Management of Bacteremia Associated with Tunneled-Cuffed Hemodialysis Catheters

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Abstract. The dominant problem associated with the use of tunneled-cuffed catheters is infection. When this occurs, two issues must be addressed: treatment of the infection and management of the catheter. The purpose of this 2-yr study was to report the results of a prospective observational series in which catheter management was based on the clinical picture presented by the patient. Data were collected on patients with catheter-related bacteremia (CRB) dealt with in one of three ways: (*1*) minimal symptoms with a normal-appearing tunnel and exit site (exchange over guidewire within 48 h of antibiotic initiation [Xchng group], 49 cases); (*2*) minimal symptoms but with tunnel or exit site infection (exchange over a guidewire with creation of a new tunnel [Nutunl group], 28 cases); and (*3*) severe clinical symptoms (catheter removal with delayed replacement after defervescence [Delay group], 37 cases). All cases were treated immediately with empiric antibiotics followed by 3 wk of antibiotic therapy based on culture sensitivities. A cure was defined as a 45-d symptom-free interval after antibiotic therapy was complete. A cure rate total of 87.8% for the Xchng group, 75% for the Nutunl group, and 86.5% for the Delay group was seen for the 114 episodes of CRB. It is concluded that in selected patients, catheter exchange over a guidewire within 48 h of antibiotic initiation followed by 3 wk of specific antibiotic therapy is a viable treatment option. Additionally, replacing the catheter in patients presenting with severe symptoms of sepsis as soon as they have defervesced is a reasonable approach to therapy.

Since their introduction in the 1980s (1–3), tunneled-cuffed catheters have come to play an increasingly important role in the delivery of hemodialysis. Data collected by the United States Renal Data System indicates that in 1997, 18.9% of all new hemodialysis patients were being dialyzed with a tunneled-cuffed catheter 60 d after starting dialysis (4).

The use of a catheter to deliver hemodialysis treatment has been associated with major problems. Catheter malfunction, secondary to thrombosis or malposition of the catheter, and catheter-related infections are common occurrences. Suhocki *et al.* (5) reported a malfunction rate of 87% in a series of 121 catheter insertions. The mean time from catheter insertion to the first malfunction was 2.8 mo. Infection rates ranging from 14 to 54% have been reported (5–8). Secondary systemic complications of catheter-related bacteremia (CRB) such as septic arthritis, endocarditis, and epidural abscess can have dire consequences (9). When a hemodialysis patient presents with CRB, there are two issues that must be addressed. First, the infection must be treated appropriately with antibiotics. Second, the issue of what to do with the catheter must be addressed.

The purpose of this study is to report the results of a prospective observational series in which catheter management was based on the clinical picture presented by the patient. Uncomplicated CRB with minimal symptoms was treated by exchanging the catheter over a guidewire. Patients with exit site or tunnel infections were treated by catheter exchange and the creation of a new exit site and tunnel. Patients with severe symptoms were treated by catheter removal and delayed replacement. Each of these approaches to catheter management was combined with prolonged antibiotic therapy.

Materials and Methods

Study Design

All patients receiving chronic hemodialysis treatment via a tunneled-cuffed catheter during the 2-yr period of January 1, 1996, through December 31, 1997, were observed for evidence of suspected CRB. All patients with CRB were included in this study except for those with an identifiable source other than the catheter. Patients with CRB were initially divided into three treatment categories based on their clinical picture. Each of these three categories was treated in a different manner.

Clinical Categories and Treatment

Based on the judgment of the treating nephrologist, patients with CRB were initially divided into two categories: (*1*) patients with mild symptoms (some combination of chills, fever, nausea, malaise, back pain) and (*2*) patients with severe symptoms (some combination of rigors, high fever, hypotension, nausea, vomiting, and mental changes). In both groups of patients, initial management in the dialysis unit involved obtaining blood cultures and administering empiric antibiotic therapy consisting of a combination of vancomycin and either cefazolin or gentamicin at the discretion of the nephrologist providing primary care to that patient.

In patients with severe symptoms, the catheter was removed as soon as practical. If the patient was on dialysis or in the process of

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starting dialysis and his or her condition permitted, the treatment was generally completed before removal. Most of these patients required admission to the hospital. Replacement of the dialysis catheter was delayed until they had defervesced. During that period of time, vascular access was obtained via a temporary femoral catheter if necessary. In the group of patients with mild symptoms, the catheter was left in place and scheduled for exchange over a guidewire within the next 48 h, providing they had defervesced and the blood culture was positive (positive blood culture was required for inclusion). Upon arrival at the vascular laboratory, the patients with only mild symptoms were further divided into two categories: those with a normal exit site and catheter tunnel and those with evidence suggesting tunnel or exit site infection. An exit site infection was defined as some combination of erythema, swelling, tenderness, and purulent drainage surrounding the catheter exit and the portion of the tunnel external to the cuff. A tunnel infection was defined as some combination of swelling, erythema, fluctuance, and tenderness over the catheter tunnel central to the cuff.

In the group with a normal exit site and tunnel, the catheter was exchanged over a guidewire using the same exit site, tunnel, and central venous entry site as the catheter being removed. In those cases in which either exit site or tunnel infection was apparent, the catheter was exchanged over a guidewire to preserve the central venous entry site, and a new tunnel and exit site were created. These three separate groups of patients formed the basis of this study: (*1*) patients with catheter exchange over a guidewire only (Xchng group); (*2*) patients with catheter exchange over a guidewire plus the creation of a new tunnel and exit site (Nutunl group); and (*3*) those with catheter removal and delayed replacement (Delay group) (Table 1).

Catheter Exchange Procedure

All procedures were performed in a vascular laboratory established within a hospital operating room, equipped with fluoroscopy and ultrasound equipment. The laboratory was used only for hemodialysis vascular access procedures. All procedures except a portion of those done in the Delay group were performed as outpatient procedures. In performing the catheter exchange, the catheter and skin site were prepped with a povidone-iodine scrub and the site was draped in a sterile manner. Both ports of the catheter were opened, and 5 cc was aspirated from each and discarded to remove the heparin lock. The patient was then sedated with midazolam. Using fluoroscopic guidance, a guidewire was passed through the venous port and down into the inferior vena cava. The exit site was infiltrated with 1% lidocaine. The Dacron cuff of the catheter was freed from the subcutaneous tissue via the tunnel using a pair of hemostats. All catheters were placed with their cuff within 2 cm of exit site so that it would be accessible in this manner to allow for ease of removal. The catheter was then extracted over the guidewire onto the patient's draped abdomen in such a manner as to not come into contact with the sterile surgical table being used for the catheter placement. The guidewire was wiped with povidone-iodine and then with sterile saline. The operator changed sterile gloves, and the new catheter was passed into place over the guidewire.

In those cases in which a new tunnel and exit site was created, the area over the venotomy site was infiltrated with 1% lidocaine. An incision was made so as to expose the catheter at that point. The catheter was lifted and transected. The peripheral end was removed and discarded. A guidewire was passed through the cut central segment of the catheter down into the inferior vena cava. This catheter segment was then removed onto the patient's draped abdomen in such a manner as to not come into contact with the sterile surgical table being used for the catheter placement. The guidewire was wiped with povidone-iodine and then with sterile saline. The operator changed sterile gloves and proceeded to create a new exit site and to tunnel the new catheter up to the previously opened venotomy site. The new catheter was then passed through a peal-away sheath into the central vein.

Definition of Treatment Results

In all patients, specific antimicrobial therapy was based on culture sensitivities and was continued for 3 wk. A repeat blood culture was obtained 7 to 10 d after completion of the course of antibiotics in most cases. Any bacteremia involving the original organism that occurred within 45 d of initial treatment was considered a treatment failure. If the patient died, the catheter was removed for an unrelated reason before the end of the 45-d period, or if the recurrence of infection was with a different organism than the previous infection, the results were classified as indeterminate. Cures were classified as either a culture-based cure, if the patient had a negative blood culture at least 1 wk after antibiotic therapy was complete in addition to the 45-d symptom free interval, or a clinically based cure if a culture was not obtained and the definition was based only on the 45-d symptom-free interval. If one of these criteria was not met, the case was classified as a treatment failure.

Statistical Analyses

A statistical comparison of the results obtained in the three groups was made using the χ^2 test (Web χ^2 Calculator, Georgetown University, Washington, DC). Comparisons were made between all three groups combined, the Xchng group *versus* the Nutunl group, the Xchng group *versus* the Delay group, and the Nutunl group *versus* the Delay group. In all instances, $P \leq 0.05$ was used to determine statistical significance.

Results

During the 2-yr period from January 1, 1996, to December 31, 1997, data were collected on all patients in whom a

Table 1. Patient groups[a]

Group	*n*	Symptoms	Exit Site	Treatment
Xchng	49	Mild	Normal	Antibiotics for 3 wk, catheter exchange
Nutunl	28	Mild	Infected	Antibiotics for 3 wk, catheter exchange, new tunnel and exit site
Delay	37	Severe	NA[b]	Antibiotics for 3 wk, remove catheter, delay replacement

[a] Xchng, catheter exchange over guidewire; Nutunl, catheter exchange over guidewire with a new tunnel and exit site; Delay, delayed catheter replacement.

[b] The character of the exit site did not influence this group.

tunneled-cuffed hemodialysis catheter was placed in a population of approximately 750 hemodialysis patients. During this period, a total of 827 catheters were placed in 387 patients. Of these catheters, 352 were new catheter insertions in patients that did not have a catheter at the time and 475 were replacements for catheters that were being removed for some existing problem. Catheters used included Soft-Cell (Vas-cath, Ontario, Canada), Circle-C (Neostar, Atlanta, GA), and PermCath (Quinton, Seattle, WA). The specific catheter used did not appear to exert an effect on any aspect of the study. Tunneled-cuffed catheters were used for a total of 36,403 d during the 2-yr period of the study. The indications for new catheter placement were: new patient with no vascular access, 53%; vascular access failure, 44%; and complication of peritoneal dialysis, 3%. The indications for catheter exchange were: catheter thrombosis, 60%; infection, 25.2%; inadvertent loss of catheter (including cuff extrusion), 7.5%; defective catheter requiring removal, 2.2%; exit site infection (without bacteremia), 1.8%; and miscellaneous, 3%. All cases of catheter thrombosis were exchanged.

CRB was seen in 67 (19%) of the 352 new catheter insertions. The interval from catheter insertion to infection was a mean of 62 d (range, 2 to 250). CRB occurred in 56 (11.7%) of the 475 catheter replacements after a mean time from insertion of 72 d (range, 2 to 435). Combining the two, 123 episodes of CRB were observed in 95 patients. The overall incidence of infection was 3.4 per 1000 catheter days (1.23 per catheter year) for the 2 yr of the study. The incidence was 4.7 per 1000 catheter days during the first year of the study and 1.6 per 1000 catheter days during the second year. This was attributed to changes that were made in the protocol for catheter management in the dialysis facility. The ages of these 95 patients represented a mean of 53.8 with a range of 20 to 90 yr. The etiology of their chronic renal failure was: diabetes mellitus, 48%; hypertension, 18%; glomerulonephritis, 15%; lupus erythematosus, 4%; HIV infection, 3%; pyelonephritis, 1%; and unknown, 11%. Neither age nor primary disease differed significantly from that of the total population of patients cared for at our hemodialysis facility.

Of the 123 episodes of CRB observed in these patients, 49 were treated by catheter exchange over a guidewire only (Xchng group), 28 were treated by catheter exchange over a guidewire with the creation of a new tunnel and exit site (Nutunl group), 37 were treated by delayed replacement (Delay group), and in nine patients the catheter was no longer needed and was not replaced. These nine patients were not included in any further analysis, leaving 114 cases that formed the basis of this study. Twenty-six of the patients in the Delay group had a normal-appearing exit site. In other words, only 39 of the 123 cases had exit site problems, and the other 84 showed no external evidence or suggestion of infection of their catheter. The duration of delay from the time the old catheter was removed until the new one was inserted in the Delay group was a mean of 3.4 d (range, −2 to 12).

The treatment results obtained in the three clinical groups are shown in Table 2. It should be noted that in 10 cases, the results were classified as indeterminate (Table 3). Although a comparison of the results noted between the three groups show numerical differences, these differences were not significant ($P = 0.10$) when evaluated using the χ^2 test. Likewise, comparisons between the Xchng group *versus* the Delay group, and the Nutunl group *versus* the Delay group revealed that the observed differences were not statistically significant ($P = 0.20$ and 1.0, respectively). The differences in results noted between the Xchng group and the Nutunl group were significant ($P = 0.025$).

A review of the cultures obtained in these 123 patients with CRB (Table 4) revealed that 104 cases (84.5%) had Gram-positive cocci, 41 (33.3%) had a Gram-negative organism, and two (1.6%) had an acid-fast organism. Because of polymicrobial infections, this totaled more than 100%. This distribution could further be characterized as Gram-positive only in 87 cases (70.7%), Gram-negative only in 22 cases (17.9%), both Gram-negative and -positive in 12 cases (9.8%), and acid-fast only in two cases (1.6%). Polymicrobial infections were seen in 20 cases. Specific bacterial isolates by species are shown in Table 4. In all eight of the treatment failures, the character of the infection changed. In five cases, the infection became polymicrobial with the addition of a new organism to the previous one, and in three cases a polymicrobial infection reverted to only one of the original organisms.

Only four CRB systemic complications were seen in these 123 cases. One patient developed an epidural abscess and one patient developed septic arthritis. Both of these cases were in the Delay group. Endocarditis was seen in two cases. One of these was in the Delay group, the other was a patient with minimal symptoms in whom the catheter was removed and not replaced because it was no longer needed. In all instances of CRB systemic complications in the Delay group, the compli-

Table 2. Cure rates for clinical groups

Group	Culture Cure[a]	Clinical Cure[b]	Failure	Indeterminant[c]
Xchng ($n = 49$)	34 (69.4%)	9 (18.4%)	0	6 (12.2%)
Nutunl ($n = 28$)	14 (50%)	7 (25%)	5 (17.8%)	2 (7.1%)
Delay ($n = 37$)	27 (73%)	5 (13.5%)	3 (8.1%)	2 (5.4%)

[a] Negative blood culture 7 to 10 d after antibiotic therapy complete, plus 45 d free of symptoms.
[b] Forty-five days free of symptoms.
[c] Infection with a new organism, death, or catheter removed before end of 45-d period for unrelated reason.

Table 3. Explanation of indeterminate group

Group	No. Indeterminate	Different Organism[a]	Catheter Removal[b]	Death[c]
Xchng	6	4	1	1
Nutunl	2	2		
Delay	2	1	1	

[a] Infection recurred within 45-d period, but with an organism different from the original.
[b] The catheter was removed during the 45-d period for unrelated reasons.
[c] Death was not related to catheter-related bacteremia.

Table 4. Microbiologic isolates from 123 episodes of catheter-related bacteremia

Organism	Isolates, *n* (%)
Gram-positive cocci	104 (84.5%)
Staphylococcus epidermidis	46
Staphylococcus aureus	37
Enterococcus faecalis	15
other group D enterococci	6
Gram-positive rods	2 (1.6%)
Corynebacterium species	4
Gram-negative rods	41 (33.3%)
Enterobacter cloacae	11
other Enterobacter species	2
Pseudomonas species	8
Acinetobacter baumanii	5
Citrobacter species	5
Serratia species	2
Klebsiella pneumoniae	4
Proteus mirabilis	1
Escherichia coli	1
Agrobacterium radiobacter	1
Alcaligenes species	1
Acid-fast organism	2 (1.6%)
Mycobacterium fortuitum	2

cation was discovered at the time the patient presented with the initial infection.

Discussion

When a hemodialysis patient presents with a tunneled-cuffed catheter and a positive blood culture, immediate and prolonged antibiotic treatment is essential. However, proper management of the catheter must also be addressed. There are several choices: leave the catheter in, change the catheter over a guidewire, change the catheter over a guidewire with a new tunnel and exit site, remove the catheter, and delay replacement until the infection has been treated. There are several issues that affect this choice.

The presence of a biofilm on the surface of the catheter may play an important role in CRB (10,11). Bacteria adhere and become embedded in the glycocalyx of the biofilm, making them more resistant to antibiotics than those floating in the circulation (11,12). Passerini *et al.* (11) demonstrated the presence of a biofilm on the surface of 100% of the central venous catheters removed from 26 intensive care unit patients. Some of these catheters had been in place for only 1 d. Bacteria were demonstrated within these biofilms in 88% of the cases. Intuitively and from a purely infectious disease viewpoint, it would seem that removal of the catheter until the infection has been treated might be the best choice (13,14).

In the dialysis patient, the issue is complicated by the fact that the patient must continue to receive dialysis treatments. Removal of the catheter creates a requirement for the use of temporary catheters and the risk of their associated complications. It mandates multiple procedures, a period of hospitalization, and increased costs. Additionally, removal of the catheter may be associated with a loss of the central venous entry site because of stenosis or thrombosis. When the indications for the use of dialysis catheters are examined, it becomes apparent that one of these devices may become necessary in any hemodialysis patient at some time during the course of their dialysis therapy. Unnecessary loss of a central venous site should be avoided if salvage of the site does not jeopardize the patient's health.

Saltissi and Macfarlane (15) suggested treating the patient with the catheter in place. However, in an attempt to do this, Marr *et al.* (16) observed a failure rate of 68% even with prolonged antimicrobial therapy. Their study indicates that this approach should not be considered as a therapeutic option.

Several studies have recommended treating infection associated with short-term, nontunneled central venous catheters by changing the catheter over a guidewire under antibiotic coverage (17–20). Carlisle *et al.* (21) demonstrated that bacteremia associated with a tunneled hemodialysis catheter in the absence of exit site or tunnel infection could be managed successfully by guidewire catheter exchange and antimicrobial coverage. Shaffer (22) demonstrated similar results in a small series of patients treated with guidewire catheter exchange, new tunnel creation, and antibiotic therapy.

In a study conducted by Robinson *et al.* (23), 23 hemodialysis patients with CRB who were treated with catheter exchange over a guidewire combined this with 3 wk of antibiotic therapy. These were patients with no evidence of tunnel infection who had defervesced within 48 h of beginning empiric antibiotic therapy. They defined technique failure as a repeat infection with any organism within 90 d of the catheter exchange. They reported a success rate of 82%. These results are comparable to those noted in the Xchng group of this study, although a different definition of treatment outcome was used.

Guidewire catheter exchange was not tested in cases of the type represented by the Delay group. Concern for the gravity of the situation presented by these patients prevented this alternative from being addressed. However, the result obtained does indicate that replacing the catheter as soon as the patient has defervesced is a reasonable approach to therapy. CRB systemic complications were seen in these cases, but they were present when the patient presented with the initial infection.

The fact that infection did not occur immediately after

surgery but was delayed for 62 d (mean) in new catheters and 72 d (mean) in replacement catheters suggests that the implantation procedure was not the cause of the CRB. The fact that 68.3% (84 cases) of the 123 patients showed no external evidence of infection, and both the tunnel and exit site were normal, suggest that the route of the infection was through the catheter lumen. These observations implicate the procedure used for catheter manipulation in the dialysis facility as the problem leading to the majority of these cases of CRB.

A statistical comparison of the three treatment groups is of limited value because both the patient and treatment selection were inherently different. However, comparisons of results do provide some interesting and potentially important insights. When the treatment results obtained in the three groups were compared, no significant difference was seen. The only statistically significant difference noted was when the Xchng group was compared with the Nutunl group. In this instance, the treatment results obtained in patients with a normal exit site and tunnel were superior to those of patients with an infected site.

In conclusion, the results obtained in this study indicate that in cases of CRB, basing catheter management on the clinical picture presented by the patient is a valid approach to therapy. In selected patients, it is possible to preserve potential venous sites for dialysis catheter placement without jeopardizing the success of the treatment of the infection. Additionally, replacing the catheter in patients with severe symptoms of septicemia as soon as defervescence has occurred is a reasonable approach to therapy.

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