Journal of Nephrology
https://doi.org/10.1007/s40620-022-01479-7

REVIEW

The use of mini-invasive surgical techniques to treat refractory exit-site and tunnel infections in peritoneal dialysis patients: a clinical approach

Antonio Scalamogna[1] · Luca Nardelli[1,2,3] · Giuseppe Castellano[1,2]

Received: 20 June 2022 / Accepted: 1 October 2022

Abstract
Peritoneal dialysis—(PD) related infections continue to be a major cause of morbidity and mortality in patients on PD. Although great advances have been made in the prevention and treatment of infectious complications over the past two decades, catheter-related infections represent a significant cause of technical failure in PD. Recent studies support the role of exit-site/tunnel infections in causing peritonitis. Peritonitis secondary to tunnel infection led to catheter loss in most cases. Thus, removing the catheter when exit-site/tunnel infection is refractory to medical therapy has been recommended. This approach requires interrupting PD and, after the placement of a central venous catheter, and transferring the patient to haemodialysis. In order to continue PD, simultaneous catheter removal and replacement of the PD catheter has been suggested. Although simultaneous catheter removal and replacement avoids temporary haemodialysis, it implies the removal/reinsertion of the catheter and the immediate initiation of PD with the risk of mechanical complications, such as leakage and malfunction. Hence, several mini-invasive surgical techniques, such as curettage, cuff-shaving, removal of the superficial cuff, and partial reimplantation of the catheter, have been proposed as rescue treatments. These procedures may allow the rescue of the catheter with a success rate of 70–100%. Therefore, in case of refractory exit-site/tunnel infection, a mini-invasive surgical revision should be considered before removing the catheter.

Keywords Peritoneal dialysis · Exit-site infection · Tunnel infection · Peritonitis · Cuff-shaving · Cuff-removal · Partial reimplantation · Ultrasound

Introduction

Peritoneal dialysis—(PD) related infections remain the main cause of morbidity and PD discontinuation, and are responsible for 35–55% of technique failure [1–3].

Recent studies seem to confirm the theory that ascribes a direct role to exit-site and tunnel infections (ESIs/TIs) in causing peritonitis [4, 5]. It has been hypothesized that microorganisms are able to migrate from the exit-site along the tunnel to the peritoneal cavity [6]. During this migration the microorganisms can colonize the Dacron superficial cuff and form a biofilm that facilitates their proliferation [7, 8]. The creation of this layer around the superficial cuff makes these infections unresponsive to medical therapy [9, 10]. In cases of ESI/TI refractory to medical therapy (no response after 3 weeks of appropriate antibiotic treatment), removing the catheter and continuing antibiotic therapy for at least 2–4 weeks has been suggested. This approach implies the interruption of PD and the transition to haemodialysis (HD) via the placement of a temporary central venous catheter, which is associated with a greater probability of infection, thrombosis, stenosis of the central vessels and increased mortality [11–14]. In order to spare the patient the change of dialysis modality, several authors have proposed the simultaneous removal and reinsertion of the PD catheter (SCR). When this procedure was used to treat ESI/TI without secondary peritonitis, it showed a success rate between 75 and

✉ Luca Nardelli
lcn.nardelli@gmail.com

1 Division of Nephrology, Dialysis and Kidney Transplantation, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Via della Commenda 15, 20122 Milan, Italy

2 Department of Clinical Sciences and Community Health, Università degli studi di Milano, Milan, Italy

3 Division of Nephrology and Hypertension, Department of Medicine, Mayo Clinic, Rochester, MN, USA

Published online: 15 December 2022

100%, but it required the removal of the catheter and the immediate resumption of peritoneal exchanges with a high risk of early leakage and catheter malfunction [15–19].

The optimal therapeutic approach should allow continuation of PD with an uninfected catheter. Thus, several non-invasive surgical techniques, such as curettage, cuff-shaving, partial reimplantation of the PD catheter and removal of the superficial cuff have been proposed [20–24].

Mini-invasive surgical techniques

Curettage

The curettage technique proposed by Ziauddin consists in removing the infected peri-catheter tissue by means of a bone curette with a sharp edge, tiny enough to enter the exit site sinus. In patients without infection of the superficial cuff, the manoeuvre was effective in 83% of cases [20].

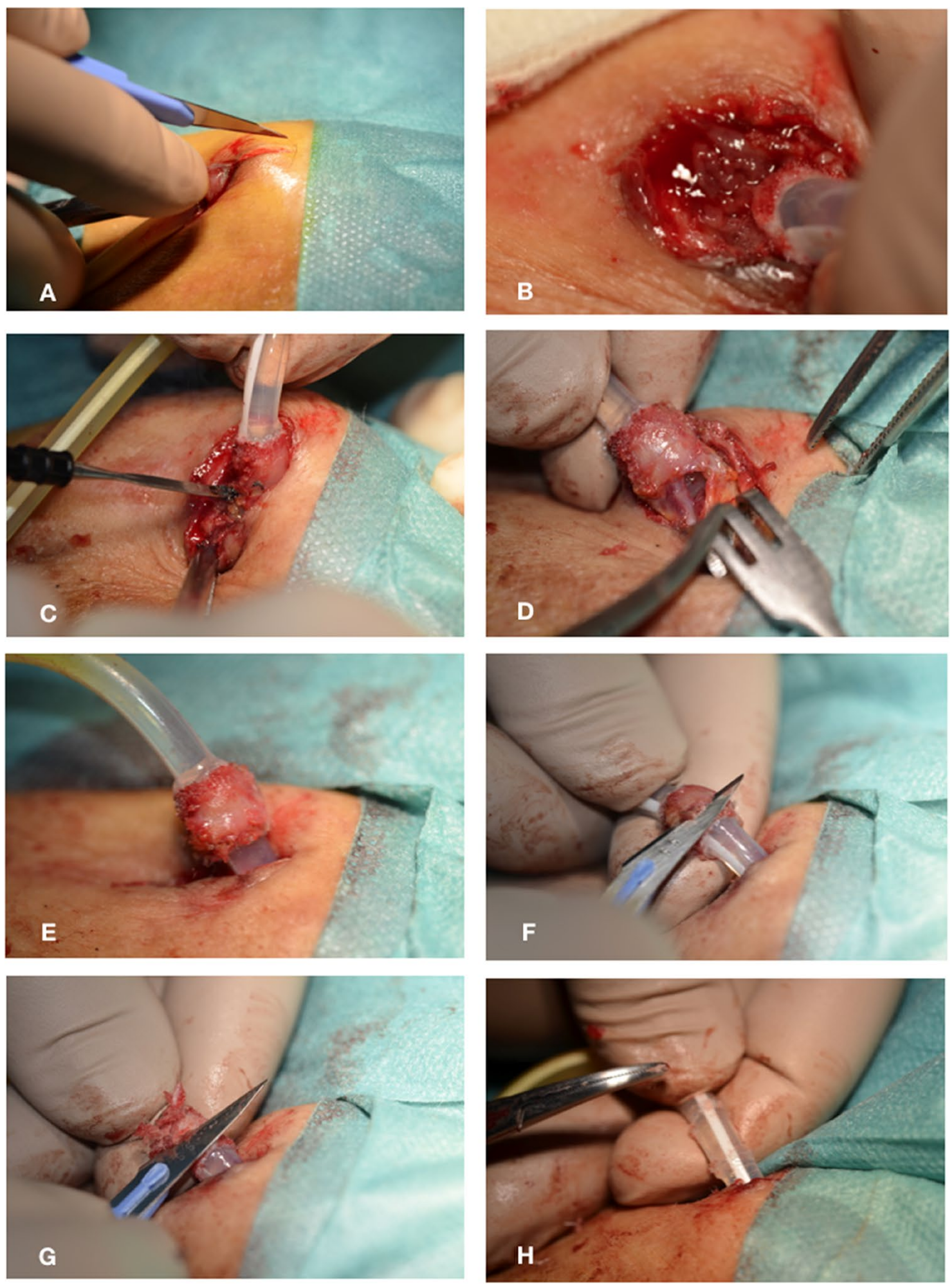

Fig. 1 **A**–**H** cuff-shaving: **A** skin incision of about 3–4 cm at the level of the exit-site in the direction of the superficial cuff; **B** localization of the superficial cuff by blunt dissection; **C**, **D** isolation of the superficial cuff from the adipose and scar cuff tissue; **E** complete isolation of the superficial cuff from the scar tissue; **F**, **G** careful shaving of the cuff using a scalpel; **H** only the shadow of the superficial cuff remains at the end of the procedure

Cuff-shaving

The cuff-shaving technique consists in making an incision from the sinus to the proximal edge of the superficial cuff, followed by the progressive shaving of the cuff and excision of the surrounding necrotic tissue (Fig. 1A–H).

This procedure was first proposed by Nichols and Nolph [21], and was subsequently used in 21 cases by Piraino et al. who reported a failure rate of 76% [25]. Our experience, based on 41 interventions, showed a satisfactory outcome in approximately 50% of cases [26].

In 13 patients without clinical signs of superficial cuff infections, Crabtree et al. obtained a success rate of 100% [27], while several Asian studies documented a success rate between 75 and 100% [28–32]. A study conducted by Cho et al. involving 13 patients who refused surgical treatment, reported that none were resolved by medical therapy and all of them ultimately required catheter removal [30]. A modified cuff-shaving procedure with a new exit-site relocation was performed in 27 refractory ESIs by Kirmizis et al. in the UK, obtaining a satisfactory outcome in 75% of cases [33].

Favourable results with the use of the cuff-shaving technique have also been described in paediatric populations

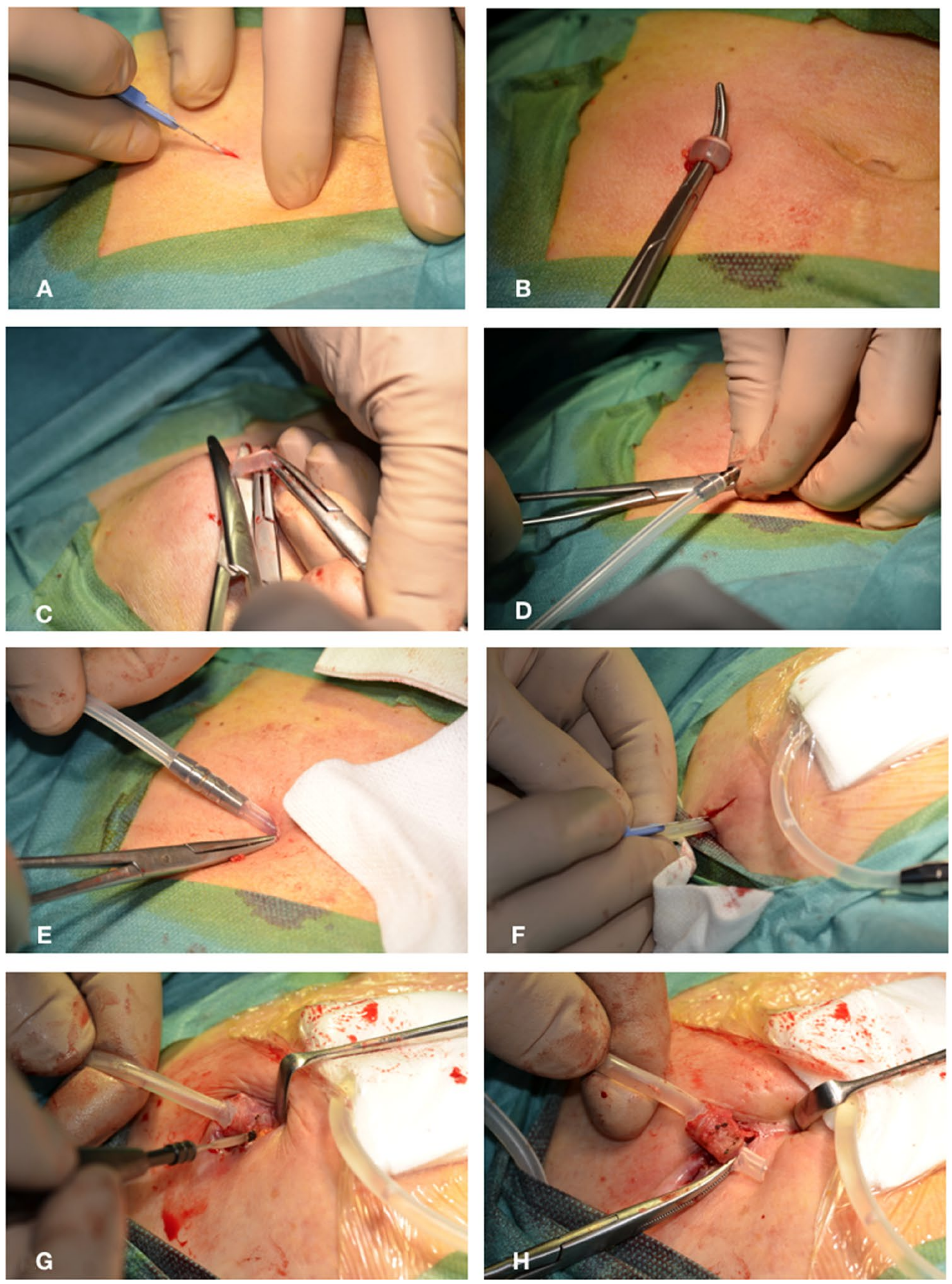

Fig. 2 **A**–**H** removal of the superficial cuff and creation of a new exit-site: **A** skin incision of approximately 5 mm, 1–2 cm from the inner edge of the superficial cuff; **B**, **C** the peritoneal catheter is retrieved through the tiny incision and cut as close as possible to the superficial cuff; **D** once outside the subcutaneous layer, the catheter is extended and a piece of new catheter is connected using a titanium adapter; **E** the adapter employed to extend the catheter remains outside the new exit-site so as not to hinder its maturation; **F** skin incision of about 1–2 cm at the level of the old exit-site sinus; **G** removal of the adipose and scar tissue attached to the infected superficial cuff; **H** removal of the infected superficial cuff connected to the distal part of the old catheter

[34, 35]. Yoshino et al. reported a success rate of 87.5% (28 cases out of 32) similar to the outcomes observed in a control group of 29 patients who were treated by catheter removal [35].

Partial reimplantion of the catheter

The partial catheter reimplantation technique consists in isolating the portion of the catheter between the two cuffs and splicing it in proximity of the deep cuff. Thereafter, the device is extended via the distal portion of another catheter and tunnelled subcutaneously in the contralateral hemi-abdomen with the creation of a new exit-site. The procedure of partial reimplantation (also known as "splicing technique") was first described by Roman et al. [22]. The main complication reported by the Authors consisted in the disconnection of the two ends at the connector level in approximately 15% of cases. Cheung et al. used this procedure for the treatment of 23 ESIs reporting a favourable outcome in approximately 50% of episodes [36], while Oki et al. successfully treated more than 85% (35 out of 40) of TIs without signs of infection beyond the superficial cuff [37]. Further encouraging data came from the studies by Chao and Sakurada who obtained a success rate between 90 and 100% [38, 39]. The technique was also used in Europe. Clouatre et al. performed 7 partial reimplantations for the treatment of 5 ESIs/TIs sustained by Staphilococcus aureus and 2 by *P. aeruginosa*. The procedure was successful in 6 out of 7 cases (86%): the only failure was caused by early leakage due to the disconnection of the extension [40]. Similar results (95% success rate) were also achieved by Fukasawa et al. who performed 22 partial reimplantations, but only in patients with no signs of abscess beyond the superficial cuff [41]. Furthermore, Muraoka et al. demonstrated the superiority of partial reimplantation over prolongation of antibiotic therapy (100% vs 60% success rate) in a series of 17 interventions [42].

Cuff removal

In order to overcome the disadvantages associated with cuff shaving, we introduced a new surgical technique. The procedure consists in isolating a portion of the catheter proximal to the superficial cuff, cutting the catheter at the level of the cuff, and extending the portion of the catheter using a new piece connected by a titanium extender; lastly, the infected cuff is removed through the old exit-site (Fig. 2A–H). This technique showed a success rate above 70% (15 out of 21 cases) in both Gram-positive (12 out of 17 cases) and Gram-negative infections (3 out of 4 cases) [23].

Prognostic value of ultrasound in tunnel infections

The position of the abscess along the catheter tunnel identified by ultrasound examination (US) possesses a well-defined prognostic value [43]. Examining almost 100 single-cuff, catheter-related infections, Vychytil et al. divided these episodes into 3 categories according to US: isolated exit-site infection, superficial tunnel infection (absence of cuff involvement) and deep tunnel infection (ultrasonographic signs of deep cuff involvement). The Authors observed that all cases of exit-site and superficial tunnel infections were efficaciously resolved by antibiotic treatment, while 40% of the deep tunnel infections were refractory to medical therapy, thus requiring catheter removal [44]. In patients with a double cuff catheter, the identification of deep cuff infection was strongly associated (> 90% of cases) with recurrence

Fig. 3 Advantages and disadvantages of the different mini-invasive surgical procedures that can be performed to treat exit-site and tunnel infections unresponsive to medical therapy

	ADVANTAGES	DISADVANTAGES
CURETTAGE	-Minimally invasive -Easy procedure	-Not effective in tunnel infection -Limited evidence
CUFF SHAVING	-No extra material needed -No catheter restructuring	-Large surgical incision -Short distance exit-site/cuff -Long wound healing time
CUFF REMOVAL	-Tiny surgical incision -No subcutaneous extension	-Short distance exit-site/cuff -Catheter restructuring
PARTIAL REIMPLANTATION	-Long distance exit-site/cuff -Exit-site far from infection -Restoration of catheter anatomy	-Large surgical incision -Catheter restructuring -Subcutaneous extension

[45]. Similarly, Plum et al. observed that the presence of a positive US in the segment between the two cuffs predicted the occurrence of secondary peritonitis in 62.5% of cases [46]. Thus, the available evidence shows that tunnel infections with involvement of the cuffs are unlikely to respond to antibiotic therapy, thereby requiring the removal of the catheter in most cases.

Mini-invasive surgical interventions: technical considerations

Curettage is the simplest and least invasive approach, while cuff-shaving involves a surgical incision that varies depending on the distance between the exit-site and the superficial cuff. In addition, removal of the fibrous tissue and the infected subcutaneous fat is responsible for bleeding and pain at the

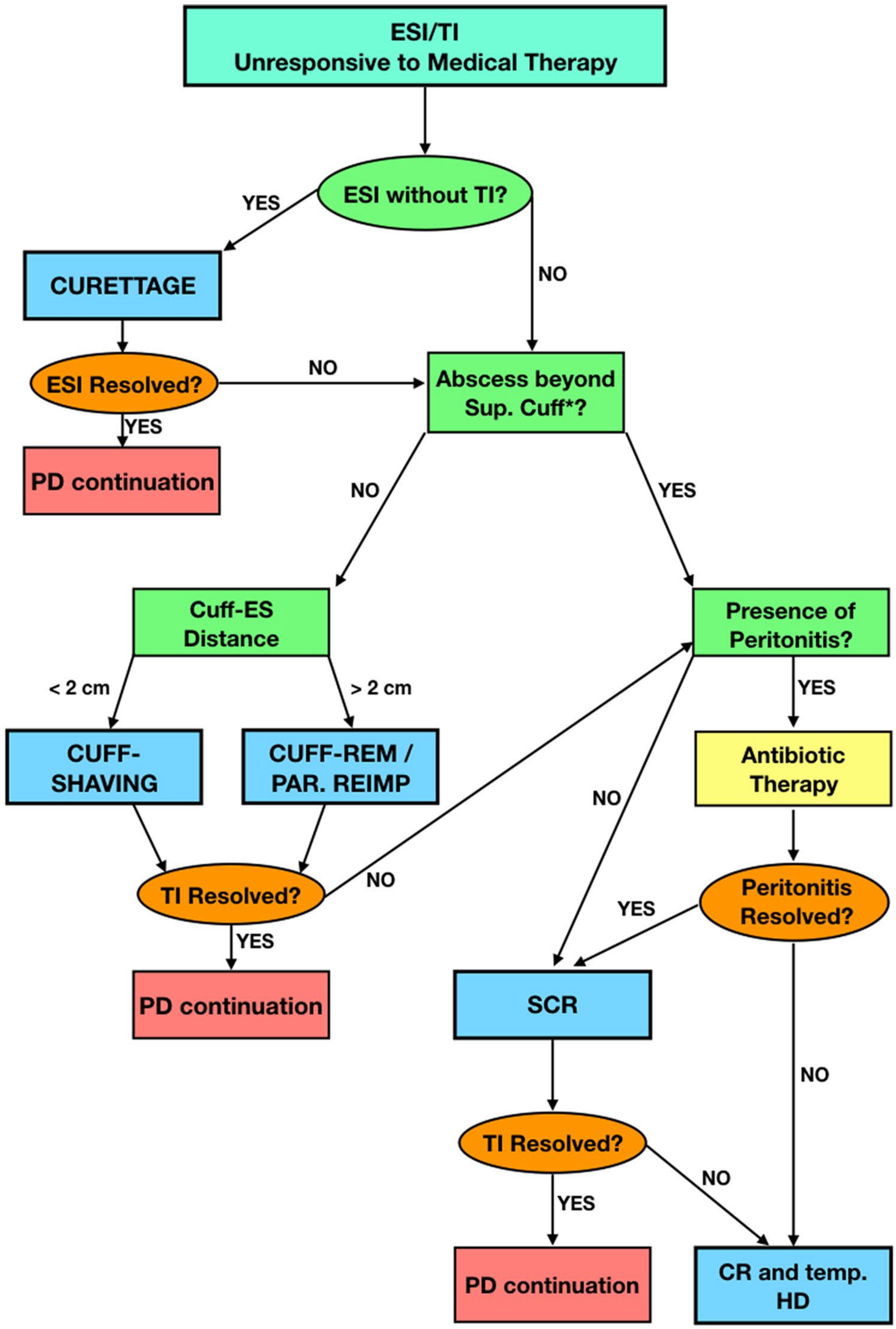

Fig. 4 Flowchart regarding the management of exit-site and tunnel infections unresponsive to medical therapy. *ESI* exit-site infection, *TI* tunnel infection, *PD* peritoneal dialysis, *ES* exit-site, *sup. Cuff* superficial cuff, *CUFF-REM* removal of the superficial cuff and creation of a new exit-site, *PAR. REIMP* partial reimplantation of the peritoneal catheter, *SCR* simultaneous peritoneal catheter removal and reinsertion, *CR* peritoneal catheter removal, *temp. HD* temporary haemodialysis. *The degree of the infectious episode should be assessed by physical examination (searching for erythema, edema, induration, or tenderness over the exit-site or subcutaneous pathway) and by ultrasonographic evaluation (detection of hypoechogenic areas between the tube/cuff of the catheter and the surrounding tissues with a diameter > 1 mm)

wound site. Compared to other procedures, cuff-shaving does not require extra material, and preserves the continuity of the peritoneal catheter. On the other hand, partial reimplantation requires making a large incision, cutting the catheter close to the deep cuff and extending the catheter into the subcutis using a titanium adapter which will then be left in place with the risk of subcutaneous leakage in case of disconnection. Removing the cuff is less traumatic and is performed through a small incision that will then become the new exit-site. The procedure does not require the removal of the fat around the infected cuff, and it avoids bleeding and wound pain. The extension of the catheter by the titanium extender takes place outside the new exit-site allowing prompt diagnosis and resolution in case of detachment (Fig. 3).

Therapeutic algorithm in refractory exit-site and tunnel infections

In light of the available evidence, we propose the following therapeutic algorithm (Fig. 4). In case of ESI refractory to medical therapy without clinical/ultrasonographic signs of TI, the curettage technique is recommended. When ESI is not responsive to curettage, or in the presence of clinical/ultrasonographic signs of TI limited to the superficial cuff, and in the absence of secondary peritonitis, the distance between the exit-site and the superficial cuff should be evaluated. If this distance is less than 2 cm, cuff-shaving should be proposed; otherwise (distance > 2 cm) removal of the superficial cuff or partial reimplantation can be adopted.

Though completely safe in cases of mechanical complications [47], SCR should be performed in the absence of active peritonitis (effluent white cell count < 100/μL for 4 consecutive days) when employed to treat TI unresponsive to cuff-shaving/partial reimplantation/removal of the superficial cuff [48]. In cases of persistent TI after SCR and in TI associated with peritonitis refractory to medical therapy, it is necessary to remove the peritoneal catheter and temporarily switch the patient to HD.

It must be underlined that in order to carry out these procedures safely, the interventionalist needs to familiarize him/herself with catheter insertion and long-term catheter management, since only a strong background in this field allows to choose the most suitable intervention for the patient at the right time.

Conclusion

Mini-invasive surgical revision represents a valid therapeutic option in case of ESI/TI that is unresponsive to medical therapy. In fact, when adopted in the appropriate clinical context, these techniques allow to resolve catheter-related infections in 70–100% of cases, thus significantly increasing PD survival. Therefore, in nephrology units where expert operators are available, mini-invasive surgical procedures should be considered in the presence of refractory ESI/TI before proceeding with the removal of the peritoneal catheter.

Author contributions Research idea and study design: AS; LN supervision or mentorship: GC. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overallwork by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

Funding None.

Data availability Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Conflict of interest We have read and understood Journal of Nephrology's reports policy on disclosing conflicts of interest and declare that we have none.

Ethical approval No required.

Informed consent to participate No required.

Informed consent to publish No doubt that anonymity can be maintained.

References

1. Kavanagh D, Prescott GJ, Mactier RA, Renal S (2004) Peritoneal dialysis-associated peritonitis in Scotland (1999–2002). Nephrol Dial Transplant 19:2584–2591
2. Piraino B, Bernardini J, Sorkin M (1989) Catheter Infections as a factor in the transfer of continuous ambulatory peritoneal dialysis patients to hemodialysis. Am J Kidney Dis 13:365–369. https://doi.org/10.1016/S0272-6386(89)80018-6
3. Jaar BG, Plantinga LC, Crews DC et al (2009) Timing, causes, predictors and prognosis of switching from peritoneal dialysis to hemodialysis: a prospective study. BMC Nephrol 10:1–12
4. van Diepen ATN, Tomlinson GA, Jassal SV (2012) The association between exit site infection and subsequent peritonitis among peritoneal dialysis patients. Clin J Am Soc Nephrol 7:1266–1271
5. Lloyd A, Tangri N, Shafer LA et al (2013) The risk of peritonitis after an exit site infection: a time-matched, case—control study. Nephrol Dial Transplant 28:1915–1921
6. Piraino B (2009) Insights on peritoneal dialysis-related infections. Contrib Nephrol 163:161–168
7. Costerton JW, Cheng KJ, Geesey GG, Ladd TI, Nickel JC, Dasgupta MMTJ (1987) Bacterial biofilms in nature and disease. Ann Rev Microbiol 41:435–464
8. Costerton JW, Lewandowski Z, Caldwell DE et al (1995) Microbial biofilms. Annu Rev Microbiol 49:711–745
9. Costerton J, Stewart P, Greenberg E (1999) Bacterial biofilms: a common cause of persistent Infections. Science (1979) 284:1318–1322
10. Nardelli L, Scalamogna A, Messa P (2021) The impact of the superficial cuff position on the exit site and tunnel infections in CAPD patients. J Nephrol 34:493–501

11. Perl J, Wald R, Mcfarlane P et al (2011) Hemodialysis vascular access modifies the association between dialysis modality and survival. J Am Soc Nephrol 22:1113–1121
12. Astor BC, Eustace JA, Powe NR et al (2005) Type of vascular access and survival among incident hemodialysis patients: the choices for healthy outcomes in caring for ESRD (CHOICE) study. J Am Soc Nephrol 16:1449–1455. https://doi.org/10.1681/ASN.2004090748
13. Ishani A, Collins AJ, Herzog CAFR (2005) Septicemia, access and cardiovascular disease in dialysis patients: the USRDS Wave 2 Study 1. Kidney Int 68:311–318
14. Patel PR, Kallen AJAM (2010) Epidemiology, surveillance, and prevention of bloodstream infections in hemodialysis patients. Am J Kidney Dis 56:566–577. https://doi.org/10.1053/j.ajkd.2010.02.352
15. Swartz R, Messana J, Reynolds J, Ranjit U (1991) Simultaneous catheter replacement and removal in refractory peritoneal dialysis infections. Kidney Int 40:1160–1165
16. Cancarini GC, Manili L, Brunori G et al (1994) Simultaneous catheter replacement-removal during infectious complications in peritoneal dialysis. Adv Perit Dial 10:210–213
17. Posthuma N, Borgstein PJ, Eijsbouts Q, Wee PM (1998) Simultaneous peritoneal dialysis catheter insertion and removal in catheter-related infections without interruption of peritoneal dialysis. Nephrol Dial Transplant 13:700–703
18. Crabtree J, Siddiqi R (2016) Simultaneous catheter replacement for infectious and mechanical complications without interruption of peritoneal dialysis. Perit Dial Int 36:182–187
19. Lui SL, Yip T, Tse KC et al (2005) Treatment of refractory pseudomonas aeruginosa exit-site infection by simultaneous removal and reinsertion of peritoneal dialysis catheter. Perit Dial Int 25:560–563
20. Ziauddin A, Choudhury D, Lee J, Girgis H (1997) The role of curettage in the care of persistent exit-site infection in CAPD patients. Perit Dial Int 17:195–197
21. Nichols W, Nolph K (1983) A technique for managing exit site and cuff infections in Tenckhoff catheters. Perit Dial Bull 3:S4–S5
22. Roman J, Gonzalez A (1984) Tenckhoff catheter repair by the splicing technique. Perit Dial Bull 4:89–91
23. Scalamogna A, De Vecchi A (2000) Nuova tecnica di rimozione della cuffia superficiale nei pazienti con infezione dell'emergenza resistente alla terapia medica. G Ital Nefrol 17:635–639. https://doi.org/10.1177/03913988
24. Scalamogna A, Nardelli L, Cosa F et al (2021) Mini-invasive surgical techniques for the peritoneal catheter rescue in refractory tunnel infections. G Ital Nefrol 1(3)
25. Piraino B, Bernardini J, Peitzman A, Sorkin M (1987) Failure of peritoneal catheter cuff shaving to eradicate infection. Perit Dial Bull 7:179–182
26. Scalamogna A, de Vecchi A, Maccario M et al (1995) Cuff-shaving procedure. A rescue treatment for exit-site infection unresponsive to medical therapy. Nephrol Dial Transplant 10:2325–2327
27. Crabtree J, Burchette R (2005) Surgical salvage of peritoneal dialysis catheters from chronic exit-site and tunnel infections. Am J Surg 190:4–8
28. Terawaki H, Nakano H, Ogura M et al (2013) Unroofing surgery with en bloc resection of the skin and tissues around the peripheral cuff. Perit Dial Int 33:573–576
29. Suh H, Wadhwa N, Cabralda T et al (1997) Persistent exit-site/tunnel infection and subcutaneous cuff removal in PD patients. Adv Perit Dial 13:233–236
30. Cho K, Do J, Park J, Yoon K (2012) Catheter revision for the treatment of intractable exit site infection/tunnel infection in peritoneal dialysis patients: a single centre experience. Nephrology 17:760–766
31. Meng C, Beco A, Oliveira A et al (2019) Peritoneal dialysis cuff-shaving—a salvage therapy for refractory exit-site infections. Perit Dial Int 39:276–281
32. Kang SH, Cho KH, Kim AY, Do JY (2022) Catheter salvage using revision for a peritoneal dialysis catheter with intractable exit site and/or tunnel infections. Semin Dial Online ahe: https://doi.org/10.1111/sdi.13094
33. Kirmizis D, Bowes E, Ansari B, Cairns H (2019) Exit-site relocation: a novel, straightforward technique for exit-site infections. Perit Dial Int 39:350–355
34. Macchini F, Testa S, Valadè A et al (2009) Conservative surgical management of catheter infections in children on peritoneal dialysis. Pediatr Surg Int 25:703–707
35. Yoshino A, Honda M, Ikeda M et al (2004) Merit of the cuff-shaving procedure in children with tunnel infection. Pediatr Nephrol 19:1267–1272
36. Cheung AHS, Wheeler MS, Limm WML et al (1995) A salvage technique for continuous Ambulatory peritoneal dialysis catheters with exit-site infections. Am J Surg 170:60–61
37. Oki R, Hamasaki Y, Komaru Y et al (2020) Catheter diversion procedure with exit-site renewal promotes peritoneal dialysis catheter survival. Kidney Int Rep 6:325–332
38. Chao S, Tsai T (1996) Partial replantation of Tenckhoff catheters to treat intractable exit-site/tunnel infection. J Am Soc Nephrol 7:1085–1087
39. Sakurada T, Okamoto T, Oishi D et al (2014) Subcutaneous pathway diversion for peritoneal dialysis catheter salvage. Adv Perit Dial 30:11–14
40. Clouatre Y, Cartier P, Charbonneau R et al (2000) Outpatient CAPD catheter salvage for persistent exit-site/tunnel infection. Nephrol Dial Transplant 15:231–234
41. Fukasawa M, Matsushita K, Tanabe N et al (2002) A novel salvage technique that does not require catheter removal for exit-site infection. Perit Dial Int 22:618–621
42. Muraoka K, Ishibashi Y, Yamaguchi J et al (2011) Early partial re-implantation of Tenckhoff catheters to treat intractable exit-site or tunnel infection. Perit Dial Int 31:350–353
43. Nardelli L, Scalamogna A, Zeiler M, Messa P (2020) Use of ultrasounds in PD catheter related infections: indications and clinical implications. G Ital Nefrol S75(7)
44. Vychytil A, Lorenz M, Schneider B et al (1998) New criteria for management peritoneal dialysis patients of catheter infections using ultrasonography. J Am Soc Nephrol 9:290–296
45. Kwan T, Tong MK, Siu Y, Leung K (2004) Ultrasonography in the management of exit site infections in peritoneal dialysis patients. Nephrology 9:348–352
46. Plum J, Sudkamp S, Grabensee B (1994) Results of ultrasound-assisted diagnosis of tunnel infections in continuous ambulatory peritoneal dialysis. Am J Kidney Dis 23:99–104
47. Scalamogna A, Nardelli L, Cicero E, Castellano G (2022) Analysis of mechanical complications in urgent-start peritoneal dialysis. J Nephrol 35:1489–1496
48. Scalamogna A, Nardelli L, Zubidat D, Castellano G (2022) Simultaneous replacement and removal of the peritoneal catheter is effective in patients with refractory tunnel infections sustained by *S. aureus*. Int Urol Nephrol. https://doi.org/10.1007/s11255-022-03288-0