Clinical and Experimental Nephrology (2021) 25:418–427
https://doi.org/10.1007/s10157-020-02001-8

ORIGINAL ARTICLE

Safety and utility of the alpha-replacer for treatment of intraluminal obstruction of peritoneal catheters by fibrin clots

Akimasa Asai[1] · Hiroshi Kinashi[1] · Yasuhiro Suzuki[2] · Hiroshi Kojima[2] · Yuka Sato[2] · Naoya Matsuoka[1] · Nao Asai[1] · Yuki Kuroyanagi[1] · Makoto Yamaguchi[1] · Hironobu Nobata[1] · Takayuki Katsuno[1] · Takuji Ishimoto[2] · Masashi Mizuno[2] · Yasuhiko Ito[1]

Received: 2 May 2020 / Accepted: 24 November 2020 / Published online: 4 January 2021
© Japanese Society of Nephrology 2021

Abstract

Background The Moncrief-Popovich technique of peritoneal catheter implantation has beneficial effects for peritoneal dialysis (PD) initiation. However, it might increase the risk of peritoneal catheter obstruction by fibrin clots, because the catheter is buried under the skin for several weeks to months. Effects of treatment of intraluminal occlusion of PD catheters with tissue plasminogen activator, recommended by the International Society for Peritoneal Dialysis guidelines/recommendations are reportedly limited. We investigated the effectiveness of the 'alpha-replacer' (JMS, Tokyo, Japan) for PD catheter obstruction.

Methods We retrospectively analyzed a total of 193 patients in whom PD was initiated. PD catheters were embedded using the Moncrief-Popovich technique in 130 of these patients. We assessed the occurrence rates of peritoneal catheter obstruction and the utility of the alpha-replacer for treating intraluminal catheter occlusion by fibrin clots.

Results Catheter obstruction occurred in eight cases with embedded catheters, one due to omental wrapping and the others due to fibrin clots, in which median catheter burial durations were 477 (interquartile range [IQR], 226–510) days. All catheter obstructions due to fibrin clots were successfully treated with the alpha-replacer, leading to improved catheter drainage. The median amount of contrast agent used in catheterography was 10 (IQR 9–10) mL, which did not adversely affect residual renal function. There were no complications. No recurrence occurred during the observation period (median 111, IQR 55.5–141 months).

Conclusion Our results suggest that treatment with the alpha-replacer is a safe and effective treatment option for intraluminal obstruction of PD catheters by fibrin clots.

Keywords Peritoneal dialysis · Peritoneal catheter obstruction · Fibrin clots · Alpha-replacer · Moncrief-popovich technique

Introduction

Peritoneal dialysis (PD) is used worldwide as a method for renal replacement therapy. The Moncrief-Popovich catheter and implantation technique [1] is useful for the immediate initiation of planned PD therapy. In this technique, the external limb of the catheter is embedded in a subcutaneous space at the catheter implantation site. When renal function deteriorates to the extent that PD is deemed necessary, the external limb of the catheter is exteriorized through a small skin incision [2]. This technique has been reported to have beneficial effects in reducing pericatheter infections, peritonitis, and leaks, which enables the patient to perform full-dose PD treatment from initiation [1–4]. Despite the acknowledged utility of this technique, we sometimes experience catheter dysfunction. Embedding catheters for months to years is associated with a 7–15% chance of catheter dysfunction after externalization [2].

Catheter dysfunction is a critical complication in PD and is usually due to catheter malposition or intraluminal obstruction [2]. There are several causes of intraluminal catheter obstruction, including fibrin clots, omental wrapping, and obstruction by the fimbriae of the uterine tube and

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10157-020-02001-8.

✉ Yasuhiko Ito
yasuito@aichi-med-u.ac.jp

Extended author information available on the last page of the article

epiploic appendices [2]. Intraluminal catheter obstruction might require invasive treatment, unless it is resolved by conservative methods, such as saline flushes and the use of tissue-type plasminogen activator (t-PA) or urokinase-type plasminogen activator (u-PA) [2, 5–8]. t-PA has been recommended by the International Society for Peritoneal Dialysis guidelines/recommendations in cases of catheter lumen obstruction by fibrin clots [2]. However, the treatment effects are reportedly somewhat limited, and recurrences of obstruction occurred in many cases [7–9]. Therefore, it is important to establish treatment options to rescue the catheter lumen obstructed by fibrin clots.

Here, we report the effectiveness of the 'alpha-replacer' (JMS Co. Ltd., Tokyo, Japan), which is a flexible metal guidewire that is generally used for transluminal replacement of a displaced peritoneal catheter [10]. To date, there has been no report of the use of the alpha-replacer for intraluminal obstruction due to fibrin clots. In this study, we retrospectively evaluated the efficacy of the alpha-replacer in the treatment of PD catheter obstruction by fibrin clots.

Patients and methods

Patients and data collection

This study was approved by the Ethics Committee for Human Research of Aichi Medical University Hospital (Nagakute, Japan) and Nagoya University Hospital (Nagoya, Japan) (Approval numbers: 2019-161 and 2005-0309, respectively). We retrospectively analyzed a total of 193 patients in whom PD was initiated at Aichi Medical University Hospital and Nagoya University Hospital from January 2005 to December 2019. In 130 cases, PD catheters were buried in the subcutaneous tissue using the Moncrief-Popovich catheter implantation technique. We collected data at the time of treatment with the alpha-replacer, including age, sex, primary kidney disease responsible for renal failure, C-reactive protein (CRP) level, duration of implantation, date of treatment with alpha-replacer, effects of forceful catheter flush, catheterography images, inflow or outflow obstruction, the volume of contrast medium injected, changes and differences in daily urine volume before and after use of the contrast medium, observation period after treatment with the alpha-replacer, relapse, and adverse effects. We also collected the data of CRP and duration of implantation from cases with no peritoneal catheter obstruction.

Alpha-replacer procedure

The alpha-replacer is a metal guidewire made of an inside "rope" and a peripheral "spring" structure. The "rope" consists of a 7-stranded wire; the "spring" has 22 turns of the wire over a distance of 10 mm. The total length of the alpha-replacer is 1800 mm, with an outer diameter of 1.73 mm (Fig. 1) [10]. The tip of the alpha-replacer is rounded and it seems to be less invasive and safer than usual guidewires when inserted into the peritoneal cavity (Fig. 1b). Procedures were aseptically performed in an X-ray fluoroscopy room. The contrast medium, Iopamiron (Bayer Yakuhin Co., Osaka, Japan), with an iodine concentration of 300 mg/mL and osmotic pressure of 620 mOsm/kg H_2O, was injected into the catheter to perform catheterography. The contrast medium was diluted 1:1 with saline. We attempted to keep the volume of the contrast medium used as low as possible. The operator inserted the alpha-replacer into the catheter and passed the alpha-replacer through it. These procedures were repeated until no contrast defects were obtained. First-generation cephalosporins were administered for a few days after these procedures.

Statistical analyses

Data are presented as the median and interquartile range (IQR). Mann–Whitney *U* tests were used to compare cases with no peritoneal catheter obstruction and cases with catheter dysfunction due to fibrin clots in terms of duration of catheter implantation and CRP levels. Changes in daily urine volume pre- and post-use of the contrast medium were analyzed using paired *t* tests. Significant differences were defined as $p < 0.05$. All statistical analyses were performed using IBM SPSS statistics version 25.0 (IBM Corporation, Armonk, NY, USA).

Results

General characteristics of the patients and treatment with the alpha replacer

PD was initiated in a total of 130 cases using the Moncrief-Popovich catheter implantation technique. A flow diagram of patient participation in this study is presented in Fig. 2. Among the 130 cases, there were 8 cases (6.2%) of outflow and/or inflow failure (Table 1). We performed catheterography, which revealed intraluminal obstruction of the peritoneal catheter due to fibrin clots in seven cases (5.4%) (Table 1a), five of whom were male and two were female. The median patient age was 68 (IQR 61–69) years. The primary kidney disease responsible for chronic renal failure was nephrosclerosis in three cases, and diabetic nephropathy, polycystic kidney disease, chronic glomerulonephritis, and unknown disease were the primary causes in the remaining cases (Table 1a). The duration of catheter implantation in the seven patients was a median of 477 (IQR 226–510) days (Table 1a), which was significantly longer than that

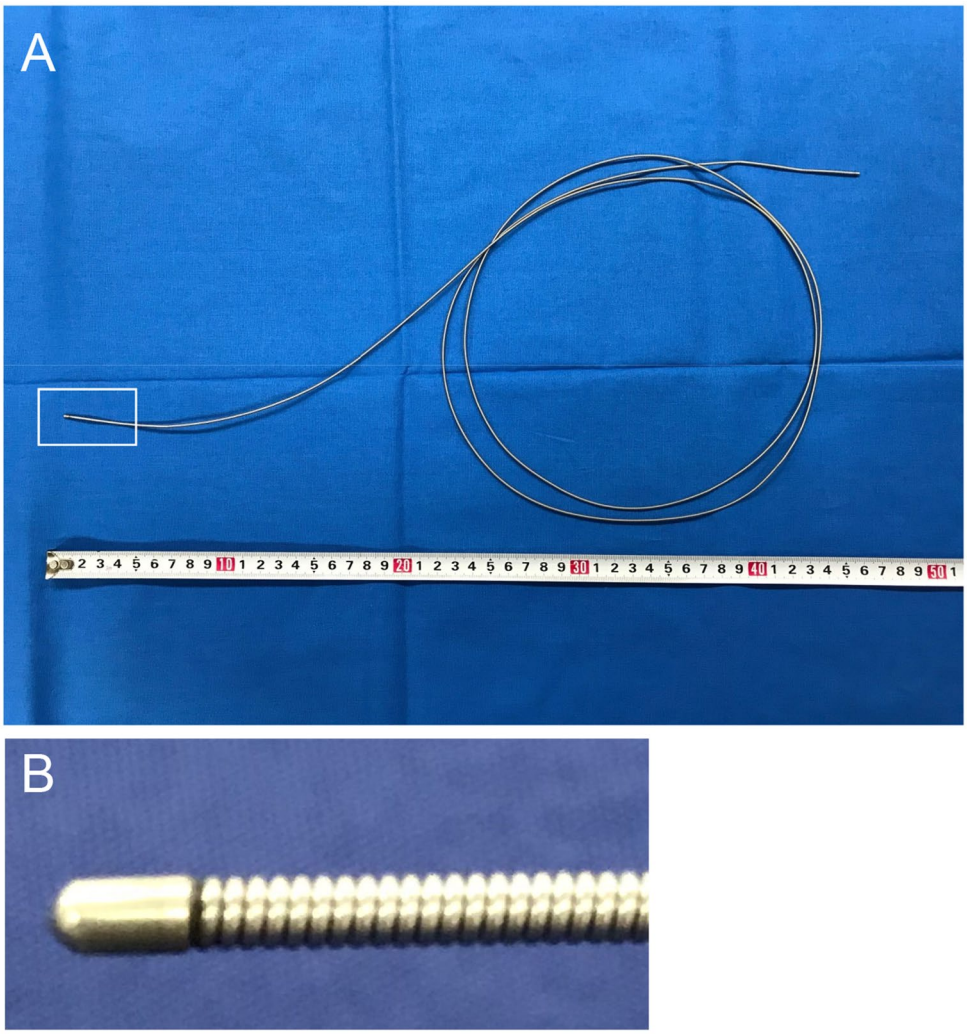

Fig. 1 Structure of the alpha-replacer. **a** The alpha-replacer is a metal guidewire made of an inside "rope" and an outer "spring" structure. The total length of the alpha-replacer is 1800 mm, with an outer diameter of 1.73 mm [10]. **b** Enlarged view of the white box in (A) showing the tip of the alpha-replacer

in cases without catheter obstruction (median, 76.5; IQR 39–171 days; $p < 0.05$). PD catheters in five of these cases were embedded for more than a year. Among seven cases with fibrin clots, five cases demonstrated outflow failure and the other two cases had both inflow and outflow failure. Forceful flushing of the catheter with saline was ineffective in all these cases. All cases showed defects in catheterography. In 5 cases, treatment with the alpha-replacer was conducted immediately after catheterography. Poor drainage was observed in Cases 2 and 4, despite which PD was continued. These cases were treated with the alpha-replacer on day 16 (Case 2) and day 43 (Case 4), respectively, because the drained volume gradually decreased (Table 1a).

Procedures and outcomes of treatment with the alpha-replacer in the seven cases with catheter dysfunction due to fibrin clots

All seven cases of intraluminal obstruction of the peritoneal catheter by fibrin clots were treated using the alpha-replacer (Fig. 2, Table 1a). In all cases, catheterography demonstrated the site of obstruction to flow of contrast medium in the catheter (Fig. 3a, e, Supplementary Video A, Table 1a). The alpha-replacer was inserted into the catheter and passed through it until it reached the end of the catheter (Fig. 3a–d). Then, catheterography was repeated and the above procedures were repeated until no contrast defect was observed and/or contrast flow had improved (Fig. 3c, d, Supplementary Video B). All seven cases were successfully treated by the alpha-replacer and flow was fully restored. The total amount of contrast medium used was a median of ten (IQR 9–10) mL (Table 1a). No recurrence of obstruction was observed during the observation period (median 111, IQR 55.5–141 months) (Table 1a). Daily urine volume was not significantly different between pre-treatment and post-treatment periods [1720 (1300–1808) vs. 1670 (1575–1825) mL, $P = 0.41$]. Further, there were no complications, such as peritonitis or bowel perforation (Table 1a).

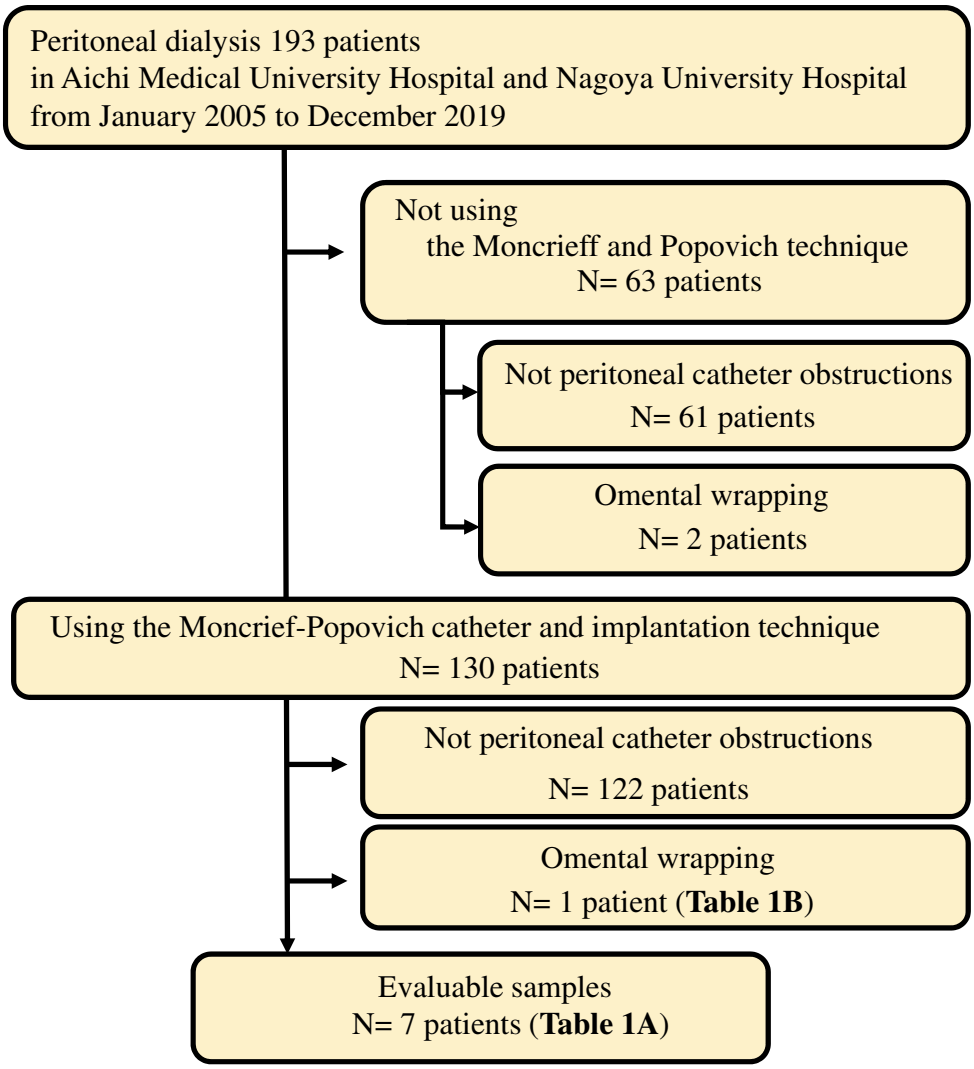

Fig. 2 Flow diagram of patient inclusion in the study

Case of omental wrapping

One case was diagnosed with omental wrapping based on the typical findings observed on computed tomography and catheterography (Fig. 2, Table 1b, Supplementary Fig. 1). In this case, only one trial of the passage of the alpha-replacer was conducted. However, since the obstruction did not improve on radiographic images, we stopped the procedure. This patient subsequently underwent surgical relief of the obstruction, which resulted in successful improvement in drained volume.

Discussion

The Moncrief-Popovich technique has been reported to improve clinical outcomes by reducing the risk of peritonitis and leaks [11]. However, long-term embedment of PD catheters might cause catheter obstruction [9]. A British facility reported that in a total of 47 PD catheters externalized after a median embedment period of 39.4 weeks, six catheters (12.8%) did not function immediately after externalization due to the presence of fibrin clots [9]. In the current study, there were 7 cases of catheter obstruction due to fibrin clots among the 130 cases (5.4%) in whom catheter embedment was performed using the Moncrief-Popovich technique. Although the frequency is different between facilities, catheter obstruction by fibrin clots can occur in cases of catheter embedment by the Moncrief-Popovich technique.

The presence of a catheter in the peritoneal cavity can reportedly promote a foreign body-induced inflammatory response, in addition to systemic inflammation associated with chronic renal failure [9, 12], which might promote coagulation. In previous reports, the duration of implantation tended to be longer in cases with catheter obstruction due to fibrin clots [11, 13, 14]. In this study, we identified longer implantation duration as a significant factor that might induce fibrin clot formation. In contrast, there were no

Table 1 Characteristics of the patients

a. Characteristics of the seven cases in whom the alpha-replacer was used to treat catheter lumen obstruction

	Sex	Age	Primary kidney diseases of renal failure	Duration of implantation (day)	Inflow or outflow obstruction	Effects of forceful catheter flush[1)]	Image of cathetergraphy	Volume of contrast medium (mL)	Date of treatment with alphareplacer (day)	Changes and differences of daily urine volume before and after usage of contrast medium (mL) pre, post (difference)	Observation period after treatment (month)	Relapse and adverse effects
1	Man	70	Nephrosclerosis	60	Outflow	Not effective	Defect	6	0	1250, 1400 (150)	177	None
2	Woman	68	Polycystic kidney disease	42	Outflow	Not effective	Defect	10	16	969, 1670 (701)	164	None
3	Man	55	Nephrosclerosis	671	Inflow and outflow	Not effective	Defect	10	0	1720, 1560 (−160)	117	None
4	Man	68	Chronic glomerulonephritis	391	Outflow	Not effective	Defect	10	43	2000, 2000 (0)	111	None
5	Woman	29	Unknown	503	Inflow and outflow	Not effective	Defect	10	0	1826, 1700 (−126)	88	None
6	Man	77	Diabetic nephropathy	477	Outflow	Not effective	Defect	10	0	1790, 1590 (−200)	23	None
7	Man	67	Nephrosclerosis	517	Outflow	Not effective	Defect	8	0	1350, 1950 (600)	22	None
Median (interquartile range)		68 (61–69)		477 (226–510)				10 (9–10)	0 (0–8)	pre 1720 (1300–1808) post 1670 (1575–1825) difference 0 (−143–375)	111 (55.5–141)	

Table 1 (continued)

b. One case of omental wrapping in a patient in whom the PD catheter was embedded. Treatment with the alpha-replacer was ineffective

	Sex	Age	Primary kidney diseases of renal failure	Duration of implantation (day)	Inflow or outflow obstruction	Effects of forceful catheter flush1)	Image of cathetergraphy	Volume of contrast medium (mL)	Date of treatment with alphareplacer (day)	Changes and differences of daily urine volume before and after usage of contrast medium (mL) pre, post (difference)	Observation period after treatment (month)	Relapse and adverse effects
8	Woman	38	Chronic glomerulonephritis	18	Outflow	Not effective	Defect	4	17	1750, 1500 (−250)	147	Not effective Required surgery After surgery, there were not relapse

1)Infusion of dialysate or normal saline with a 50 mL syringe using moderate pressure

significant differences in the serum levels of CRP between the groups with (median 0.04, IQR: 0.02–0.07) and without (median 0.1, IQR: 0–0.2) fibrin clots ($p = 0.114$).

Several papers about the treatment of intraluminal obstruction of peritoneal catheters have been reported to date (Table 2). An electronic search of the PubMed database (January 1967–February 2020) was conducted using the keywords ‘peritoneal dialysis catheter’, ‘occlusion’, ‘fibrin’, ‘guide wire’, ‘radiological manipulation’, ‘alteplase’, ‘tissue plasminogen activator’ and ‘urokinase-type plasminogen activator’. t-PA, which has been recommended by the International Society for Peritoneal Dialysis guidelines/recommendations [2], was reported to be effective for the treatment of intraluminal catheter obstruction by fibrin clots [2, 5–8, 15–18]. However, treatment with t-PA is often associated with recurrence of catheter obstruction and detailed information of these cases was not fully reported [7, 9, 15–18]. Additionally, the previous reports did not provide information about catheterography. In a previous study, 24 treatments with t-PA were performed for catheter obstruction. Among them, one patient had four recurrences, three patients had one recurrence, and two patients had two recurrences of the obstruction [7]. Also, u-PA was reportedly effective in cases of PD catheter occlusion after peritonitis. However, the effects of u-PA were considered to be limited in cases of early obstruction and in children with peritonitis [8]. Surgery was necessary when t-PA or u-PA was ineffective.

Previously, procedures involving the passage of a neonatal bronchoscope or a guidewire through the PD catheter were also reported to effectively relieve the obstruction, enabling avoidance of open abdominal surgery [19, 20]; however, the efficacy, certainty, and safety of these methods have not been established. In the current study, we reported a novel technique for the treatment of PD catheter obstruction using the alpha-replacer, which can remove or push the fibrin clots into the peritoneal cavity. All seven cases were successfully and safely treated, suggesting that treatment with the alpha-replacer might be an option for the treatment of PD catheter obstruction due to fibrin clots. Indeed, procedures involving pressurized saline injection should be performed before alpha-replacer treatment. CT scan, ultrasonography, and catheterography are useful to differentiate the wrapping of the catheter by the omentum or fimbriae of the fallopian tube from obstruction by fibrin clots; however, this might be difficult in some cases. If the alpha-replacer is used in cases with omental wrapping, the procedure might cause tissue damage leading to bleeding. In such cases, operation with “catheter repair by forefinger” is effective and relatively safe [21]. Thus, if there is suspicion of omental wrapping (SupplementaryFig. 1a, b) or failure following one passage of the alpha-replacer in cases with catheter dysfunction, surgery

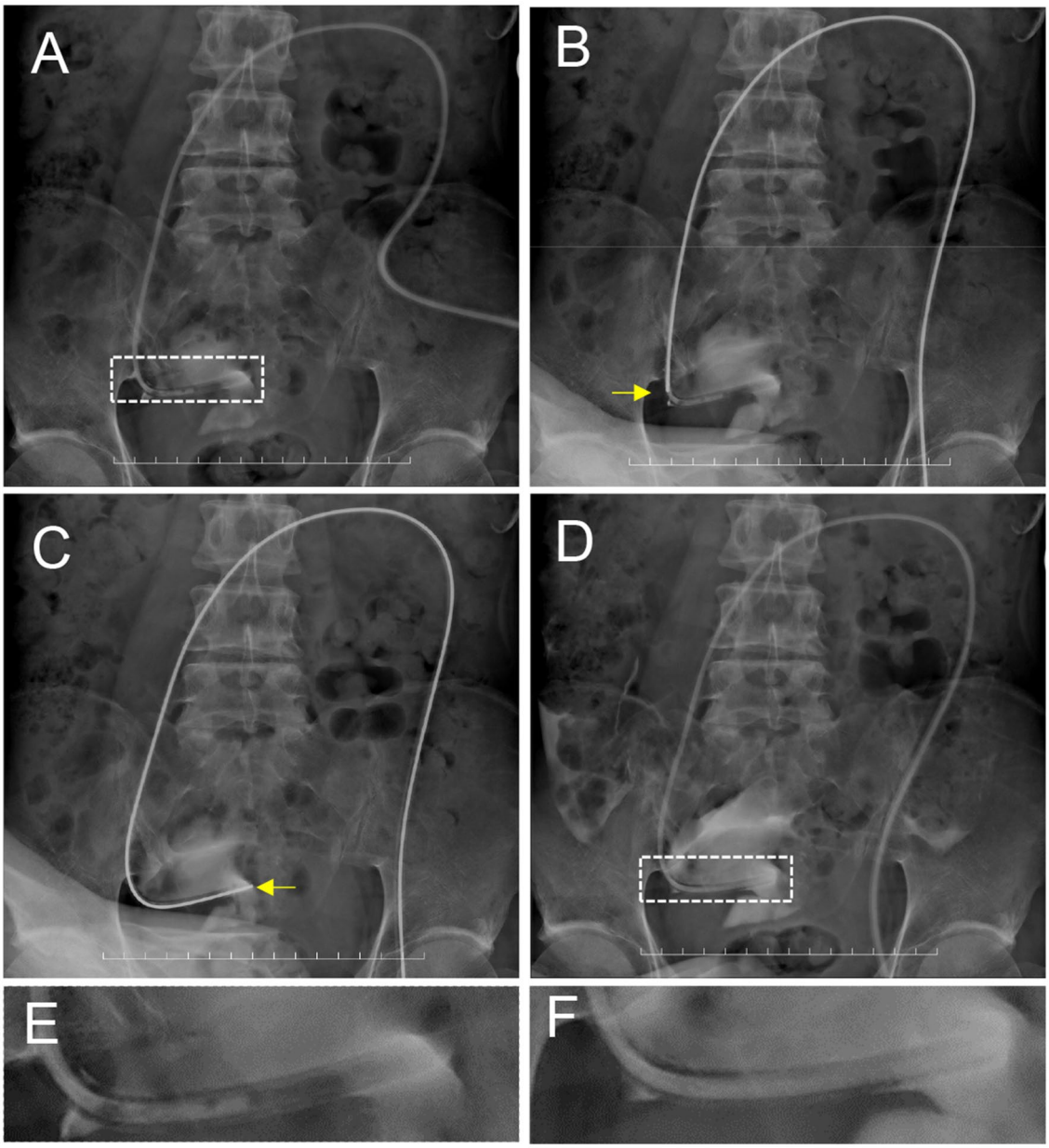

Fig. 3 Fluoroscopy and treatment by the alpha-replacer of a patient with catheter obstruction due to fibrin clots. **a** Fluoroscopy showed an area of contrast defect near the catheter tip (white box), which was diagnosed as obstruction due to fibrin clots. **b** The alpha-replacer was passed through the catheter up to just before the contrast defect. The arrow indicates the tip of the alpha-replacer. **C** Under fluoroscopy, the fibrin clots were gently pushed into the abdominal cavity using the alpha-replacer. The arrow indicates the tip of the alpha-replacer. **d** After the treatment, the contrast defect had disappeared, and flow through the catheter had improved significantly. **e** Enlarged view of the area within the white box in Figure (A). Contrast defects were observed. **f** Enlarged view of the white box in Figure (D). The contrast defects disappeared after treatment

should be considered instead of alpha-replacer treatment. In such cases, PD can be started on the day of operation.

Importantly, the total amount of contrast medium used for catheterography was small and did not reduce urine volume, suggesting that our strategy did not reduce residual renal function. It was previously reported that administration of radio-contrast medium does not lead to a persistent decline in residual renal function in PD patients [22, 23]. Careful management during the performance of procedures with the alpha-replacer is required for preventing complications such as postoperative peritonitis due to unsterile conditions and intraperitoneal damage. In a previous report, treatments with a Fogarty catheter in 34 PD patients presenting for replacement of displaced PD catheters did not

Table 2 Literature review of previous cases of treatment with tissue plasminogen activator for catheter dysfunction

Article	Age	The Moncrief-Popovich catheter and implantation technique	Duration from catheter exterization to failure	No of cases	Effective cases	Ineffective cases	Causes of ineffective case	Adverse event	Cases of recurrence	Follow up period
Zorzanello MM et al. [7]	Not reported	Not reported	Not reported	29 cases	24 cases	5 cases	2 cases: catheter malposition 2 cases: constipation 1 case: adhesion	None	11 cases*	Not reported
Sinha S et al. [9]	Median 62.1 years (IQR: 51.3–73.0)	22 cases	Not reported	22 cases	2 cases (temporarily successful)	20 cases	12 cases: catheter malposition 4 cases: fibrin plugs 3 case: damage at externalisation 1 case: adhesions	Not reported	2 cases (surgical rescue was required)	Not reported
Shea M et al. [15]	0.07–16.5 (years, range)	Not reported	14–425 (days, range)	7 cases	4 cases	3 cases	2 cases: no clear cause 1 case: catheter malposition	None	1 case (6 weeks later)	10 months
Sahani MM et al. [16]	Not reported	Not reported	Not reported	4 cases	4 cases	Not reported	None	None	Not reported	Not reported
Sakarcan A et al. [17]	6 (months)	None	Not reported	1 case	1 case	Not reported	None	None	1 case (6 weeks later)	Not reported
Krishnan RG et al. [18]	4 (years)	Not reported	9 (months)	1 case	1 case	Not reported	None	None	Not reported	Not reported

IQR interquartile range, *SD* standard deviation

*Eleven recurrences in six patients, four recurrences in one patient, two recurrences in two patients and one recurrence in three patients

cause procedure-related peritonitis or exit-site trauma [24]. In another study, treatment with the alpha-replacer for catheter malposition in 22 PD cases resulted in no serious complications, such as abdominal trauma or peritonitis [25]. In addition, the tip of the alpha-replacer is rounded (Fig. 1b), enhancing the safety of its use and minimizing complications by the careful performance of the procedure. In fact, there were no complications following the procedures in this study. Of course, treatment with the alpha-replacer was not effective in a case with catheter obstruction due to omental wrapping, the management of which required surgery (Fig. 2, Table 1b, Supplementary Fig. 1).

Our study has several limitations. The sample size of cases treated with the alpha-replacer was small. Furthermore, since none of the cases of intraluminal catheter occlusion were treated with t-PA or u-PA before treatment with the alpha-replacer, it was impossible to compare therapeutic efficacy between t-PA or u-PA and the alpha-replacer. In addition, the use of the alpha-replacer might be limited by the fact that it is only available in Japan. Further, it is not clear whether the alpha-replacer can be used in patients in whom a titanium extender is used in the catheter diversion procedure for exit site renewal.

To summarize, we demonstrated that the alpha-replacer might be a useful and safe tool for the treatment of intraluminal catheter obstruction due to fibrin clots.

Compliance with ethical standards

Conflicts of interest None.

Ethical standards All procedures performed in this study were in accordance with the ethical standards of The Ethics Committee for Human Research of Aichi Medical University Hospital and Nagoya University Hospital (Nagoya, Japan) where the studies were conducted (Approval numbers: 2019-161 and 2005-0309, respectively), and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Since the data were anonymized, the requirement for informed consent was waived by our institutional ethics committee.

References

1. Moncrief JW, Popovich RP, Broadrick LJ, He ZZ, Simmons EE, Tate RA. ASAIO J. 1993;39:62–5.
2. Crabtree JH, Shrestha BM, Chow KM, Figueiredo AE, Povlsen JV, Wilkie M, et al. Creating and maintaining optimal peritoneal dialysis access in the adult patient: 2019 update. Perit Dial Int. 2019;39:414–36.
3. Dasgupta MK. Moncrief-Popovich catheter and implantation technique: the AV fistula of peritoneal dialysis. Adv Ren Replace Ther. 2002;9:116–24.
4. Caruso DM, Gray DL, Kohr JM, Rodgers LL, Weiland DE, VanderWerf BA. Reduction of infectious complications and costs using temporary subcutaneous implantation of PD catheters. Adv Perit Dial. 1997;13:183–9.
5. Gokal R, Alexander S, Ash S, Chen TW, Danielson A, Holmes C, et al. Peritoneal catheters and exit-site practices toward optimum peritoneal access: 1998 update. Perit Dial Int. 1998;18:11–33.
6. Ogunc G. Malfunctioning peritoneal dialysis catheter and accompanying surgical pathology repaired by laparoscopic surgery. Perit Dial Int. 2002;22:454–62.
7. Zorzanello MM, Fleming WJ, Prowant BE. Use of tissue plasminogen activator in peritoneal dialysis catheters: a literature review and one center's experience. Nephrol Nurs J. 2004;31:534–7.
8. Stadermann MB, Rusthoven E, van de Kar NC, Hendriksen A. Local fibrinolytic therapy with urokinase for peritoneal dialysis catheter obstruction in children. Perit Dial Int. 2002;22:84–6.
9. Sinha S, Fok M, Davenport A, Banga N, Lindsey B, Fernando B, et al. Use of the embedded peritoneal dialysis catheter. Ann R Coll Surg Engl. 2018;100:534–44.
10. Terawaki H, Nakayama M, Nakano H, Hasegawa T, Ogura M, Hosoya T, et al. Transluminal replacement of displaced peritoneal catheter using a special "alpha-replacer" guidewire: effectiveness and limitations. Perit Dial Int. 2007;27:702–6.
11. Brum S, Anabela A, Rocha S, Carvalho MJ, Nogueira C, Magalhães C, et al. Moncrief-Popovich technique is an advantageous method of peritoneal dialysis catheter implantation. Nephrol Dial Transplant. 2010;25:3070–5.
12. Flessner MF, Credit K, Richardson K, Potter R, Li X, He Z, et al. Peritoneal inflammation after 20-week exposure to dialysis solution: effect of solution versus catheter-foreign body reaction. Perit Dial Int. 2010;30:284–93.
13. Sloand JA, Shelly MA, Brien JM, Schiff MJ, Dhakal MP. Success of prolonged hibernation of subcutaneously-placed peritoneal dialysis catheters. Perit Dial Int. 2001;21:617–9.
14. Junejo K, Jeboda F, Chawdhery MZ, Stoby-Field M, Fan SL. Use of embedded peritoneal dialysis catheters – a UK perspective and a single center's experience. Perit Dial Int. 2008;28:305–8.
15. Shea M, Hmiel SP, Beck AM. Use of tissue plasminogen activator for thrombolysis in occluded peritoneal dialysis catheters in children. Adv Perit Dial. 2001;17:249–52.
16. Sahani MM, Mukhtar KN, Boorgu R, Leehey DJ, Popli S, Ing TS. Tissue plasminogen activator can effectively declot peritoneal dialysis catheters. Am J Kidney Dis. 2000;36:675.
17. Sakarcan A, Stallworth JR. Tissue plasminogen activator for occluded peritoneal dialysis catheter. Pedatr Nephrol. 2002;17:155–6.
18. Krishnan RG, Moghal NE. Tissue plasminogen activator for blocked peritoneal dialysis catheters. Pediatr Nephrol. 2006;21:300.
19. Kawabata C, Kinugasa S, Kamijo Y, Iida H, Saito K, Furutera R, et al. Peritoneal inflammation after twenty-week exposure to dialysis solution: effect of the solution versus catheter-foreign body reaction. Perit Dial Int. 2015;35:101–3.
20. Miller M, McCormick B, Lavoie S, Biyani M, Zimmerman D. Fluoroscopic manipulation of peritoneal dialysis catheters: outcomes and factors associated with successful manipulation. Clin J Am Soc Nephrol. 2012;7:795–800.
21. Matsui K, Tsuzuku Y, Funaki T, Kubota M. Peritoneal dialysis catheter obstruction caused by fimbriae of the fallopian tube: six case reports. J Jap Soc Dial Therapy. 2014;47:576–94 ((**in Japanese**)).
22. Dittrich E, Puttinger H, Schillinger M, Lang I, Stefenelli T, Hörl WH, et al. Effect of radio contrast media on residual renal function in peritoneal dialysis patients-a prospective study. Nephrol Dial Transplant. 2006;21:1334–9.
23. Moranne O, Willoteaux S, Pagniez D, Dequiedt P, Boulanger E. Effect of iodinated contrast agents on residual renal function in PD patients. Nephrol Dial Transplant. 2006;21:1040–5.

24. Gadallah MF, Arora N, Arumugam R, Moles K. Role of Fogarty catheter manipulation in management of migrated, nonfunctional peritoneal dialysis catheters. Am J Kidney Dis. 2000;35:301–5.
25. Saka Y, Ito Y, Iida Y, Maruyama S, Matsuo S. Efficacy and safety of fluoroscopic manipulation using the alpha-replacer for peritoneal catheter malposition. Clin Exp Nephrol. 2015;19:521–6.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Affiliations

Akimasa Asai[1] · Hiroshi Kinashi[1] · Yasuhiro Suzuki[2] · Hiroshi Kojima[2] · Yuka Sato[2] · Naoya Matsuoka[1] · Nao Asai[1] · Yuki Kuroyanagi[1] · Makoto Yamaguchi[1] · Hironobu Nobata[1] · Takayuki Katsuno[1] · Takuji Ishimoto[2] · Masashi Mizuno[2] · Yasuhiko Ito[1]

Akimasa Asai
asai.akimasa.002@mail.aichi-med-u.ac.jp

Hiroshi Kinashi
kinashi.hiroshi.909@mail.aichi-med-u.ac.jp

Yasuhiro Suzuki
suzuki11@med.nagoya-u.ac.jp

Hiroshi Kojima
kojima14@med.nagoya-u.ac.jp

Yuka Sato
soba15@med.nagoya-u.ac.jp

Naoya Matsuoka
matsuoka.naoya.029@mail.aichi-med-u.ac.jp

Nao Asai
mizutani.nao.996@mail.aichi-med-u.ac.jp

Yuki Kuroyanagi
inoue.yuki.186@mail.aichi-med-u.ac.jp

Makoto Yamaguchi
yamaguchi.makoto.231@mail.aichi-med-u.ac.jp

Hironobu Nobata
nobata@aichi-med-u.ac.jp

Takayuki Katsuno
t-katsuno@aichi-med-u.ac.jp

Takuji Ishimoto
i-takuji@med.nagoya-u.ac.jp

Masashi Mizuno
mmizu@med.nagoya-u.ac.jp

[1] Department of Nephrology and Rheumatology, Aichi Medical University, 1-1 Karimata, Yazako, Nagakute City, Aichi Prefecture 480-1195, Japan

[2] Department of Renal Replacement Therapy and Nephrology, Nagoya University Graduate School of Medicine, Nagoya, Japan

Clinical & Experimental Nephrology is a copyright of Springer, 2021. All Rights Reserved.