Effect of renal center characteristics on mortality and technique failure on peritoneal dialysis

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Background. Recent studies report decreased mortality in patients on peritoneal dialysis (PD) over time, suggesting that advances in PD have resulted in improved patient outcomes. Our investigation sought to assess the effect of renal center characteristics on mortality and technique failure (TF) rates.

Methods. Covariates of interest included center-specific cumulative number of PD patients treated, percentage of patients who initiated dialysis on PD, and academic status. Using data obtained from the Canadian Organ Replacement Register, the 17,900 patients who received PD during the 1981 to 1997 period were studied. Mortality and TF rate ratios (RR) were estimated using Poisson regression, adjusting for age, gender, race, primary renal diagnosis, province, follow-up time, and type of PD.

Results. As the cumulative number of PD patients treated increased, covariate-adjusted mortality significantly decreased ($P < 0.05$); a weaker yet significant association was observed between number of PD patients treated and TF. As the percentage of patients initiating dialysis on PD increased, TF rates decreased significantly. No association was observed between center academic status and PD mortality or TF rates.

Conclusions. These results imply that a center's experience with and degree of specialization toward PD impact strongly on PD outcomes. One hypothesis is that a center's propensity to exploit technical and non-technical advances in PD increases directly with these variables. It is also possible that, through experience, centers become more adept at identifying appropriate patients to receive PD. More detailed research is required to evaluate these hypotheses.

Recently, much research has been devoted to comparing mortality in patients on peritoneal dialysis (PD) and hemodialysis (HD) therapy [1–5]. However, it also is useful to observe PD in isolation over a broad period of time to examine trends and determine factors affecting patient outcomes. Many changes to PD have occurred since the technique's inception, including several technical advancements and changes in patient management strategies [6–9]. Recent reports indicate that PD mortality is decreasing in North America [10, 11] and that technique failure (TF) rates have decreased in Canada [12], suggesting that the enhancements to PD indeed are resulting in improved patient outcomes.

It is reasonable to hypothesize that PD mortality and TF rates are not constant across renal centers. Characteristics such as a center's experience in PD delivery, emphasis placed on PD relative to HD, and academic status may well affect patient outcome. Since very few studies have examined the effect of renal center characteristics on PD mortality and TF rates, the objective of our investigation was to assess these associations using a nationwide organ failure database.

METHODS

Data were obtained from the Canadian Organ Replacement Register (CORR) of the Canadian Institute for Health Information (CIHI), a population-based, nationwide organ failure registry [13]. Baseline demographic data are collected by each of the 86 renal centers from all patients at renal replacement therapy (RRT)-initiation, including date of birth, gender, province of residence, race and primary renal diagnosis (PRD). Patient-specific treatment history data are submitted annually by each center, including dialytic modality assignments and switches, transplantations, and graft failures. Date and cause of death, where applicable, are reported along with the other follow-up information. Data were available on all patients initiating therapy between January 1, 1981, and December 31, 1997. Beginning in 1988, CORR began collecting information on predialysis comorbid conditions for all incident patients. Data were available on cardiovascular disease (that is, symptomatic angina, acute myocardial infarction, pulmonary edema, cerebrovascular accident, and peripheral vascular disease), chronic obstructive lung

disease, malignancies, and any "other serious illnesses" (that is, diseases expected to greatly reduce 5-year survival probability, but not falling cleanly into each of the listed categories; for example, HIV infection).

The study population included the 17,900 patients who received peritoneal dialysis between January 1, 1981, and December 31, 1997. Each patient's follow-up time on PD was computed. Patients were classified by gender, PRD, and race (black, Caucasian, Aboriginal Canadian, Asian, East Indian, and other/unknown). Person years (PY) of follow-up among patients receiving PD were classified by age (≤ 14, 15 to 44, 45 to 64, 65 to 74, ≥ 75), calendar period (1981 to 1985, 1986 to 1989, 1990 to 1993, 1994 to 1997), follow-up time (1-year intervals) and type of PD [continuous ambulatory/cyclic PD (CAPD/CCPD), intermittent PD (IPD)]. Of course, age, calendar time, follow-up interval, and PD type were dynamic variables in that patients could contribute PYs to more than one category as they progressed through the period of observation.

With respect to renal center, patients were assigned to the center at which they first received PD. Three covariates were used to characterize centers: (*1*) cumulative number of patients treated with PD, (*2*) percentage of patients who received PD (%PD) among those initiating chronic dialysis, and (*3*) academic status. The "cumulative PD patient count" variable was intended to represent the experience of each renal center with peritoneal dialysis, while the "% PD" variable was intended to reflect degree of specialization towards PD relative to hemodialysis. These two center-specific variables, for each patient, were computed based on the experience at the center up to and including the patient's year of PD initiation. For example, consider a patient who received PD for the first time at center 4 in 1991. The cumulative PD patient count variable would be computed as the total number of patients who received PD at center 4 between 1981 and 1991. The % PD variable would be calculated as follows: $n_{PD} \div (n_{PD} + n_{HD}) \times 100\%$, where n_{PD} denotes the just-described cumulative PD patient count, summed over years 1981 through 1991 inclusive, and n_{HD} is defined analogously for hemodialysis. Cumulative PD patient count was divided into six categories: ≤ 99, 100 to 199, 200 to 299, 300 to 399, 400 to 499, and ≥ 500. The % PD variable was subdivided into $\leq 19\%$, 20 to 29, 30 to 39, 40 to 49, 50 to 59, and $\geq 60\%$. Centers were classified as academic or nonacademic, based on whether they were directly affiliated with a medical school.

Mortality rates were computed as the ratio of deaths to person-time on PD. With respect to mortality, an "as-treated" analysis was performed, wherein patients were followed after switching modalities, with deaths were attributed to the dialytic modality received at the time of death. Technique failure (TF) rates were computed

Table 1. Baseline characteristics of patients initiating peritoneal dialysis (PD) 1981–1997

Characteristic[a]	N	%[b]
Age group *years*		
0–14	487	2.7
15–44	4,421	24.7
45–64	6,614	36.9
65+	6,378	35.6
Gender		
Female	7,840	43.8
Male	10,058	56.2
Unknown	2	0.0
Race		
Black	432	2.4
Caucasian	14,367	80.3
Aboriginal Canadian	687	3.8
Asian	910	5.1
East Indian	421	2.4
Other/unknown	1,083	6.1
Calendar Period		
1981–85	3,519	19.7
1986–89	3,626	20.3
1990–93	5,227	29.2
1994–97	5,528	30.9
Primary renal diagnosis		
Diabetes	4,964	27.7
Glomerulonephritis	2,865	16.0
Polycystic kidneys	857	4.8
Renal vascular	2,850	15.9
Other	6,364	35.6
Total	17,900	100

[a] Patients classified based on date of PD initiation
[b] Percentages may not add to 100.0 due to rounding

similarly, except that patients were censored after their first TF (that is, switch from PD to HD) since subsequent TF's for the same patient would be dependent. Poisson regression [14, 15] was used to compare rates among the categories of cumulative PD patient count, % PD, and academic status covariates while adjusting for age, gender, race, province, PRD, calendar period, follow-up interval, and type of PD. The rate ratio (RR, that is, rate for each renal center category, relative to the arbitrarily chosen reference category) served as the parameter of interest.

RESULTS

In Table 1, baseline demographic and clinical characteristics are listed for patients who initiated PD in Canada during the 1981 to 1997 period ($N = 17,900$). Approximately 37% of patients were in the 45 to 64 age group upon PD initiation, while about 36% were aged ≥ 65 years. The male:female ratio was approximately 56:44. Eighty percent of PD patients were Caucasian, while the second most frequent race was Asian (5%). Aboriginal Canadians comprised less than 4% of the study population. Great increases in the number of PD patients occurred over calendar time, as over 60% of the study population was composed of patients who initi-
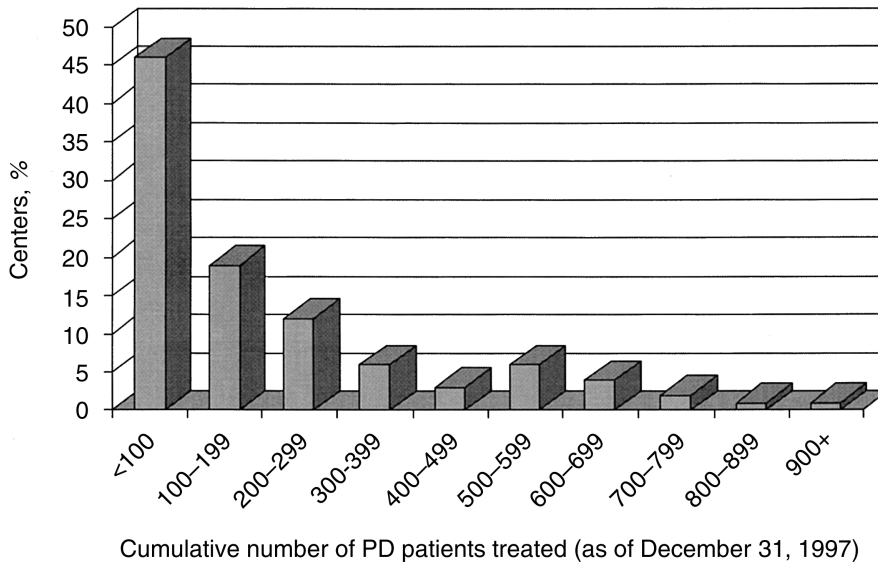
Fig. 1. Distribution, by center, of cumulative number of peritoneal dialysis (PD) patients as of December 31, 1997.

Cumulative number of PD patients treated (as of December 31, 1997)

ated PD after January 1, 1990. Among the specified and known PRDs, diabetes was the most common at 28%.

The frequency distribution by center of cumulative number of patients treated with PD (as of December 31, 1997) is presented in Figure 1. Approximately 46% of centers had treated less than 100 registered patients with PD, while 19% had treated between 100 and 199. One center had treated over 900 registered PD patients during the period of observation.

The distribution by center of the fraction of patients initiating dialysis on PD is depicted in Figure 2. At 17% of Canadian centers, PD was offered as an initial mode of dialysis to less than 10% of patients. For slightly less than one fifth of centers, the percentage of patients initiating dialysis on PD was greater than 50%. More than 90% of patients initiated dialysis on PD at only 5% of centers.

Category-specific mortality rates and rate ratios are listed in Table 2 for each renal center characteristic. Overall, there were 6,269 deaths during the 33,937 PYs of observation on PD, for an unadjusted mortality rate of 184.7 deaths per 1000 PYs. Unadjusted and adjusted mortality rates decreased in a monotone fashion as the total number of PD patients treated increased. In fact, statistically significant ($P < 0.05$) reductions in adjusted mortality were observed for all cumulative PD patient groupings (relative to the reference category: ≤99 patients) except in the 100 to 199 patient category. Unadjusted mortality rates ranged from 202.7 in the ≤99 patient category down to 138.9 in the ≥500 group. For centers where at least 500 registered PD patients had been previously treated, adjusted mortality was 29% less (RR = 0.71), relative to that for centers wherein ≤99 patients had ever been treated. There was little differ-

ence between the unadjusted and adjusted RRs, and little difference between RRs adjusted for all covariates except other center characteristics (that is, cumulative PD patient count, academic status) and those adjusted for all covariates including other center characteristics.

Crude death rates showed practically no trend across %PD categories (Table 2), with unadjusted RR ≈1 for all nonreferent categories. Upon adjustment for all covariates except other center characteristics, RRs for all %PD categories were strongly elevated relative to the reference level (≥60% of patients initiating RRT on PD), with partially adjusted RRs ranging from 1.17 to 1.23. However, upon adjustment for center-specific cumulative PD patient count and academic status, RRs were greatly reduced for each category. Covariate-adjusted RRs were still significantly increased for the 40 to 49% and 50 to 59% categories; no dose-response relationship was apparent between the fraction of patients initiating RRT on PD and covariate-adjusted mortality.

Unadjusted PD mortality rates per 1000 were 212.7 for and 177.1 for nonacademic and academic centers, respectively (Table 2). Upon adjustment for all covariates except other center characteristics (%PD, cumulative PD patient count), the RR increased from 0.84 to 0.97; upon adjustment for other center characteristics, the RR rose to 1.07 (1.00, 1.14), barely failing to attain statistical significance.

Technique failure rates and rate ratios by center characteristic are presented in Table 3. In total, there were 5,956 first TFs over 31,919 PY of observation for an overall TF rate of 186.6 per 1000 PYs. Unadjusted TF rates decreased monotonically from 202.7 (≤99 patients) to 138.9 (≥500 patients) per 1000. Generally, covariate-adjusted RRs decreased as the center-specific total num-
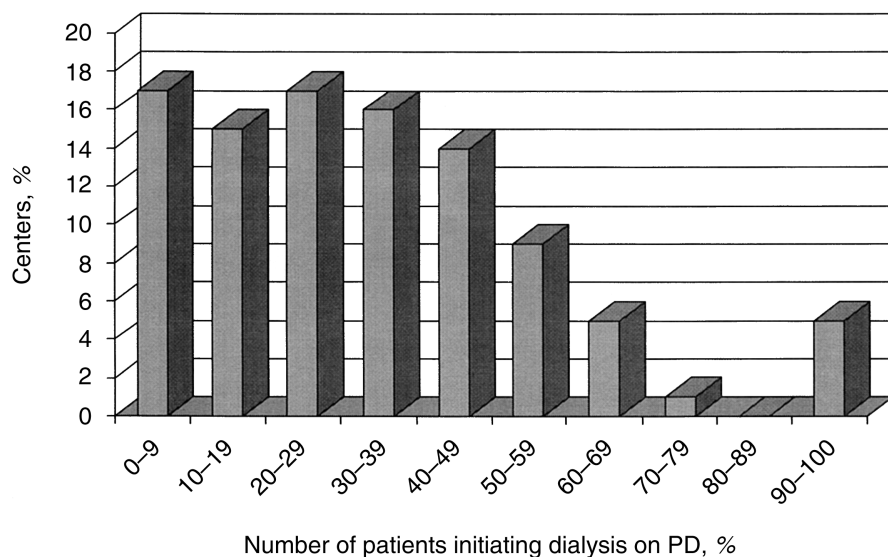
Fig. 2. Distribution, by center, of percentage of patients initiating dialysis on peritoneal dialysis (PD), as of December 31, 1997.

Table 2. Peritoneal dialysis (PD) mortality rates and rate ratios by center characteristic

Characteristic[a]	Deaths	PY[b]	Unadjusted mortality rate per 1,000	Unadjusted RR[c]	Partially adjusted RR[d]	Covariate-adjusted[e] RR	95% CI[f]
Cumulative number of PD patients treated[g]							
≤99	2,094	10,328	202.7	1	1	1	—
100–199	1,435	7,176	200.0	0.99	0.96	0.95	0.88–1.03
200–299	969	5,076	190.9	0.94	0.89	0.87	0.79–0.97
300–399	595	3,352	177.5	0.88	0.87	0.85	0.75–0.95
400–499	430	2,635	163.2	0.81	0.83	0.80	0.70–0.91
≥500	746	5,369	138.9	0.69	0.72	0.71	0.63–0.81
Percentage of patients initiating dialysis on PD[h]							
≤29%	685	3,695	185.4	0.98	1.23	1.06	0.94–1.20
30–39%	1,597	9,492	168.2	0.89	1.23	1.09	0.98–1.21
40–49%	1,399	7,460	187.5	0.99	1.22	1.12	1.02–1.23
50–59%	1,261	6,284	200.7	1.06	1.17	1.11	1.02–1.20
≥60%	1,327	7,006	189.4	1	1	1	—
Center academic status							
Non-academic	1,552	7,296	212.7	1	1	1	—
Academic	4,717	26,641	177.1	0.84	0.97	1.07	1.00–1.14
Total	6,269	33,937	184.7				

[a] Patients were classified based on the center at which PD was initiated
[b] PY, patient-years of follow-up on PD
[c] RR, ratio of category-specific rate to rate for reference category
[d] RR, estimated using Poisson regression and adjusted for age, gender, race, province, primary renal diagnosis, calendar period, follow-up time and type of PD (i.e., CAPD/CCPD, IPD), but not other center characteristics
[e] RR, estimated using Poisson regression and adjusted for other center characteristics in addition to all other covariates listed in footnote[d]
[f] CI = confidence interval
[g] Number of patients ever receiving PD at that center up to and including the year of RRT-initiation
[h] Based on all years up to and including the year of PD-initiation, for each patient; fraction = PD/(PD + HD) × 100%

ber of PD patients increased, the reduction attaining statistical significance for all categories except the 100 to 199 patient category. Covariate-adjusted RRs decreased strongly as the percentage of patients beginning on PD decreased, with RR = 1.75 (1.54, 1.98) for centers in the ≤29% category relative to those in which ≥60% of dialysis patients began on PD. There was no difference between academic and nonacademic centers with respect to covariate-adjusted TF rates (RR = 0.98).

Based on Table 2, the total number of PD patients treated appears to have a strong and significant effect on mortality; the same can be said with respect to TF for the percentage of patients initiating dialysis on PD. The robustness of each of these effects is examined separately in Table 4, where results based on 1981 to 1997 and 1990 to 1997 patients are compared. Regarding mortality, the effect ranged from RR = 0.95 (100 to 199 patient category) down to RR = 0.71 (≥500 category),

Table 3. Peritoneal dialysis (PD) technique failure (TF) rates and rate ratios by center characteristic

Characteristic[a]	TF	PY[b]	Unadjusted mortality rate per 1,000	Unadjusted RR[c]	Partially adjusted RR[d]	Covariate-adjusted[e] RR	95% CI[f]
Cumulative number of PD patients treated[g]							
≤99	1,889	9,460	199.7	1	1	1	—
100–199	1,333	6,683	199.5	1.00	1.00	0.97	0.89–1.05
200–299	865	4,689	184.5	0.92	0.92	0.89	0.80–0.99
300–399	543	3,226	168.3	0.84	0.84	0.81	0.71–0.91
400–499	453	2,570	176.3	0.88	0.88	0.82	0.72–0.94
≥500	873	5,284	165.2	0.83	0.83	0.83	0.73–0.95
Percentage of patients initiating dialysis on PD[h]							
≤29%	707	3,690	208.5	1.44	1.97	1.75	1.54–1.98
30–39%	1,656	8,722	189.9	1.31	1.70	1.58	1.42–1.76
40–49%	1,391	7,009	198.5	1.37	1.71	1.64	1.48–1.80
50–59%	1,216	6,974	203.6	1.41	1.44	1.41	1.29–1.54
≥60%	986	6,818	144.6	1	1	1	—
Center academic status							
Non-academic	1,398	6,846	204.2	1	1	1	—
Academic	4,558	25,067	181.8	0.89	0.88	0.98	0.92–1.06
Total	5,956	31,913	186.6				

[a] Patients were classified based on the center at which PD was initiated
[b] PY, patient-years of follow-up on PD
[c] RR, ratio of category-specific rate to rate for reference category
[d] RR, estimated using Poisson regression and adjusted for age, gender, race, province, primary renal diagnosis, calendar period, follow-up time and type of PD (i.e., CAPD/CCPD, IPD), but not other center characteristics
[e] RR, estimated using Poisson regression and adjusted for other center characteristics in addition to all other covariates listed in footnote[d]
[f] CI = confidence interval
[g] Number of patients ever receiving PD at that center up to and including the year of RRT-initiation
[h] Based on all years up to and including the year of PD-initiation, for each patient; fraction = PD/(PD + HD) × 100%

displaying a monotone dose-response relationship for 1981 to 1997 patients. The trend is preserved when only 1990 to 1997 patients are considered; however, the effect is more marked, ranging from RR = 0.81 (100 to 199 patients) to 0.54 (≥500 category). For 1990 to 1997 patients, the effect changed little upon adjustment for comorbid conditions and decreased slightly for categories where they did differ, ranging from RR = 0.78 (100 to 199 patients) down to RR = 0.51 (≥500 patients), with statistical significance attained for all non-referent categories. Regarding TF, the effect based on 1981 to 1997 patients (Table 3) ranged from RR = 1.44 (50 to 59% patients beginning on PD) to RR = 1.97 (≤29%). This effect was maintained and only slightly dampened by considering only 1990 to 1997 patients, ranging from RR = 1.30 (50 to 59% PD) to RR = 1.67 (≤29%). Within the 1990 to 1997 cohorts, covariate and covariate/comorbidity effect estimates for TF were identical.

Note that no discernible trends across center characteristics were observed when mortality and TF rates were examined by cause of death or when specific patient subgroups were examined.

DISCUSSION

As the cumulative number of PD patients treated by a center increased, covariate-adjusted mortality decreased ($P < 0.05$); a smooth dose-response relationship was observed across the six categories ranging from RR = 1

(≤99 PD patients ever treated) to RR = 0.71 (≥500 patients). A statistically significant but weaker association was observed between number of PD patients treated and technique failure. As the percentage of patients initiating dialysis on PD increased, TF rates decreased significantly, with RR = 1.75 for centers with ≤29% (relative to ≥60%) of patients beginning on PD. No association was observed between center academic status and PD mortality or TF rates.

Among outcomes, mortality on PD was our chief interest. Rates of TF were examined because they were also of interest; but also, since mortality and TF "compete" with each other (that is, a patient cannot be counted as both a TF and a death), a covariate's effect on mortality is of limited interpretability unless its effect on TF is assessed also. It could be hypothesized that the decrease in mortality with increasing number of PD patients treated could be the result of high PD use centers being more likely to switch their patients off PD to HD. The same argument could be made against %PD as an initial dialytic modality. However, the fact that adjusted TF rates also were found to decrease significantly offers strong evidence against this hypothesis.

The as-treated method of analysis was used throughout this investigation, wherein patients contribute PD patient time and events only while they are receiving PD. However, the magnitude of our findings is not related to our arbitrarily chosen method of analysis. The most sophisticated means of handling TF when examining

Table 4. Rate ratios based on 1990–97 experience and adjusted for comorbidity

Outcome	Characteristic	1981–97 Covariate-adjusted RR	1990–97 Covariate-adjusted RR	1990–97 Covariate- and comorbidity-adjusted RR	95% CI
Mortality	Cumulative number of PD patients treated				
	≤99	1	1	1	—
	100–199	0.95	0.81	0.78	0.67–0.91
	200–299	0.87	0.73	0.71	0.60–0.84
	300–399	0.85	0.69	0.69	0.57–0.83
	400–499	0.80	0.66	0.63	0.51–0.78
	≥500	0.71	0.54	0.51	0.41–0.64
Technique failure	Percentage of patients initiating dialysis on PD				
	≤29%	1.97	1.67	1.67	1.34–2.07
	30–39%	1.70	1.65	1.65	1.38–1.98
	40–49%	1.71	1.59	1.59	1.35–1.88
	50–59%	1.44	1.30	1.30	1.11–1.52
	≥60%	1	1	1	—

mortality was described in a recent paper by Collins et al [3]. Here, PD patients were censored 60 days following a modality switch, with deaths during the 60-day window attributed back to PD. As an example, when we adopted these methods, the mortality RR's for cumulative PD patient count actually decreased (for example, RR = 0.64 for ≥500 patients compared with RR = 0.71 in Table 2), indicating a strengthening of the effect.

It was postulated a priori that mortality and TF rates would decrease with the number of PD patients previously treated, with the degree of specialization towards PD, and among academic renal centers. Hemodialysis has been available more than 20 years longer than PD, and the latter was once considered by many nephrologists as an inferior form of dialysis. It is possible that nephrologists from centers where a relatively large number of PD patients have been treated were more aggressive in terms of exploiting the numerous advances to patient management since the inception of the modality and its widespread adoption. Examples might include the introduction of new technologies such as Y-set and double-bag systems, which reduce the risk of peritonitis, the delivery of higher clearances and the more effective management of infectious complications, volume status and cardiovascular diseases. It is also possible that through experience centers become more adept at identifying appropriate patients to receive PD. Unfortunately, there are no data to evaluate the extent to which either of these phenomena may underlie our results. Indeed, results from this investigation are mostly of the hypothesis-generating nature, providing a basis for more detailed examination.

The cumulative PD patient count variable served to quantify each renal center's experience with PD. Patient-specific data were only available from 1981 onward (that is, "registered patients"). Thus, we could not succeed in enumerating every single patient who had actually received PD at each center, since patients who initiated PD

prior to January 1, 1981 would not be included. However, the goal was not to count the number of exact number of patients, per se; but to assign the centers to ordered categories. Thus, to the extent that the observed ordering based on registered patients is appropriate, centers were classified correctly. We detected statistically significant associations between cumulative PD count and covariate-adjusted mortality and TF. If misclassification occurred with respect to the ordered categorization of the center-specific numbers of PD patients treated, provided it arose independently of outcome (that is, termed "non-differential misclassification" by epidemiologists [16]), it would have served to bias the RRs toward 1, and, hence resulted in our underestimation of the impact of a center's PD experience on mortality.

The %PD variable represents an attempt to quantify each center's degree of specialization towards PD relative to hemodialysis. A possible source of misclassification arises from the fact that the %PD variable was computed independently of a center's case mix. For example, one renal center might give more emphasis to PD than a second center. However, the second center might have a greater percentage of patients initiating dialysis on PD because the first has a greater percentage of patients whose health contra-indicates assignment to PD. Although adjusting the %PD variable was indeed an option, it was not pursued due to concerns regarding interpretability. That is, unadjusted percentages are more readily interpreted than adjusted odds ratios, particularly since the latter would be measured with respect to an arbitrarily selected reference center whose identity would not be revealed.

Previous investigations of the CORR database reported significant decreases in PD mortality [11] and TF [12] over calendar time. A lack of data on practice patterns meant that the authors could only speculate on the factors that might be responsible for the decrease. A natural hypothesis is that, as calendar time progresses, clinicians

and centers practicing PD gain valuable experience with each patient treated, the cumulative effect of which is improvement in patient outcomes through the development and refinement of patient management strategies. A concern is that cumulative PD patient count is, naturally, a nondecreasing quantity as calendar time progresses. Thus, the calendar time and PD count covariates will exhibit positive correlation. However, the improvement associated with increased PD experience is not an artifact resulting from the correlation between PD patient count and calendar time, since calendar time was adjusted for in the current analysis. The question then arises regarding how much of the improvement over time can be explained away by the PD experience effect. Our results indicate that the PD patient count accounts for only a fraction of the calendar time effect. For example, the adjusted mortality RR for the 1994 to 1997 calendar period (vs. 1981 to 1985), accounting for the cumulative increase in PD patients (data not tabulated) is estimated at 0.71 (0.66, 0.77), compared with that not adjusting for PD count: RR = 0.63 (0.58, 0.67) [11]. Thus, as one might expect, the decrease in PD mortality over time is partly attributable to increased experience with the technique, resulting from the cumulative increase in the number of PD patients treated. However, it cannot be attributed to this factor alone. Thus, advances in PD practices such as improvements in the in the management of infections, low clearances, cardiovascular, and volume status will eventually be introduced in less, as well as more experienced programs. Also, some of the calendar time effect may reflect favorable trends in the patient population (beyond covariates available from the CORR database), perhaps related to factors such as improving diet, better social conditions, and decreased severity of comorbidities.

Naturally, our investigation has some limitations. As recently discussed in detail by Ward and Brier [17], registry databases are inherently limited in terms of the specificity of the information they provide. For example, although the CORR database contains information on various comorbid illnesses, each disease is defined in the dichotomous sense (absent/present). For the main analysis, data from all PD patients on file (1981 to 1997) were used. Comorbidity was not adjusted for since pertinent data were unavailable prior to 1988. Subsequently, attention was restricted to recent (≥1990) experience and adjustment for comorbidity was made, for supplementary analysis of the effect of number of PD patients on mortality and association between %PD and TF. The RRs for PD patient count were markedly increased, implying that more complete data on a center-specific case mix might actually strengthen, not weaken, the estimated association. The RRs for %PD were decreased only slightly, indicating that the effect originally observed was not attributable merely to lack of case mix data. Naturally, comorbidity information collected by CORR is

quite imprecise. Nonetheless, the discrepancy between the covariate- and covariate/comorbidity-adjusted RRs can be used as an indicator of how results would be changed upon incorporation of more precise comorbidity data (for example, severity index).

Our investigation provides evidence that a renal center's experience with PD (measured by the cumulative number of PD patients treated) and degree of specialization toward PD (measured by the percentage of patients initiating dialysis on PD) are strong predictors of outcomes after adjusting for known prognostic factors. Since pertinent data are unavailable, we are unable to assess which specific factors, other than experience, are associated with improved PD outcomes. As such, future studies should examine the decreases in further detail to determine which specific center clinical and operational characteristics (for example, nurse:patient ratio) impact on mortality and TF rate reduction. Despite the value of registry data, this will entail data collection of much greater detail than that typically available from CORR and other renal failure registries. Although an ambitious undertaking, information gained by such an effort will be of great value to the nephrology community, and ultimately to patients who receive PD.

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