SIMULTANEOUS CATHETER REPLACEMENT FOR INFECTIOUS AND MECHANICAL COMPLICATIONS WITHOUT INTERRUPTION OF PERITONEAL DIALYSIS

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◆ **Background:** Conventional management for peritoneal dialysis (PD)-related infectious and mechanical complications that fails treatment includes catheter removal and hemodialysis (HD) via a central venous catheter with the end result that the majority of patients will not return to PD. Simultaneous catheter replacement (SCR) can retain patients on PD by avoiding the scenario of staged removal and reinsertion of catheters. The aim of this study was to evaluate a protocol for SCR without interruption of PD.

◆ **Methods:** Clinical outcomes were analyzed for 55 consecutive SCRs performed from 2002 through 2012 and followed through 2013.

◆ **Results:** Simultaneous catheter replacements were performed for 28 cases of relapsing peritonitis, 12 cases of tunnel infection, and 15 cases of mechanical catheter complications. All cases for peritonitis and tunnel infection and 80% for mechanical complications continued PD on the day of surgery using a low-volume, intermittent automated PD protocol. Systemic antibiotics were continued for 2 weeks postoperatively (up to 4 weeks for *Pseudomonas*). Simultaneous catheter replacement was performed as an outpatient procedure in 89.1% of cases. Only 1 of 55 procedures was complicated by peritonitis within 8 weeks. No catheter losses occurred during this postoperative timeframe. Long-term, SCR enabled a median technique survival of 5.1 years.

◆ **Conclusions:** In most instances, SCR can be safely performed without interruption of PD for selected cases of peritonitis and tunnel infection and for mechanical catheter complications. The procedure spares the patient from a central venous catheter, a shift to HD, the psychological ordeal of a change in dialysis modality, and a second surgery to insert a new catheter.

if patients desire to return to this modality, re-implantation of a new PD catheter after an interval period. This staged approach significantly increases the cost of care as well as exposing patients to the complications associated with central venous catheters. Moreover, once on HD, the majority of patients will not return to PD.

Simultaneous catheter replacement (SCR) with good results has been previously described for selected cases of peritonitis and exit-site/tunnel infections (1, 2). In addition, it has been used for mechanical complications, e.g., flow failure, pericatheter leaks, and irreparable tubing damage (3). Often, PD was continued after the catheter exchange procedure without temporary HD, but the practices were incompletely described (4–7). On occasion, management included temporary HD with a central venous catheter while waiting for surgical wounds to heal sufficiently to prevent dialysate leakage.

The present study examines the clinical outcomes of a treatment protocol implemented at the authors' institution which allowed simultaneous catheter insertion and removal for infectious and mechanical complications without interruption of PD in most cases. Details of the catheter replacement technique, postoperative dialysis routine, and perioperative antibiotic management are presented.

MATERIALS AND METHODS

The study population was comprised of all patients undergoing simultaneous catheter insertion and removal for infectious and mechanical complications from July 2002 through December 2012 and followed through December 2013. Peritoneal dialysis infection data, surgical interventions, and patient outcomes were recorded prospectively in an Institutional Review Board-approved database.

Several PD catheter types were used during this experience to provide a customized access based upon the patient's body habitus and included coiled-tip, 2-cuff Tenckhoff catheters with or without a preformed intercuff bend and 2-piece extended catheters for remote exit-site locations to the upper abdomen or chest. Regardless of the catheter configuration, insertion of the abdominal portion was performed by the same technique using a laparoscopic approach previously described in detail (8).

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KEY WORDS: Peritoneal dialysis; simultaneous catheter replacement; relapsing peritonitis; tunnel infection; peritoneal catheter complications; technique survival.

Conventional management for peritoneal dialysis (PD)-related infections that fails antibiotic treatment is catheter removal, hemodialysis (HD) via a central venous catheter, and,

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After initiation of PD, patients were normally evaluated on a monthly basis in the clinic and immediately in the event of an acute problem. Exit-site infections were diagnosed if signs of redness and purulent discharge were present (9). Tunnel infection included induration or redness over the subcutaneous course of the catheter associated with tenderness and pain, with or without abscess formation (9). Patients were considered candidates for SCR for exit-site and tunnel infections if there was a failure to respond within 2 – 4 weeks to a treatment program that included appropriate antibiotic therapy and intensified exit-wound care.

Peritonitis was defined clinically as abdominal pain and a cloudy dialysate yielding a leukocyte count greater than 100/ μ L with greater than 50 percent polymorphonuclear cells (9). Removal of peritoneal catheters for refractory peritonitis was performed if no improvement was noted within 5 days of starting appropriate antibiotic treatment. Patients were considered as candidates for simultaneous catheter insertion and removal for relapsing episodes of peritonitis if antibiotic treatment resolved clinical signs of infection, the dialysate leukocyte count was < 100/ μ L, and the infecting organisms were not mycobacteria, fungi, enteric, or *Pseudomonas* species in origin. Relapsing peritonitis was defined as an episode that occurred within 4 weeks of completion of therapy of a prior episode with the same organism.

Candidates for SCR for infectious complications were kept on antibiotic therapy until the procedure could be performed and continued for 2 weeks following the procedure and for as long as 3 to 4 weeks for *Pseudomonas* tunnel infection. Postoperatively, SCRs performed for peritonitis received intravenous antibiotics at the outpatient infusion center. Intraperitoneal antibiotics were not used during the postoperative period.

Catheter replacement for mechanical complications was performed for persistent pericatheter leak, irreparable tubing damage, and for mechanical flow dysfunction when the manner of previous catheter insertion was found unacceptable to justify any attempt at revision.

The catheter insertion and removal procedure was performed under general anesthesia. The replacement catheter was implanted laparoscopically on the abdominal side opposite of the catheter being removed. In the absence of mechanical obstruction, the existing catheter was used to insufflate the abdomen to create the pneumoperitoneum. The catheter transfer set was directed off the side of the operating room table so that the circulating nurse had access to the twist clamp connection to the insufflation tubing. The PD catheter exit site and catheter tubing out to its junction with the transfer set were included in the skin preparation but excluded from the primary operative field by sterile towels and an iodine impregnated plastic adhesive skin barrier. A 5 mm port for the laparoscope was placed in a pararectus location close to the costal margin so that when the pneumoperitoneum was released at the end of the procedure, the puncture wound ended up above the costal margin, thereby minimizing the risk of postoperative dialysate leak. Using the catheter to create the pneumoperitoneum invariably resulted in reduced visibility

from bubbling of residual peritoneal fluid by gas insufflation through the submerged catheter tip. Therefore, insufflation of the abdomen was continued by attaching a second insufflation hose to the laparoscopic port after the circulating nurse closed the old catheter's transfer set twist clamp connection to the first insufflation tubing.

The new catheter (clean step) was inserted before removal of the old catheter (dirty step). Since the procedure was performed under laparoscopic guidance and in order to reduce the risk of contamination, an irrigation test of the new catheter was not performed in the presence of the old catheter. An absorbable purse-string suture was placed around the new catheter at the anterior rectus sheath to reduce the risk of pericatheter leak.

After insertion of the new catheter, incisions were closed and dressings applied. The drapes were then retracted sufficiently to remove the old catheter. If the catheter replacement procedure was being performed for chronic exit-site and tunnel infection, the old catheter insertion site was uncovered first, permitting removal of the intraperitoneal segment with transection of the tubing external to the deep Dacron cuff, watertight repair of the fascia, and closure of the skin incision before exposing the infected exit site and removing the remaining portion of the catheter. Depending on the severity of the exit-site and tunnel infection, the wound was debrided and left open or closed loosely with application of a saline wet-to-dry dressing.

On the evening of surgery, patients resumed dialysis with a protocol of low-volume automated PD (APD) using 1- to 1.2-L dialysate volumes with 10 cycles over 10 hours while remaining supine. During the daytime ambulatory periods, the abdomen was left dry. After 1 week, the dialysate volume was increased to 1.5 L. Patients returned to their normal dialysis regimen after the second week.

Continuous variables were expressed as mean $\pm$ SD and categorical data as count (%). Peritoneal dialysis catheter and technique survivals were estimated using the method of Kaplan and Meier, censoring all causes for loss except infectious and mechanical complications. Interim HD for > 30 days was considered PD technique failure. Comparison of survival curves was performed with the log-rank test. Analyses were performed with GraphPad Prism version 6.02 (GraphPad Software, San Diego, CA, USA). All results were considered significant at $p < 0.05$.

RESULTS

A total of 55 consecutive SCRs were performed on 49 patients during the study period. Study population demographics according to SCRs performed for peritonitis, tunnel infections, and mechanical complications are summarized in Table 1.

PERITONITIS

Twenty-six SCRs were performed on 22 patients following a median of 2 (interval: 1, 3) episodes of relapsing peritonitis. Two patients with concurrent tunnel infection underwent SCR

TABLE 1
Patient Demographics According to Indication for Simultaneous Catheter Replacement

	Peritonitis	Tunnel infection	Mechanical
Number of subjects	28	12	15
Age (years) (mean ± SD)	56.9±14.8	51.5±15.47	49.5±12.5
Male (%)	12 (42.9)	7 (58.3)	8 (53.3)
Body mass index (kg/m ²) (mean ± SD)	31.8±4.7	29.9±5.9	30.3±6.6
Diabetic (%)	18 (64.3)	4 (33.3)	7 (46.7)
Prior catheter duration (months) (mean ± SD)	29.3±16.8	31.8±20.2	21.3±30.8
Replacement catheter follow-up (months) (mean ± SD)	22.7±18.7	25.9±14.8	24.8±21.4
Total replacement catheter follow-up (months)	636.1	310.4	372.3
Replacement catheter type			
Tenckhoff (%)	6 (21.4)	8 (66.7)	8 (53.3)
2-piece upper abdominal (%)	18 (64.3)	3 (25)	7 (46.7)
2-piece upper chest (%)	4 (14.3)	1 (8.3)	0 (0)
Replacement as outpatient procedure (%)	26 (92.9)	10 (83.3)	13 (86.7)
Uninterrupted peritoneal dialysis (%)	28 (100)	12 (100)	12 (80)

SD = standard deviation.

following the first episode of peritonitis caused by a different organism. Organisms leading to SCR for peritonitis are listed in Table 2. At the time of SCR, patients were asymptomatic with a mean peritoneal cell count of 9.6 ± 10.4 leukocytes/ μL (interval: 0, 33). From the time of onset of the peritonitis episode leading to SCR, patients were on antibiotics for a mean of 23.6 ± 13.1 days (interval: 5, 55) until the procedure was performed. Prolonged antibiotic therapy was mostly due to operating room access issues and patient indecision.

All patients resumed PD on the evening of surgery using the intermittent recumbent low-volume APD protocol. Only 1 patient experienced a pericatheter leak after sitting up at the bedside during the first postoperative night. This resolved with the patient remaining recumbent during subsequent dialysis sessions.

During the 8 weeks following SCR, amounting to a 6-week period beyond completion of antibiotic coverage, there were no exit-site or wound infections, no episodes of relapsing peritonitis, and only a single case of successfully treated recurrent peritonitis by a different organism that occurred 3 weeks after the procedure.

TUNNEL INFECTIONS

Infecting organisms for the 12 cases of SCR performed for tunnel infections are listed in Table 2. From the time of onset of the tunnel infection until SCR, patients were on antibiotics for a mean of 26.2 ± 16.3 days (interval: 1, 54). All patients resumed PD on the evening following surgery using the intermittent recumbent low-volume APD procedure. Postoperative antibiotic coverage was continued for 2 to 4 weeks following the procedure, the longer timespan when *Pseudomonas* was the infecting organism. There were no instances of pericatheter or incisional leaks, exit-site or wound infections, or peritonitis during the 8 weeks following SCR.

TABLE 2
Micro-Organisms by Site of Infection-Related Indication for Simultaneous Catheter Replacement

Location of Infection	Organism	Patients (n)
Peritonitis		28
	Coagulase-negative <i>Staphylococcus</i>	24
	Coagulase-negative <i>Staphylococcus</i> (concurrent <i>Escherichia coli</i> tunnel infection)	1
	Coagulase-negative <i>Staphylococcus</i> (concurrent <i>Pseudomonas aeruginosa</i> tunnel infection)	1
	<i>Staphylococcus aureus</i>	1
	<i>Streptococcus viridans</i>	1
Tunnel infection		12
	<i>Pseudomonas aeruginosa</i>	6
	<i>Staphylococcus aureus</i> and <i>Pseudomonas aeruginosa</i>	1
	<i>Serratia marcescens</i>	1
	<i>Corynebacteria</i>	2
	<i>Mycobacterium chelonae-abscessus</i>	1
	No growth	1

MECHANICAL COMPLICATIONS

The indications for SCR for mechanical complications included 8 cases referred for technical errors in catheter placement, 3 instances of catheter damage too short to repair, 2 patients with flow obstruction from severe abdominopelvic adhesions, and 1 case each of persistent pericatheter leak and pericatheter hernia.

Twelve of the 15 patients (80%) resumed PD on the evening of surgery. Two patients were already on HD prior to the SCR procedure. One of these patients, electively transferring from HD to PD, experienced a persistent leak after the first catheter insertion and continued HD by way of an existing arteriovenous fistula following SCR. The second patient received HD by a central venous catheter while recovering from open abdominal hysterectomy. The patient's catheter was not irrigated postoperatively and SCR was required for catheter obstruction from severe abdominopelvic adhesions. She continued on HD during the convalescent period following SCR. A third patient, undergoing SCR and repair of a large pericatheter hernia, was noted to have a leak from the exit site and surgical incision while still in the recovery room. A non-cuffed HD catheter was utilized for 1 week before successfully commencing intermittent low-volume APD.

With exception of the 2 patients with leaks, those undergoing SCR for mechanical complications received only a single preoperative dose of antibiotics for antistaphylococcal coverage. Postoperatively, there were no instances of exit-site or wound infection or peritonitis during the first 8 weeks.

CATHETER AND TECHNIQUE SURVIVAL

Catheter survival time until loss from peritonitis, tunnel infection, and mechanical complications was significantly better for replacement catheters than former catheters (Figure 1). The replacement catheters fared significantly better even when the survival analysis was limited to comparing times until loss from any infection ($p = 0.013$), from peritonitis alone ($p = 0.048$), or from mechanical complications alone ($p = 0.01$) (data not shown).

Simultaneous catheter replacement enabled the majority of patients to successfully continue PD uninterrupted, thereby preserving this technique as their mode of renal replacement therapy. Six of the 49 patients benefitted from 2 catheter replacement procedures. Excluding the 2 patients who were already on HD for over 30 days prior to catheter replacement, technique survival for the 47 patients who profited from SCR is shown in Figure 2. Simultaneous catheter replacement enabled a significant increase in median technique survival time from 1.9 years to 5.1 years.

DISCUSSION

The 55 SCR procedures reported herein were 100% successful from the standpoint that there were no catheter losses from infectious or mechanical complications during the first 8 weeks, representing a 6-week period beyond any antibiotic exposure for infectious indications (4 weeks for catheter replacement for *Pseudomonas* tunnel infections). In a previously published review of 20 studies, the overall success of SCR was 93% for exit-site and tunnel infections and 86% for peritonitis with or without concurrent exit-site/tunnel infection (2).

Figure 1 — Survival time until catheter loss from infectious and mechanical complications for replacement and prior catheters were significantly different: log-rank test $\chi^2 = 12.02$, $df=1$, $p = 0.0005$.

Figure 2 — Technique survival was significantly improved with the use of simultaneous catheter replacement. Log-rank test $\chi^2 = 35.91$, $df=1$, $p < 0.0001$.

The success of SCR relies upon proper patient selection and technical performance of the procedure. Although previously published experiences vary in the details of application and conduct of the procedure, general guidelines of performance that promote a positive outcome can be recognized (Table 3). The present report describes how we filled in the specifics of these procedural steps.

The International Society for Peritoneal Dialysis (ISPD) guidelines for PD-related infections do not address the optimal duration of antibiotic coverage following SCR (9). Previous studies have described postoperative antibiotic coverage for 3–5 days (4,10), 1 week (5,11,12), 2 weeks or more (13), or omitted mentioning it altogether (6,7). Using the Centers for Disease Control and Prevention's classification of surgical wounds, we categorized SCR for peritonitis and tunnel infections as Class IV cases consisting of an existing infection with organisms present before the procedure (14). Typically,

TABLE 3

General Guidelines for Simultaneous Catheter Replacement

- Procedure acceptable for peritonitis not due to mycobacteria, fungi, enteric organisms, or *Pseudomonas* species.
- Procedure acceptable for bacterial exit-site and tunnel infections.
- Clinical signs of peritonitis must be resolved and peritoneal leukocyte count is $<100/\mu\text{L}$.
- Continue appropriate antibiotic coverage perioperatively.
- Insert new catheter (clean step) before removal of old catheter (dirty step).
- Close watertight all penetrating points through musculofascial layers of abdominal wall.
- Utilize intermittent regimen of supine, low-volume peritoneal dialysis during interval of postoperative recovery; leave peritoneum dry during ambulatory periods.

in Class IV cases that have been treated with proper control of the infection source, antibiotic therapy is given for 5 to 7 days, but may be extended depending on the clinical situation (15). Because of patient characteristics that increase infection risk (age, diabetes, obesity, new foreign body in the surgical wound), we chose to provide a period of antibiotic coverage identical to the ISPD guidelines for treatment of initial peritonitis and tunnel infections (9). Certainly, appropriate duration of antimicrobial therapy following SCR requires further study.

Results appear comparable whether the new catheter is placed before removal of the old catheter (7,13) or vice versa (5,11,12). However, in addition to respecting sound surgical principles by performing the clean step before the dirty step, the inefficiencies and extra costs of reprepping and draping, switching surgical instruments, and rescrubbing and gowning when the dirty part is performed first can be avoided. The important technical point to prevent cross-contamination of wounds is to adequately isolate the old catheter from the primary surgical field while implanting the new catheter.

Peritoneal dialysis catheters can be used immediately following SCR if care is taken to create a watertight seal at the insertion site and at any other points of abdominal wall penetration. Although no standard dialysis prescription exists for immediate resumption of PD, a low volume, supine, intermittent PD protocol to minimize the risk of leak was used in most studies (5,7,10,12,13). The use of a cycler in this clinical setting is particularly convenient. Since 85 to 90% of our patients were already on APD during the timeframe of this study, it was a simple task for the PD nursing staff to assist patients in reprogramming their cyclers for the postoperative protocol. To minimize low-drain alarms in our mostly obese patient population, starting volumes of 1 – 1.2 L were used. Because most patients had residual renal function, no problems with inadequate dialysis were encountered using our intermittent APD protocol over the short term. Similar to practices followed by others, our patients resumed their usual dialysis regimen after 2 weeks (7,10,12).

Replacement catheters had significantly better survival than former catheters. The improved survival may be attributable

to our program of patient retraining and home inspection following infectious complications. In addition, patients may be better motivated to follow proper technique having endured the hardships of infection and catheter replacement.

Following catheter removal for infectious and mechanical complications with transfer to HD, only 18 – 45% of patients will return to PD (6,10,16). Therefore, SCR becomes an important strategy for retaining patients on PD therapy. In the present report, patients undergoing SCR had a median technique survival of 5.1 years, a better outcome than the 2.1 – 2.7 years median technique survival described for general PD populations (17–19).

In conclusion, SCR can be safely performed without interruption of PD for selected cases of peritonitis and tunnel infection and for mechanical catheter complications. The procedure spares the patient from a central venous catheter, a shift to HD, the ordeal of a change in dialysis modality, and a second surgery to insert a new catheter. Technique survival is improved.

DISCLOSURES

JHC has served as a consultant for MedComp, Inc. and Baxter Healthcare and as a member of the speakers' bureau for Baxter Home Therapies Institute, DaVita Healthcare Partners, and Fresenius Medical Care Advanced Renal Education Program. RAS has no financial conflicts of interest to declare.

REFERENCES

1. Singhal MK, Vas SI, Oreopoulos DG. Treatment of peritoneal dialysis catheter-related infections by simultaneous catheter removal and replacement. Is it safe? *Perit Dial Int* 1998; 18:565–7.
2. Mitra A, Teitelbaum I. Is it safe to simultaneously remove and replace infected peritoneal dialysis catheters? Review of the literature and suggested guidelines. *Adv Perit Dial* 2003; 19:255–9.
3. Swartz RD, Messana JM. Simultaneous catheter removal and replacement in peritoneal dialysis infections: update and current recommendations. *Adv Perit Dial* 1999; 15:205–8.
4. Fredensborg BB, Meyer HW, Joffe P, Fugleberg S. Reinsertion of PD catheters during infections performed either simultaneously or after an intervening period. *Perit Dial Int* 1995; 15:374–8.
5. Paterson AD, Bishop MC, Morgan AG, Burden RP. Removal and replacement of Tenckhoff catheter at a single operation: successful treatment of resistant peritonitis in continuous ambulatory peritoneal dialysis. *Lancet* 1986; 2:1245–7.
6. Swartz R, Messana J, Reynolds J, Ranjit U. Simultaneous catheter replacement and removal in refractory peritoneal dialysis infections. *Kidney Int* 1991; 40:1160–5.
7. Cancarini GC, Manili L, Brunori G, Camerini C, Zubani R, Colombrita D, et al. Simultaneous catheter replacement-removal during infectious complications in peritoneal dialysis. *Adv Perit Dial* 1994; 10:210–3.
8. Crabtree JH, Burchette RJ. Effective use of laparoscopy for long-term peritoneal dialysis access. *Am J Surg* 2009; 198:135–41.
9. Li PK, Szeto CC, Piraino B, Bernardini J, Figueiredo AE, Gupta A, et al. Peritoneal dialysis-related infections recommendations: 2010 update. *Perit Dial Int* 2010; 30:393–423.
10. Majkowski NL, Mendley SR. Simultaneous removal and replacement of infected peritoneal dialysis catheters. *Am J Kidney Dis* 1997; 29:706–11.
11. Ludlam HA, Young AE, Wing AJ. Removal and replacement of Tenckhoff catheter at single operation. *Lancet* 1989; 1:1028.
12. Lui SL, Yip T, Tse KC, Lam MF, Lai KN, Lo WK. Treatment of refractory

- Pseudomonas aeruginosa* exit-site infection by simultaneous removal and reinsertion of peritoneal dialysis catheter. *Perit Dial Int* 2005; 25:560–3.
13. Posthuma N, Borgstein PJ, Eijssbouts Q, ter Wee PM. Simultaneous peritoneal dialysis catheter insertion and removal in catheter-related infections without interruption of peritoneal dialysis. *Nephrol Dial Transplant* 1998; 13:700–3.
 14. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control* 1999; 27:97–132.
 15. Blot S, De Waele JJ. Critical issues in the clinical management of complicated intra-abdominal infections. *Drugs* 2005; 65:1611–20.
 16. Cho Y, Badve SV, Hawley CM, McDonald SP, Brown FG, Boudville N, *et al.* Peritoneal dialysis outcomes after temporary haemodialysis transfer for peritonitis. *Nephrol Dial Transplant* 2014; 29:1940–7.
 17. Tangri N, Ansell D, Naimark D. Predicting technique survival in peritoneal dialysis patients: comparing artificial neural networks and logistic regression. *Nephrol Dial Transplant* 2008; 23:2972–81.
 18. Shen JI, Mitani AA, Saxena AB, Goldstein BA, Winkelmayer WC. Determinants of peritoneal dialysis technique failure in incident US patients. *Perit Dial Int* 2013; 33:155–66.
 19. Kumar VA, Sidell MA, Yang WT, Jones JP. Predictors of peritonitis, hospital days, and technique survival for peritoneal dialysis patients in a managed care setting. *Perit Dial Int* 2014; 34:171–8.