# Comparison of Infectious Complications between Incident Hemodialysis and Peritoneal Dialysis Patients

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**The impact of dialysis modality on infection, especially early in the course of dialysis, has not been well studied. This study compared infection between hemodialysis (HD) and peritoneal dialysis (PD) from the start of dialysis and evaluated factors that have an impact on infection risk. In this observational cohort study, all incident dialysis patients ($n = 181$; HD 119 and PD 62) at a single center from 1999 to 2005 had data collected prospectively beginning day 1 of dialysis. Excluded were those with any previous ESRD therapy. Infection rates were evaluated using multivariate Poisson regression. Overall infection rates were similar (HD 0.77 *versus* PD 0.86/yr; $P = 0.24$). Only HD patients had bacteremia (0.16/yr), and only PD patients had peritonitis (0.24/yr). Bacteremia that occurred ≤90 d after start of HD was 0.44/yr, increased compared with overall rate of 0.16/yr ($P < 0.004$). HD catheters, used in 67% of patients who started HD, were associated with a strikingly increased rate of bacteremia. Peritonitis ≤90 d was 0.22/yr, no different from the overall rate. Modality was not an independent predictor of overall infections (PD *versus* HD: relative risk 1.30; 95% confidence interval 0.93 to 1.8; $P = 0.12$) using multivariate analysis. PD and HD patients had similar infection rates overall, but type of infection and risk over time varied. HD patients had an especially high risk for bacteremia in the first 90 d, whereas the risk for peritonitis for the PD cohort was not different over time. These results support the placement of permanent accesses (fistula or PD catheter) before the start of dialysis to avoid use of HD catheters.**

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Infection is the second leading cause of death among dialysis patients, accounting for 33 deaths per 1000 patient years in the prevalent US Renal Data System (USRDS) cohort for 2001 through 2003 (1). Septicemia, which is poorly defined, accounts for 79.7% of infectious deaths (1). Dialysis patients who are hospitalized for bacteremia/septicemia have a relative risk (RR) for death of 7 for the first 6 mo after the event compared with those without hospitalization for septicemia, and the increased risk persists for at least 48 mo (2). The adjusted mortality rate for the 6 mo after hospitalization for septicemia is 120.1 per 1000 patient-years, compared with approximately 10 per 1000 patient-years in those without hospitalization for septicemia.

The rates of hospital admissions for septicemia are higher in hemodialysis (HD) patients than peritoneal dialysis (PD) patients (2,3). HD compared with PD as an initial modality doubles the risk for hospitalization for septicemia (3). The hospitalization rates for septicemia in PD have remained relatively constant since 1997, whereas the rates for hospitalization in HD patients have doubled between 1991 and 2001, because of a striking increase in the admission rate for vascular access infection (2). However, the recorded rate of death for septicemia is higher for PD patients (29.3 per 1000 patient-years) than for HD patients (26.1 per 1000 patient-years) for the most current period for which data are available (1). These results seem inconsistent and confusing.

Most previous reports that used USRDS data did not include the critical initial period of time on dialysis, because USRDS collection of information does not begin until the 90th day of dialysis. This is a time when a high proportion of patients are using HD catheters, which are known to increase the risk for bacteremia (4,5). Excluding this period of time will underestimate the rate of infections.

The use of HD catheters has been shown repeatedly to be an independent predictor of death in HD patients (6–9). Data from elderly patients with preexistent Medicare, permitting tracking of information from day 1 of HD, indicate that 15.1% of patients with an HD catheter die in the first 90 d compared with 6.7% with a fistula, with a hazard ratio of death with an HD catheter of 2.15 (9). Therefore, the risk for bacteremia and death in HD are especially high in the first 3 mo of dialysis.

A common perception is that PD is associated with a higher risk for infection compared with HD. However, the impact of dialysis modality on the rate and particularly type of infection has not been well studied, especially during the first few months of dialysis. Using a dialysis registry that tracks patients from the first day of dialysis, we designed this study to compare the rates and type of infections in patients who were incident to either HD or PD, controlling for important variables.

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## Materials and Methods

Since 1999, we have had dialysis registries to collect information prospectively on patients who undergo both HD and PD at Dialysis Clinics Inc. (DCI) of Oakland dialysis center, an urban unit with physicians who are affiliated with the University of Pittsburgh Medical Center. The dialysis registries are approved by the university's Institutional Review Board and DCI administrative review office, and the patients provided informed consent at the start of dialysis to collect data prospectively for research purposes. None of the PD patients and one of the HD patients (<1%) declined participation in the registry. We retrieved data from these prospective databases on incident patients from January 1, 1999, to September 1, 2006.

We excluded 63 patients who were on HD and 57 who were on PD and had any previous ESRD therapy, including failed renal transplants. This was done to focus on patients who initiated dialysis as a first ESRD therapy and to avoid confounding a potential impact of one therapy on another and the access related to that modality. Eight patients who were incident to ESRD during the period studied were excluded because all were started on HD (but not at our center) and transferred to PD at our center within 3 mo of initiation of dialysis (range 0.33 to 1.90 mo) and therefore were on two modalities. To evaluate any potential bias, we ran an additional analysis that included these eight patients in the PD group. Modality was defined as that started on the first day of dialysis and time at risk began at the outpatient dialysis treatment for HD and the first day of training for PD. The majority of time on PD was on automated PD (APD; 92%), with the remaining time on continuous ambulatory PD (CAPD).

Follow-up continued to September 1, 2005. Individuals were censored at transfer to another modality (three on HD and seven on PD), improvement in residual renal function that led to discontinuation of dialysis (two on HD and one on PD), transplantation (four on HD and 15 on PD), permanent transfer to another center on the same modality (five on HD and zero on PD), and death (33 on HD and seven on PD). Temporary transfers to another modality, transient cessation of dialysis as a result of partial recovery of renal function, no dialysis as a result of catheter malfunction, or time in a rehabilitation center were not reasons for censoring when the patient returned to the original modality in <1 mo (six each on HD and PD). However, the time off the dialysis therapy was excluded as were infections during this short period for both HD and PD because the focus of this article is on infections on one modality *versus* the other.

Prospective data that were collected included demographics, comorbid conditions at dialysis initiation, serum albumin at the start of dialysis, infection episodes, and hospitalizations as a result of infections. Comorbidity status at the start of dialysis was assessed using Charlson Comorbidity Index (CCI) (10), scored by an experienced physician assistant for HD and an experienced research nurse for PD. A careful review of the patient's medical history and physical examination was used to determine the correct score. Diabetes was defined as elevated blood glucose and a history of diabetes on the basis of review of the history of the patient regardless of the use of insulin or hypoglycemic medications. The guide for scoring the CCI is in Appendix 1. Infections that were included in the registry were those related to the access regardless of whether hospital admission was required and all infections that required hospital admission.

Infections were classified as catheter infections, either exit site (defined as drainage, erythema, or exit-site pain) or tunnel infection (defined as swelling or pain/tenderness with or without erythema over the catheter tunnel) for both HD and PD. Pneumonia was defined as radiologic evidence of pneumonia in the clinical setting of pneumonia. Peritonitis was defined as cloudy effluent with $\geq 100/\mu l$ white cells with ≥50% of these polymorphonuclear cells. Cellulitis was defined as infection of subcutaneous tissue that required hospitalization. Bacteremia and fungemia were defined by positive blood cultures. "Other infections" that required hospital admission included infected limb ulcers.

Infectious rates were calculated by dividing the total number of infections by total time at risk in the HD or PD cohorts and expressed as number of infections per dialysis year. We also expressed rates as the number of episodes per 1000 d at risk because this is the way it generally is expressed in HD. All hospitalizations as a result of infections were included in the analysis as well as all access-related infections. We also determined the rate of infection during the first 90 d of dialysis, both HD and PD.

Protocols to reduce the risk for infections were used in both the HD and PD programs. All patients with HD catheters had antibiotic cream placed at the exit site after cleansing of the site at the end of dialysis as part of routine HD catheter care, done by the staff. All HD patients with a catheter were asked to keep this dry and specifically to refrain from showers. All PD patients were instructed to wash the PD catheter exit site using antibacterial soap in the shower and then after the shower use a cotton swab to put antibiotic cream around the catheter at the exit site. PD patients were told to avoid tub baths.

### *Statistical Analyses*

Variables (PD *versus* HD) were compared using *t* test, Mann-Whitney U test, or $\chi^2$ test, as appropriate. Poisson regression analysis was used to assess the impact of various factors on outcome of interest (total

*Table 1.* Demographic characteristics of the HD and PD cohorts[a]

| Characteristic | HD | PD | *P* |
|---|---|---|---|
| No. of patients | 119 | 62 | |
| Follow-up on dialysis (mo; median [range]) | 18 (0.3 to 75) | 15 (0.13 to 72) | 0.96 |
| Age at start of dialysis | 59 ± 16 | 55 ± 17 | 0.15 |
| Men (%) | 57 | 44 | 0.12 |
| White (%) | 48 | 84 | <0.001 |
| Diagnosis diabetes (%) | 54 | 46 | 0.35 |
| Albumin at dialysis start (g/dl) | 3.2 ± 0.6 | 3.7 ± 0.6 | <0.001 |
| CCI (median [range]) | 6 (2 to 14) | 6 (2 to 14) | 0.23 |
| HD catheter as first access (%) | 67 | 0 | |
| PD catheter as first access (%) | 0 | 100 | |

[a]CCI, Charlson Comorbidity Index; HD, hemodialysis; PD, peritoneal dialysis.

*Table 2.* Infections in the HD and PD cohorts

| Parameter | HD | PD | *P* |
|---|---|---|---|
| Patients infection-free | 54 (45%) | 25 (40%) | NS |
| Infections, total per time at risk (median [range]) | 1 (0 to 14) | 1 (0 to 10) | NS |
| Infection rates per year at risk | | | |
| bacteremia/fungemia, overall | 0.16 | 0 | <0.0001 |
| bacteremia in the first 90 d | 0.47 | 0 | <0.0001 |
| peritonitis | 0 | 0.24 | <0.0001 |
| peritonitis in the first 90 d | 0 | 0.22 | <0.001 |
| catheter exit-site and tunnel infections | 0.35 | 0.41 | NS |
| total infection rate per dialysis year | 0.77 | 0.86 | NS |
| Hospitalization rates per year at risk | | | |
| admission for bacteremia | 0.10 | 0 | <0.001 |
| admission for peritonitis | 0 | 0.19 | <0.001 |
| admission for cellulitis | 0.06 | 0 | <0.001 |
| admission for pneumonia | 0.07 | 0.02 | <0.001 |
| admission for other serious infections | 0.13 | 0.21 | 0.04 |
| all admissions for infection | 0.29 | 0.42 | 0.02 |
| total admissions including noninfectious | 2.4 | 1.4 | <0.0001 |

infections and infections that required hospitalization). Because age and diabetes are part of CCI, they were not analyzed as separate covariables. Two different models were used for multivariate Poisson regression to evaluate the impact of variables (one with age and diabetes and the other with CCI along with other variables) because age and diabetes are part of CCI. Interactions of dialysis modality with age, race, gender, diabetes, and CCI were tested. Because an interaction was found between modality and diabetes, separate models also were run in those with and without diabetes. Number Crunch Statistical System software (Dr. Jerry Hintze, Kaysville, UT) was used for statistical analysis.

## Results

A total of 181 incident dialysis patients (119 on HD and 62 on PD) met the inclusion criteria. The demographics of the two groups of *de novo* dialysis patients are shown in Table 1. The HD cohort was slightly older, had more black patients, and had a lower serum albumin level at the start of dialysis. Sixty-seven percent of the HD patients began dialysis using an HD catheter. The median comorbidity index was the same for the two groups at the start of dialysis. Cardiac disease was present in 44 and 57% ($P = 0.10$), malignancy in 11 and 19% (NS), pulmonary disease in 15 and 13% (NS), and systemic immune disease in 3 and 7% (NS) for HD and PD, respectively. Peripheral vascular disease was present more frequently in the PD patients (10 and 22%; $P = 0.03$) whereas liver disease was more frequent in the HD patients (18 and 3%; $P < 0.003$).

Infection rates for each group are summarized in Table 2 and Figure 1. The overall infection rates were the same in the HD and PD cohorts. However, the rates for various types of infections were different in HD and PD patients. Bacteremia and fungemia occurred only in HD patients, whereas peritonitis occurred only in PD patients.

The rate of bacteremia was much higher during the first 90 d of HD than during the overall time at risk in HD patients ($P < 0.004$). Forty percent of all episodes of bacteremia during the observation period occurred in the first 90 d on HD. The risk for bacteremia fell significantly after 90 d from 0.42 per year to 0.12 per year ($P = 0.001$). The risk for infections varied for HD by the type of access, with the highest risk for acute dialysis catheters and tunneled dialysis catheters (Figure 2). In contrast, in PD patients, the peritonitis rate was 0.22 episodes per year at risk during the first 90 d, not different from the overall rate of 0.24 per year at risk for the total time for the PD cohort.

Organisms that caused dialysis-related infections were similar in the HD and PD cohorts. Gram-positive bacteria accounted for 62% of the bacteremic episodes in the HD patients (rate 0.10 episodes per year at risk) and 46% of the peritonitis episodes (0.11 per year at risk). The rate of *Staphylococcus aureus* bacteremia was 0.01 per year for HD, and the rate of *S aureus* peritonitis was 0.04 per year for PD ($P = 0.12$). Gram-negative organisms accounted for 22% of bacteremic episodes in HD

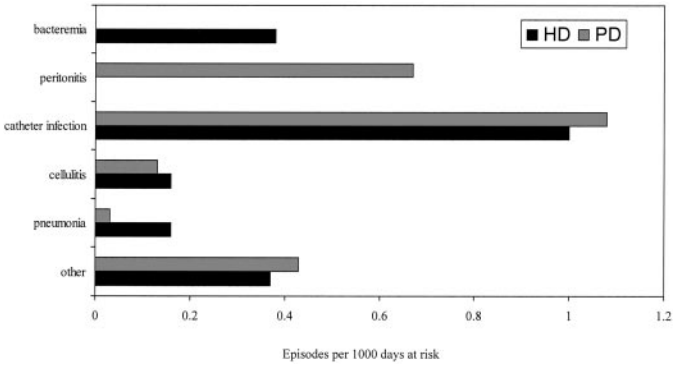


*Figure 1.* Comparison of infection rates in hemodialysis (HD; ■) and peritoneal dialysis (PD; ▨). Data are episodes per 1000 d at risk.

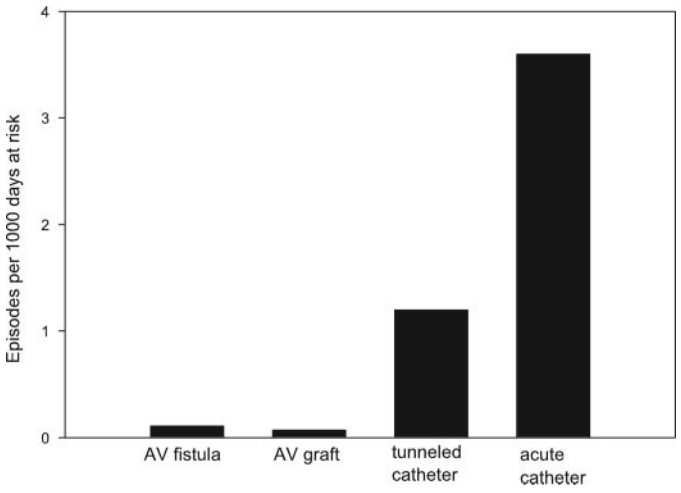


*Figure 2.* Rates of bacteremia by access in the HD patients.

(0.04 per year at risk) and 54% of peritonitis episodes (0.13 per year for PD).

Overall rates of catheter infection (exit site and tunnel) were similar for HD and PD patients (0.35 *versus* 0.41 per year; $P = 0.20$, respectively). *S. aureus* catheter infections for HD were 0.05 per year. This was comparable to 0.07 per year for PD ($P = 0.30$).

Rates of infection for CAPD *versus* APD were not different. There were no episodes of peritonitis on CAPD compared with 0.26 per year on APD ($P = 0.14$). Catheter infection rates were similar, 0.35 per year on CAPD and 0.42 per year on APD ($P = 0.43$).

Table 3 shows the results of the multivariate analysis. In the first model, CCI (which includes both age and diabetes) was used, whereas in the second model, age and diabetes were used in place of CCI. In both models, a decreased serum albumin at the start of dialysis was a strong predictor of subsequent infection. Black patients were at decreased risk for infection in both models. Dialysis modality (PD *versus* HD) was not an independent risk for infection; neither was gender. In the second model, which separates diabetes and age, younger age was a risk factor for infection as was the presence of diabetes.

We ran an additional analysis to include the eight incident-to-dialysis patients who had 3 mo or less on HD before PD. This constituted 11% of PD patients. Inclusion of these few patients did not change the results of the study because there were no differences in overall infection rates or hospitalization between PD (now 70 patients) and HD (119 patients).

### *Interactions*

There was not a significant interaction of modality with age, albumin, or CCI. However, significant interactions were seen with modality and diabetes ($P = 0.02$). In addition, there were important interactions in infection risk for modality and gender ($P = 0.04$).

The interaction between modality and diabetes for infection risk was explored further. Patients who had diabetes and were on PD had higher infection rates than patients who had diabetes and were on HD (1.28 *versus* 0.84/yr; $P < 0.004$). Conversely, patients without diabetes had a lower risk for infection on PD than on HD (0.51 *versus* 0.69/yr; $P < 0.03$). Separate models were run in patients with and without diabetes. Adjustment for albumin, age, race, gender, and dialysis modality was NS in individuals with diabetes (RR 1.13; 95% confidence interval [CI] 0.76 to 1.67; $P = 0.55$) or in individuals without diabetes (RR 0.67; 95% CI 0.37 to 1.21; $P = 0.18$).

The interaction between modality and gender ($P = 0.04$) for infection risk also was evaluated further. Men who were on PD had a significantly higher rate of infection than women who were on PD (1.07 *versus* 0.71/yr; $P < 0.009$). In contrast, infec-

*Table 3.* Multivariate Poisson regression analysis models for overall infection rate[a]

| Parameter | RR | 95% CI | *P* |
|---|---|---|---|
| Model 1: Using albumin, race, gender, modality, and CCI | | | |
| albumin, for each g/dl | 0.62 | 0.50 to 0.77 | <0.001 |
| race (black) | 0.62 | 0.47 to 0.82 | 0.008 |
| modality (PD) | 1.13 | 0.82 to 1.55 | 0.45 |
| gender (male) | 1.05 | 0.83 to 1.41 | 0.73 |
| CCI, for each point | 1.01 | 0.81 to 1.35 | 0.67 |
| Model 2: Using albumin, race, gender, modality, diabetes, and age | | | |
| age, per 10-yr increase | 0.87 | 0.80 to 0.95 | 0.002 |
| albumin, for each g/dl | 0.66 | 0.53 to 0.82 | <0.001 |
| diabetes | 1.48 | 1.13 to 1.94 | 0.004 |
| gender (male) | 1.03 | 0.80 to 1.33 | 0.82 |
| race (black) | 0.58 | 0.44 to 0.77 | <0.001 |
| modality (PD) | 0.98 | 0.70 to 1.36 | 0.90 |

[a]CI, confidence interval; RR, relative risk.

tion rates were the same in men and women who were on HD. When stratified by gender and controlling for age, race, and diabetes, significant differences were seen in infection rate by modality for men (PD *versus* HD: RR 1.92; 95% CI 1.13 to 3.27; $P = 0.02$) and women (PD *versus* HD: RR 0.61; 95% CI 0.39 to 0.96; $P = 0.03$).

White patients had a similar infection rate on PD and HD (0.99 *versus* 0.97/yr). However, black patients had a lower rate of infections on PD than on HD (0.44 *versus* 0.68; $P < 0.002$). This held true with the multivariate analysis as well.

*Hospitalization for Infections*

The all-cause admission rate was 2.4 per dialysis year for HD and 1.4 per dialysis year for PD ($P < 0.001$). However, PD patients had a higher rate of infection-related hospitalization (0.42 *versus* 0.29 hospitalization per year at risk; $P < 0.001$). Two models were used for multivariate Poisson regression analysis for infections that required hospitalization, one with CCI, albumin, gender, race, and modality and a second model using age, diabetes, albumin, gender, race, and modality (Table 4). Albumin and modality were significant predictors in both models. CCI was significant in the first model as were age and diabetes in the second model. There were no significant interactions of race or diabetes with modality for the risk for hospitalization for infection. However, there was a trend for interaction of gender with mode for hospitalization for infection ($P = 0.06$). Men who were on PD had a higher admission rate for infection compared with men who were on HD (0.59 *versus* 0.32 per dialysis year), whereas women who were on PD had similar rates of infection as women who were on HD (0.29 *versus* 0.24 per dialysis year).

## Discussion

This study demonstrated that patients who start dialysis on HD compared with those who start on PD have similar overall rates of infection, controlling for comorbidity, race, diabetes, age, gender, and initial serum albumin level. However, there were marked differences in both the type of infections and the risks during the first 90 d of dialysis among patients who were on these two modalities. Only HD patients had bacteremia, and only PD patients had peritonitis. Both of these complications likely are related to the dialysis access or contamination during connection.

The risk for bacteremia in HD patients was strikingly increased during the first 90 d of dialysis. The early risk for bacteremia in HD patients very likely is related to the use of HD catheters as the initial access in 67% of our HD patients, similar to that reported in the CHOICE study (8). HD catheters are widely known to increase the risk for bacteremia (4,5). These results support the need for a fistula-first protocol so that all patients who want HD have a fistula placed before commencement of dialysis (5). If HD catheter use could be avoided with careful planning of dialysis initiation, then it is possible that the risk for infection actually may be lower for HD compared with PD. In some cases, this may require placing an HD graft if a primary fistula cannot be achieved in a timely manner. For patients who desire PD, a prudent approach would be to place a PD catheter in a timely manner and avoid a period on HD with an HD catheter. This approach is very likely to decrease the risk for bacteremia.

Our study refutes the common misconception that PD is associated with an overall higher rate of infection as compared with HD. In particular, we found bacteremia to be a complication almost solely of HD. These results are consistent with those of Abbott and Agodoa (11), who examined 327,993 patients who initiated dialysis between January 1992 and June 1997 for risk for hospitalization for bacterial endocarditis. HD patients had an RR of 17.86 (95% CI 6.62 to 48.90) compared with the general population in 1996. This was in contrast to PD patients, who had an insignificant increased risk compared with the general population (10.54; 95% CI 0.71 to 158.13).

When septicemia is examined, as opposed to endocarditis, the evidence is less clear. Powe *et al.* (12) examined data from the USRDS and found that 11.7% of HD patients and 9.4% of PD patients had during 7 yr at least one episode of septicemia.

*Table 4.* Multivariate Poisson regression analysis for infections that required hospitalization

| Parameter | RR (95% CI) | *P* |
|---|---|---|
| Model with CCI | | |
| albumin (per 1-g/dl increase) | 0.38 (0.27 to 0.53) | <0.001 |
| CCI (per point increase) | 0.91 (0.82 to 1.01) | 0.07 |
| gender (male) | 1.45 (0.96 to 2.20) | 0.07 |
| race (black) | 0.61 (0.39 to 0.96) | 0.03 |
| modality (PD) | 1.96 (1.20 to 3.21) | 0.008 |
| Model with age and diabetes | | |
| age (per 10-yr increase) | 0.84 (0.73 to 0.96) | 0.01 |
| albumin (per 1-g/dl increase) | 0.40 (0.28 to 0.57) | <0.001 |
| diabetes | 1.46 (0.96 to 2.21) | 0.07 |
| gender (male) | 1.45 (0.96 to 2.19) | 0.07 |
| race (black) | 0.60 (0.38 to 0.95) | 0.03 |
| modality (PD) | 1.73 (1.03 to 2.91) | 0.04 |

*Charlson Comorbidity Index*[a]

| Score | Condition | Definition |
|---|---|---|
| 1 | Myocardial infarct | Not ECG changes only |
| | Congestive heart failure | With dyspnea, responded to treatment |
| | Peripheral vascular disease | Includes untreated aneurysm ≥6 cm |
| | Cerebrovascular disease | CVA with minor or no residual, TIA |
| | Dementia | Includes cognitive deficits |
| | Chronic pulmonary disease | Mild, moderate, and severe |
| | Connective tissue disorder | SLE, polymyositis, MCTD, polymyalgia rheumatica, RA |
| | Ulcer disease | With or without bleeding |
| | Mild liver disease | Cirrhosis without portal HTN, chronic hepatitis (includes C) |
| | Diabetes[b] (without end-organ disease) | Not diet-controlled alone |
| 2 | Hemiplegia | |
| | Moderate or severe renal disease | With retinopathy or neuropathy, or nephropathy, or juvenile onset, or brittle diabetic |
| | Diabetes[b] (with end-organ damage) | Dialysis dependent |
| | Any tumor | Without mets, first treatment in last 5 yr |
| | Leukemia | Acute, chronic, lymphocytic, and polycythemia vera |
| | Lymphoma | Hodgkin's lymphosarcoma, Waldenström's macroglobulinemia, myeloma, and all lymphomas |
| 3 | Moderate or severe liver disease | Cirrhosis with portal HTN with or without bleeding, ± variceal bleeding |
| 6 | Metastatic solid tumor | |
| | AIDS | Not just HIV+ |
| Age score: For each decade >40 yr of age, a score of 1 is added to the above score | | |
| 1 | 50 to 59.9 | |
| 2 | 60 to 69.9 | |
| 3 | 70 to 79.9 | |
| 4 | 80 to 89.9 | |

[a]ECG, electrocardiogram; SLE, systemic lupus erythematosus.
[b]Assign only a 1 or a 2 for diabetes.

Part of the problem with examining septicemia from the USRDS is the lack of clarity regarding the definition of septicemia as pointed out recently by O'Seaghdha and Foley (13). Sepsis and septicemia may be confused with peritonitis by the coding doctors. The USRDS does not provide a definition of septicemia, and it is not clear that doctors are using this only for bacteremia. To study this further through the USRDS successfully will require abandoning the term "septicemia" and replacing it with more specific terms, such as bacteremia and peritonitis.

In a center with a low incidence of both bacteremia in HD patients and peritonitis in PD patients, the overall rate of infection was similar in the two cohorts. Our center rate for catheter-related bacteremia in HD of 1.2 per 1000 d (Figure 1) is well below recent published rates of 2.5 to 5.5 per 1000 patient days (14). Likewise, our center rate for peritonitis of 0.24 per patient year (one episode per 50 dialysis months) is a low rate but certainly achievable by other centers (15). The low rates of bacteremia and peritonitis at our center may be due to the close attention to infectious risk, patient and staff training, and prophylactic use of exit-site antibiotic cream to prevent exit-site infection in both HD and PD patients (16,17).

We found a low serum albumin at the start of dialysis, younger age, race, and the presence of diabetes to be the strongest risk factors for overall infections, regardless of modality and controlling for other comorbid conditions. Our findings are consistent with other studies showing the presence of diabetes, low serum albumin, and temporary vascular access to be risk factors for septicemia in HD patients (10,18,19). Hypoalbuminemia also has been shown to be a risk factor for subsequent peritonitis (20–22). This relationship between hypoalbuminemia and infection in dialysis patients is an association rather than a proven causal relationship. Precisely how a low serum albumin level increases the risk for infection in both HD and PD patients is uncertain.

We found a higher rate of admissions for infection in the PD patients compared with the HD patients. PD patients were likely to be admitted to the hospital for management of infections, especially limb ulcers and peritonitis. Vascular access may make it less likely to hospitalize HD patients for treatment of limb ulcers, because patients can receive intravenous antibiotics during dialysis. However, the overall hospitalization rate was lower among PD patients. Many dialysis-related infections are treated as outpatients. Studies that use only admissions for

infections will not determine accurately the infection rates for the two modalities.

There were interesting interactions between infection risks on the two modalities and both race and diabetes. Black patients had a lower rate of infection on PD than on HD. Historically, in the United States, black patients are less likely to be placed on PD for somewhat unclear reasons, but some literature suggests a higher risk for infection on PD compared with other patients (23). Most of this literature is older; with new technology and the decrease in coagulase-negative infections, black patients may no longer have a higher risk for infection. Our results suggest that PD may be underused in black patients and that in regard to infection risk, PD is a good choice for this population. However, the total number of black patients who were on PD in our study is small, so further studies should confirm our finding.

Patients with diabetes seem to have a higher risk for infection on PD than on HD. This result was independent of serum albumin level at the start of dialysis. These results are consistent with the finding of Sarnak and Jaber (24), who found that patients who have diabetes and are on PD had a strikingly higher risk for death from "sepsis" than patients who did not have diabetes and were on PD. We also found a lower rate of infection on PD for individuals without diabetes. It is interesting to speculate as to whether this may explain the results of some observational studies showing a higher risk for death with increasing time on dialysis with PD compared with HD for patients with diabetes. More studies will be needed in this area.

There are limitations to this study. The study is based on a single center. Our unit is an academic dialysis unit, and our overall infection rate is low in both PD and HD compared with many other centers. As with all observational studies, there may be confounding by selection bias. We use exit-site antibiotic prophylaxis to decrease the rate of both peritonitis (PD) and bacteremia (HD), and this may be a different approach than in other programs. Our numbers limit the evaluation of the interactions between race and diabetes with infections on modalities. Whether our results could be generalized to other sites or units with higher infection rates is not known.

## Conclusion

This study provides evidence that dialysis modality is not an independent predictor of overall infection rate in a cohort of incident dialysis patients but is a strong predictor of the type of infection and the difference in risk during the first 90 d of dialysis. Patients should be informed that there is a high risk for bacteremia when starting dialysis using an HD catheter and that the risk of peritonitis in association with a PD catheter during the first 3 mo of PD is considerably lower than the risk for bacteremia with an HD catheter. Choice of modality should not be dictated by the concern of higher infection rate on PD; rather, it should be based on the individual patient's preference.

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B.P. and J.B. are consultants and on the Speakers Bureau for Baxter Healthcare Corporation. We do not believe that these represent a conflict of interest for the subject matter of this article.

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