephrectomy, partial and allograft nephrectomy as well as renal transplantation, affecting the renal parenchyma, perirenal space or iliac fossa (14, 15). Thus, it can be said that CT-guided percutaneous aspiration and drainage plays an important role for minimally invasive treatment of renal or perirenal abscesses.

Thus, the purpose of this retrospective study was the evaluation of the technical outcome, clinical success, and safety of percutaneous pigtail drainage (PPD) placement performed under low-milliampere CTF in one of the biggest patient cohorts to our knowledge, presenting with symptomatic renal and perirenal fluid collections comprising renal abscesses, infected renal cysts, as well as infected, delineated postoperative retroperitoneal fluid collections.

Main points

- Renal and perirenal abscesses are a comparatively rare complication of urinary tract infection (UTI).
- Besides UTI-related renal and perirenal abscesses, symptomatic infected and sterile retroperitoneal fluid collections are frequently observed after renal surgery such as nephrectomy, partial and allograft nephrectomy, as well as renal transplantation.
- Our study demonstrates that in patients with renal and perirenal abscesses, CT fluoroscopy-guided percutaneous pigtail drainage placement in combination with a directed antibiotic therapy can achieve an excellent technical and clinical outcome.

Methods

This retrospective study included all consecutive patients who underwent single lumen PPD placement in symptomatic renal and perirenal fluid collections under low-milliampere CTF guidance in our institution from August 2005 to November 2016. These fluid collections comprised infected renal cysts, abscesses of the renal parenchyma and perirenal space (outside the renal capsule into Gerota's fascia) due to comorbidities, and symptomatic retroperitoneal fluid collections after renal surgery. This retrospective study was approved by the ethics commission of Ludwig-Maximilians University (registration number: 17-422). All procedures performed in our study were in accordance with the Helsinki Declaration. Informed consent by adult patients or his or her legal guardian to undergo CTF-guided PPD placement had been obtained a minimum of 24 hours and directly prior to each intervention after detailed explanation of the planned therapeutic intervention.

Study population

In each case, the indication for PPD placement had been discussed and confirmed by urologists, abdominal surgeons and interventional radiologists in a multidisciplinary setting. The clinical patient charts of 56 patients who transferred to our department for PPD placement in symptomatic renal and perirenal fluid collections after a urological ultrasound examination were retrospectively reviewed.

Inclusion criteria for PPD placement and study analysis were: 1) clinical symptoms of infection (fever, lumbar pain, dysuria, chills, flank pain, and abdominal/flank mass) (16); 2) laboratory signs of infection (leukocyte and/or CRP count above normal levels, urinalysis, urine culture, blood culture) before and during the course of up to 30 days after the intervention (16); 3) CT signs of infection (wall enhancement and thickening, adjacent fat stranding, entrapped gas within fluid collection, attenuation of fluid collection in Hounsfield Units) (17). Accordingly, exclusion criteria were: 1) missing verification of infection by laboratory analysis comprising the abovementioned parameters; 2) omission of CTF-guided PPD placement after contrast-enhanced CT evaluation of suspected renal and perirenal fluid collection due to percutaneous aspiration only or biopsy only due to CT characterization of the formation as non-liquid. In these cases, only aspiration or biopsy were performed.

From August 2005 to November 2016, 56 patients with symptomatic renal and perirenal fluid collections were sent to our unit by the local urology department for CTF-guided PPD placement and 48 were included in the study analysis (please see the results section for exclusions).

Peri-interventional imaging and image guidance

Before the planned interventional procedure, previous contrast-enhanced cross-sectional images not older than 48 hours, such as CT, MRI or PET-CT were analyzed in all patients by a board-certified radiologist with working experience of more than 10 years.

All interventions were performed using a 16- (Somatom Sensation 16, Siemens) or 128-slice (Somatom Definition AS+; Somatom Definition Edge, Siemens) CT scanner with fluoroscopy capability (CARE Vision CT®, Siemens). For each procedure, an unenhanced pre- and post-interventional CT scan of the abdomen was performed. The pre-interventional CT scan included 5 mm slices and coronal and sagittal reconstructions for planning of the PPD insertion trajectory. This was correlated to the diagnostic contrast-enhanced CT scan on which the indication for drainage was decided. An additional contrast-enhanced CT scan during the nephrographic phase was acquired in selected cases in order to better visualize the size and exact localization of the infected fluid collection/abscess in relation to the renal parenchyma prior to drain insertion. For better visualization of supposed arteries along the needle access route, an early arterial phase was occasionally added, depending on the location of the fluid collection.

PPD insertion was implemented under intermittent quick-check CTF acquisitions, using low-milliampere CTF at a tube current-exposure time product of 10 mAs (18). Measures of radiation protection for the performing interventional radiologist during CTF included thyroid shields, aprons, and eyeglasses of 0.5 mm lead equivalent.

To reduce scattered radiation, an additional shield was put onto the lower half of the patient before sterile draping. During CTF, angular beam modulation (Hand Care®) was activated for reducing radiation exposure of the operator's hands, i.e., the radiation exposure is switched off between eleven and three o´clock positions of the x-ray tube.

After PPD placement, a contrast-enhanced or unenhanced CT scan with multiplanar reconstructions was performed for assessment of peri-interventional complications.

Procedure

All interventions were carried out by interventional radiologists with an experience in CT-guided interventions of at least 10 years. During the intervention, patients with severe cardiorespiratory comorbidities were monitored by pulse oximetry. Local anesthesia with 10 to 20 mL of 2% Mepivacaine hydrochloride (Scandicain®, AstraZeneca GmbH) was used after sterile draping and disinfection of the skin overlying the planned PPD entry point. Following a minimal skin incision, the PPD (Flexima™ All Purpose Drainage, Boston Scientific Corporation or ReSolve® Non-Locking Drainage Catheter, Merit Medical) was then introduced and advanced to the fluid collection applying the curved trocar-technique under intermittent quick-check CTF (19). After PPD placement within the fluid collection an unenhanced CT scan covering at least 10 cm above and below the entry point along the z-axis was performed in order to confirm the correct final PPD position and rule out immediate complications. Then the PPD was fixed at the skin level with a suture and covered with a sterile bandage. All patients were monitored clinically for at least 24 hours.

Assessment of technical outcome and complications

Two experienced interventional radiologists (M.D; C.G.T) evaluated the technical and clinical outcome in a retrospective analysis of patients' imaging studies available in the local PACS, radiology reports and remaining medical records, as well as the complications associated with CTF-guided PPD placement during a post-interventional period of 30 days.

Technical success was described as PPD insertion within the fluid collection with consecutive fluid aspiration for microbiological analysis. Cases in which the PPD could not be inserted into the fluid collection or could not be aspirated were regarded as technical failure.

Clinical success was defined as normalization or marked improvement of clinical symptoms and inflammatory parameters (leukocyte count, CRP) under minimally invasive combination therapy (intravenous broad-spectrum antibiotics, PPD) within one month after the intervention.

Evaluation of complications was performed using the CIRSE classification (20).

Patient radiation dose

According to Kloeckner et al. (21), CT dosimetry was performed for all procedures using the dose length product (DLP, mGy·cm), documented by the CT unit as primary dosimetric quantity data. DLP was evaluated for the pre-interventional planning CT scan, the sum of all intra-interventional CT fluoroscopic acquisitions, and the post-interventional control CT scan.

Statistical analysis

All data analysis was conducted in R (22). After initial assessment of the data for normality using the Shapiro–Wilk test, descriptive statistics was presented with n (%); median (25th, 75th percentiles) were given for variables with non-normal distribution, while mean ± standard deviation (SD) for variables with normal distribution. The Wilcoxon signed rank test was used to compare the significance of individual characteristic variables at the time of intervention and at patient discharge. A level of significance of α=0.05 was used throughout the study.

Table 1. Patient characteristics

Characteristics	n (%)
Age (years) (mean±SD) (range)	57.1±18.5 (20.7–83.1)
Sex	
Male	23 (52.27)
Female	21 (47.72)
Total	44 (100)
Affected patients with symptomatic	
Renal cysts	5 (11.36)
Renal/perirenal abscess due to comorbidities	10 (22.73)
Renal/perirenal abscess after surgery	29 (65.91)
Total	44 (100)
Type of renal/perirenal fluid collection	
Renal cyst	9 (12.68)
Renal/perirenal abscess due to comorbidities	17 (12 r/5 p) (23.94)
Renal/perirenal abscess after surgery/intervention	45 (5 r/40 p) (63.38)
Total	71 (100)
Localization of fluid collection	
Right kidney	31 (43.66)
Left kidney	40 (56.34)
Total	71 (100)

SD, standard deviation; r, renal; p, perirenal.

Results

Of 56 patients referred for CTF-guided PPD placement, 12 patients were excluded from the study analysis due to missing confirmation of infection after combined laboratory (leukocyte and/or CRP count, urinalysis, urine culture, blood culture) and fluid analysis (75%) or biopsy only (25%). The study cohort comprised 44 patients (52.27% men; 57.1±18.5 years) with 71 renal and perirenal fluid collections in the form of renal cysts (12.68%) (Fig. 1), renal and perirenal abscesses due to comorbidities (23.94%) (Fig. 2), and renal and perirenal abscesses after renal surgery or intervention (63.38%) (Fig. 3). Table 1 shows the patient characteristics and Table 2 shows the etiology of the renal and perirenal fluid collections.

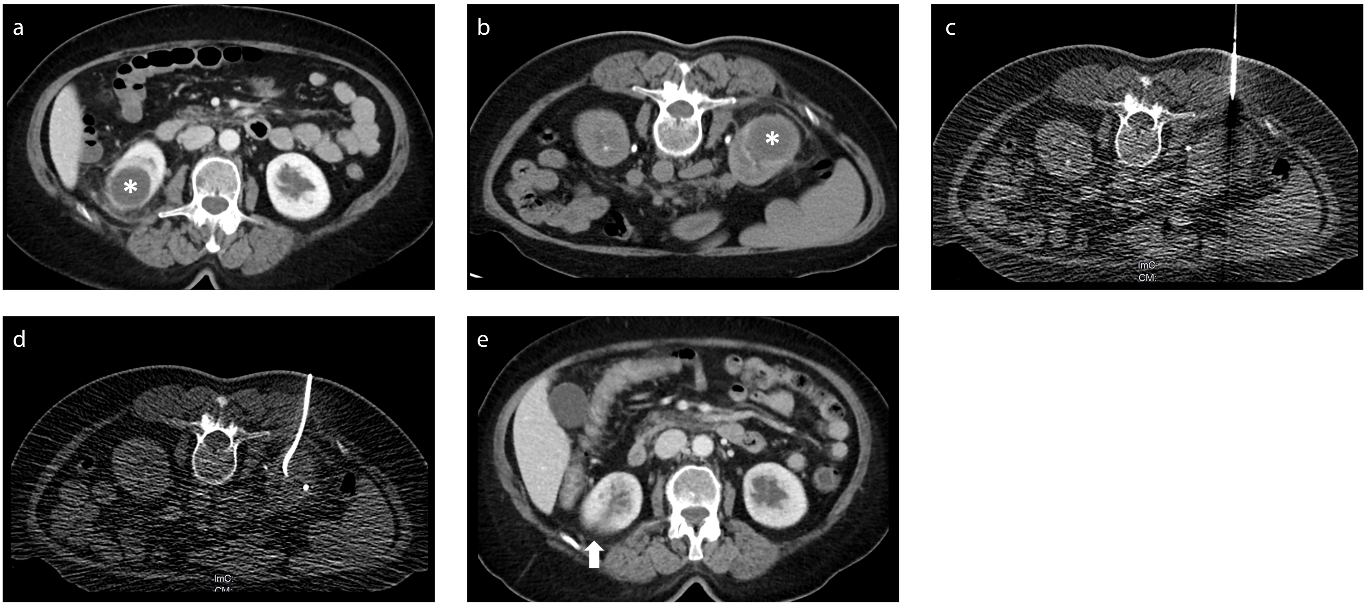

Figure 1. a–e. A 74-year-old woman presenting with fever, right flank pain and elevated inflammatory parameters (leukocyte count, 10.6 $\times 10^9$ /L; CRP 11.4 mg/L) and positive urinalysis but negative urine culture. Contrast-enhanced CT of the abdomen (venous phase) **(a)** shows a 3.8 cm cyst at the lower pole of the right kidney with a marked rim enhancement. Unenhanced CT image **(b)** in prone position before CT fluoroscopy (CTF)-guided percutaneous pigtail drainage (PPD) placement shows a discrete residual rim-enhancement of the infected cyst *(asterisk)*. Image **(c)** shows CTF-guided PPD placement (8 F pigtail drainage) under local anesthesia using a posterior access and the trocar technique. CTF image **(d)** shows successful PPD placement. Note the decrease in cyst size after aspiration of 10 mL slightly hemorrhagic fluid. Microbiological analysis of the cyst content revealed an *E. coli* infection. Contrast-enhanced CT image **(e)** of the abdomen 4 weeks after PPD removal: after combined antibiotic and drainage treatment there is only a small residual cortical defect at the posterior lower pole of the right kidney.

Adapted to the size and assumed viscosity of the abscess fluid, 73 single lumen PPD with diameters between 7.5 F and 12 F were utilized (7.5 F, 2.73%; 8 F, 49.32%; 10 F, 43.84%; 12 F, 4.11%). Mean size of the fluid collections was 7.1±3.0 cm (range, 2.0–15.2 cm).

CTF-guided PPD placement was performed in 44 patients and 61 sessions (1 session, 49.18%; 2 sessions, 18.03%; 3 sessions, 4.92%), respectively, including 73 single lumen PPD in 71 fluid collections. In four cases, PPD could not be inserted into the fluid collection (4.11%) or the fluid could not be aspirated (1.37%) due to a markedly viscous consistency of the respective fluid, corresponding to a technical success rate of 94.52% (69 of 73 PPD placements). In these selected cases, microbiological analysis was based on core biopsy with an 18 G needle. Mean duration of functioning PPD before removal was 10.9 days.

Most common microorganisms isolated out of the aspirated fluid were *Escherichia coli*, *Proteus mirabilis* and *Candida albicans* (Table 3). Urine analysis was positive in 20 of 44 patients (45.45%). However, urine culture turned out to be positive only in 8 patients (18.18%). Microorganisms most commonly isolated in urine culture were *E. coli* and *P. mirabilis*.

Clinical symptoms at the time of the intervention comprised fever (60% of the patients), pain (56.67%), poor general condition (13.33%), macrohematuria (6.67%) and nausea (6.67%), while in most patients a combination of several symptoms was seen. Mean total duration of hospital stay was 22 days. Median leukocyte count (25th–75th percentiles) at the time of the intervention and at discharge were 12.00 $\times 10^9$/L (8.48–15.60 $\times 10^9$/L) and 7.70 $\times 10^9$/L (6.25–9.20$\times 10^9$/L) ($p < 0.001$; Fig. 4, Table 4). Median CRP values at the time of the intervention and at discharge were 12.70 mg/dL (7.33–18.68 mg/dL) and 4.30 mg/dL (1.10–6.85 mg/dL) ($p < 0.001$). Median creatinine values at the time of the intervention and at discharge were 1.30 mg/dL (0.98–1.73 mg/dL) and 1.20 mg/dL (0.90–1.93 mg/dL) ($p = 0.025$; Table 4).

Additional invasive measures after primary CTF-guided PPD were required in 5 patients; namely, nephrectomy (6.82%), partial nephrectomy (2.27%), and surgical drainage (2.27%). Thus, clinical success using only minimally invasive measures was achieved in 39 of 44 patients (88.64%).

Adverse events within 30 days comprised PPD failure (2.27%) or secondary dislocation (11.36%; Grade 3) and one death (2.27%; Grade 6, unrelated to intervention).

Mean total DLP was 749±385 mGy·cm. This value included mean pre- and post-interventional DLP of 413±245 mGy·cm and 250±185 mGy·cm, and median intra-interventional DLP of 45 mGy·cm (23.5–83 mGy·cm).

Discussion

Renal and perirenal abscesses may arise as a complication of surgery such as renal transplantation or nephrectomy, progression of pyelonephritis or secondary infection of intra- or perirenal fluid collections.

In our study, patients' characteristics and predisposing conditions demonstrated a noteworthy similarity to previous series (6, 7, 9, 16, 23–25). The majority of the patients suffered from diabetes mellitus, nephrolithiasis or ADPKD.

While a variety of methods have been described to catheterize the abscess cavity (26), we introduced and advanced the drainages to the fluid collection using the trocar technique only. Particularly in poorly compliant patients, compared to the Seldinger technique, a faster placement in one step is possible given a sufficient stiffness of the drainage and a good directional control (27). Additionally, we generally applied the curved trocar technique described by Young et al. (19), allowing for

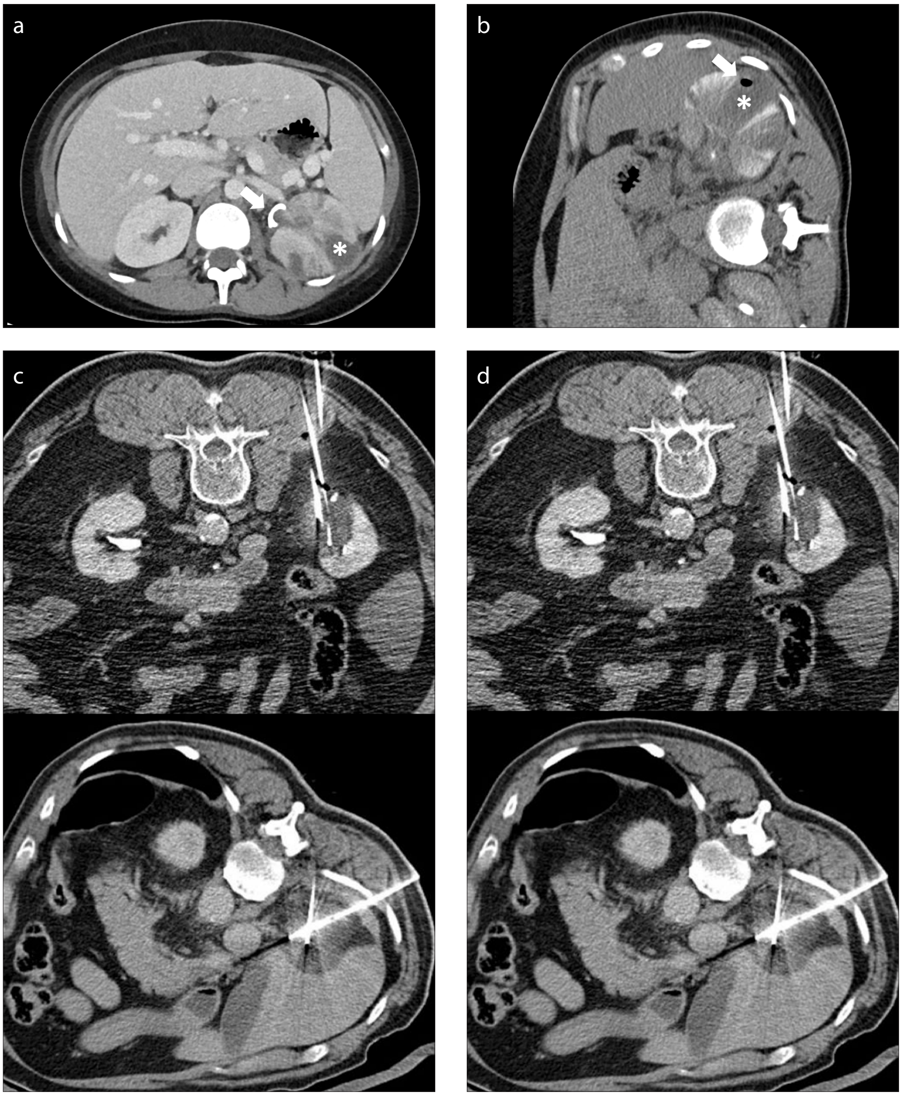

Figure 2. a–d. A 21-year-old woman with history of nephrolithiasis complicated by pyelonephritis of the left kidney with multiple abscesses, presenting with nausea, vomiting, left flank pain and colics (positive urinalysis, leukocyte count 7.4 $\times 10^9$ /L, CRP 14.9 mg/L). In panel **(a)**, a left ureteric double-J stent had previously been inserted *(arrow)*. After unsuccessful nephrostomy placement by urology, CTF-guided PPD placement into the largest abscess *(asterisk)* was decided in an interdisciplinary team meeting. Unenhanced CT image **(b)** in right lateral decubitus position before PPD placement shows a small gas bubble *(arrow)* within the target abscess *(asterisk)*. Panel **(c)** shows CTF-guided PPD placement (8 F) under local anesthesia. Note the black streak artifact *(framed arrow)* of the superficially inserted drainage tip within the subcutaneous fat tissue of the dorsolateral abdominal wall delineating the access trajectory, as well as the small gas bubble *(arrow)* marking the upper margin of the abscess. Unenhanced CT image **(d)** shows successful PPD placement. The inserted 8 F pigtail drainage shows a typical loop within the abscess cavity. Microbiological analysis of the abscess content revealed an *E. coli* infection. After targeted antibiotic treatment, the patient could be discharged with complete convalescence 30 days after the intervention.

PPD placement within the CT gantry under quick-check CT fluoroscopic acquisitions in most patients.

Hereby, we could achieve an excellent technical outcome of 94.52%, which parallels the results of several other studies (9, 10, 16, 28–32). In our series, 7.5 to 12 F catheters were used depending of the size of the abscess, expected fluid consistency and personal preference of the performing interventional radiologist which corresponds to current recommendations (5, 16, 33). Only in a small number of cases, PPD insertion in the renal abscess was not successful due to a markedly viscous consistency of the respective fluid. In these selected cases, aspiration was sufficient for microbiological sampling (26).

All patients in our study showed a significant decrease of the inflammatory parameters (leukocyte count, CRP) after the intervention, whereas the creatinine levels remained stable. Our results demonstrate that combined antibiotics and CTF-guided PPD of infected renal and perirenal fluid collections provide an excellent technical and clinical outcome.

In comparison with conservative antibiotic treatment alone, CTF-guided PPD facilitates diagnostic drainage providing knowledge of the underlying organisms and their antimicrobial susceptibilities. Nevertheless, in medium-sized renal and perirenal abscesses measuring 5 cm or less, Lee et al. (34) reported a high clinical success rate (49/51 abscesses; 96.08%) using broad-spectrum antibiotics only. Indeed, intravenous antibiotic therapy can be sufficient in selected cases when therapeutic drainage implies a considerable risk. On the other hand, in our experience even in small superinfected renal cysts, CTF facilitated a precise and near real-time targeting and drainage of the affected cyst. This may allow for a nephron-sparing preservation of renal parenchyma unaffected by the inflammation, microbiological sampling, and potentially a faster patient recovery (11).

In our study, five patients (11.36%) secondarily required open surgical revision with nephrectomy, partial nephrectomy or surgical drainage insertion, mostly because of a late diagnosis or poor residual function of the infected kidney. While our analysis only included patients primarily treated by combining antibiotics and percutaneous drainage, Fulla et al. (31) reported primary surgery and nephrectomy rates of nearly 30% and 20.5%, in 44 patients with renal abscesses, respectively. However, the authors underlined that minimally invasive procedures were applied progressively during the 10-year period of their study, which is in line with the experience in our institution.

In our study, complications of the CTF-guided drainage procedure were unusual and comprised one PPD failure, five secondary drainage dislocations, and one death which was unrelated to the intervention and occurred due to a delayed treatment onset and severe comorbidities. These findings are consistent with those of several other studies (5, 9, 10, 14, 16, 28–31, 35). Specific adverse events not encountered in our series were renal vascular and ureteral injuries or inadvertent placement of the drainage catheter into the gastrointestinal

Table 2. Etiology of the renal and perirenal fluid collections

Etiology		n (%)
Comorbidities of patients with infected renal cysts		
ADPKD		2 (40)
Unknown		2 (40)
DM, nephrolithiasis		1 (20)
Total		5 (100)
Comorbidities of patients with renal/perirenal abscess*		
Pyelonephritis		2 (20)
DM		1 (10)
DM, nephrolithiasis		1 (10)
DM, pyelonephritis		1 (10)
Nephrolithiasis		1 (10)
Crohn disease with steroid-induced DM		1 (10)
Hydronephrosis after cystectomy and neobladder reconstruction		1 (10)
History of previous renal abscess		1 (10)
ESBL infection		1 (10)
Total		10 (100)
Preceding disease of patients with renal/perirenal abscess after surgery/intervention	Preceding surgery / intervention	
Tumor-associated		
Renal cell carcinoma	NE (n=8); PNE (n=2); Cryoablation (n=1)	11 (68.75)
Oncocytoma	PNE	1 (6.25)
Teratoma	PNE	1 (6.25)
Angiosarcoma	NE	1 (6.25)
Urothelial carcinoma	NE	1 (6.25)
Non-seminoma	NE	1 (6.25)
Total		16 (100)
Not tumor-associated		
DM	PNE	3 (23.08)
ADPKD	NE	2 (15.39)
DM	TxNE	2 (15.39)
Focal segmental glomerulosclerosis	TxNE	1 (7.69)
Lymphangioleimyomatosis	PEComa resection	1 (7.69)
Tuberous sclerosis with multiple renal angiomyolipomas	PNE	1 (7.69)
Laurence-Moon-Bardet-Biedl syndrome	TxNE	1 (7.69)
Pyonephrosis	Nephrostomy	1 (7.69)
Nephroureteral cystolithiasis	ESWL	1 (7.69)
Total		13 (100)

ADPKD, autosomal dominant polycystic kidney disease; DM, diabetes mellitus; ESBL, extended spectrum beta-lactamase; NE, nephrectomy; PNE, partial nephrectomy; TxNE, transplant nephrectomy; PEComa, perivascular epithelioid cell tumor; ESWL, extracorporeal shock wave lithotripsy.
*Combination of several comorbidities in one patient is possible.

Table 3. Microbiological analysis

Microorganisms	n (%)
Escherichia coli	9 (16.98)
Proteus mirabilis	9 (16.98)
Candida albicans	6 (11.32)
Enterococcus faecium	5 (9.43)
Candida glabrata	4 (7.55)
Enterococcus faecalis	3 (5.66)
Coagulase-negative *staphylococci*	3 (5.66)
Staphylococcus aureus	2 (3.77)
Lactobacillus spp	2 (3.77)
Streptococcus anginosus	2 (3.77)
Propionibacterium acnes	2 (3.77)
Aureobasidium pullulans	1 (1.89)
Morganella morganii	1 (1.89)
Candida krusei	1 (1.89)
Finegoldia magna	1 (1.89)
Enterobacter cloacae	1 (1.89)
Staphylococcus capitis	1 (1.89)
Total	53 (100)

*Combination of several microbiological organisms in one patient is possible.

tract (36, 37). Furthermore, abscess recurrence and pyelonephritis/kidney failure rates after percutaneous drainage of up to 12.2% and a 4.5% have been described (14).

Prior to the availability and development of antibiotics, most perirenal abscesses were caused by hematogenous spread of gram-positive bacterial infection (e.g., *Staphylococcus aureus*) (8, 38, 39). Meanwhile aerobic gram-negative bacteria, notably *P. mirabilis* and *E. coli*, are the most frequently isolated microorganisms (5, 9, 16, 31, 35). Gram-positive cocci, fungi, as well as various types of tuberculosis have been on the rise in recent years, particularly affecting immuno-compromised patients (40).

In our patients series, PPD placement was performed under intermittent quick-check CT fluoroscopic acquisitions, using low-milliampere CTF (with a tube current-time product of 10 mAs) which decreases patient radiation dose and total procedure time (18, 41). The observed patient radiation exposures due to pre- and postinterventional CT as well as intra-interventional CTF are in line with the results reported for CT drainage procedures by Kloeckner et al. (21), with mean DLP_{total} 749 mGy·cm and mean DLP_{CTF} 83 mGy·cm in the present study compared with mean DLP_{total} 648 mGy·cm and mean DLP_{CTF} 37 mGy·cm in Kloekner et al. As stated by the authors, the use of single-slice CTF (in our setting intermittent quick-check CTF) markedly reduces radiation exposure while continuous (real-time) CTF is only necessary during insertion of biopsy needles, drainage or ablation probes into lesions that are not easily accessible (41).

Our analysis is characterized by several limitations. First, we present retrospective single-center data reflecting the mixed and

Figure 3. a–c. A 72-year-old woman with recurrent nephroureteral cystolithiasis and urinary tract infection *(Proteus mirabilis)*. Unenhanced CT image **(a)** of the abdomen shows a large calculus within the left renal pelvis *(arrow)* as well as pyramidal calcifications. The patient underwent extracorporeal shock wave lithotripsy (ESWL) treatment as well as ureterorenoscopy laser lithotripsy with fragment extraction (2 sessions each). Two months after the ESWL and ureterorenoscopy laser lithotripsy treatments, the patient presented with left flank pain, elevated inflammatory parameters (leukocyte count 19.1 ×10^9 /L, CRP 19.8 mg/L) and positive urinalysis. Unenhanced CT image **(b)** revealed a large left perirenal fluid collection *(arrow)*, presumably an infected perirenal hematoma after the preceding urological interventions. Unenhanced CT image **(c)** was acquired after CTF-guided PPD placement (12 F) and drainage of 640 mL hemorrhagic fluid. Microbiological fluid analysis confirmed a *Proteus mirabilis* infection. After targeted antibiotic treatment and removal of the drainage after 11 days, the patient was discharged from the hospital.

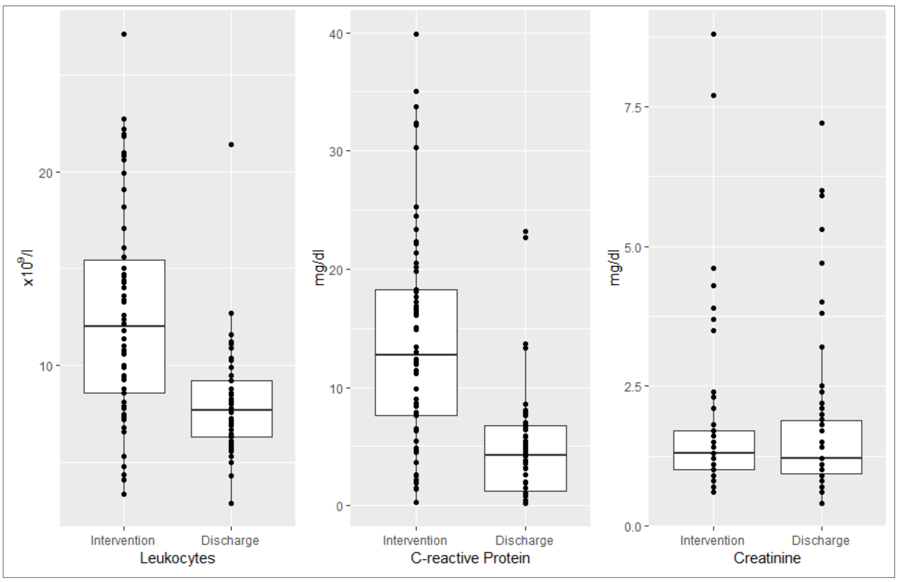

Figure 4. Box plots show the median values (25th, 75th percentiles) of leukocyte count, C-reactive protein and creatinine at the time of the intervention and at discharge.

Table 4. Leukocyte count, C-reactive protein and creatinine at the time of the intervention and at discharge

Parameter	Intervention*	Discharge*	Wilcoxon test *(p)*
Leukocyte count (×10^9 /L)	12.00 (8.48, 15.60)	7.70 (6.25, 9.20)	< 0.0001
C-reactive protein (mg/L)	12.70 (7.33, 18.68)	4.30 (1.10, 6.85)	< 0.0001
Creatinine (mg/dL)	1.30 (0.98, 1.73)	1.20 (0.90, 1.93)	0.025

*Median value (25th percentile, 75th percentile).

heterogeneous spectrum of a university hospital with comparatively complex urological patients, as the summary of the patient comorbidities and etiologies associated with spontaneous and postoperative/postinterventional renal and perirenal abscesses shows (e.g., Laurence-Moon-Bardet-Biedl syndrome (42); primary renal angiosarcoma (43)). Second, we only included patients who primarily were sent to our unit for CTF-guided drainage while the clinical outcome of patients primarily undergoing surgery or urological intervention was not analyzed for comparison. Third, we did not exclude small intraparenchymal renal abscesses from our analysis as—in contrast to the recommendations of several publications (16, 34)—in the presented cases, our multidisciplinary urological and radiological team had preferred the placement of small pigtail drainages for microbiological analysis to antibiotic treatment only. Fourth, we did not compare intermittent quick-check CTF against standard CT-guidance or continuous real-time fluoroscopy, particularly with regard to radiation exposure.

In conclusion, our study demonstrates that in patients with renal and perirenal abscesses occurring spontaneously or in the postoperative period, CTF-guided PPD placement in combination with a directed antibiotic therapy can achieve an excellent technical and clinical outcome. The major advantages of CTF-guided PPD are the minimally invasive access to the abscess, the instantaneous sampling of microbiological organisms for a directed antibiotic therapy, and a low complication rate allowing for a “nephron-sparing” treatment, reducing the need for open surgical incision and drainage in the often critically ill and heterogeneous patient population. Nevertheless, early and correct imaging diagnosis remains an important factor in the successful management of renal and perirenal abscesses.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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