Life expectancy, expected years of life lost and survival of hemodialysis and peritoneal dialysis patients

Tze-Wah Kao [1, 2], Jenq-Wen Huang [1], Kuan-Yu Hung [1], Yu-Yin Chang [2], Pau-Chung Chen [2, 3], Chung-Jen Yen [1], Yung-Ming Chen [1], Tzong-Shinn Chu [1], Ming-Shiou Wu [1], Tun-Jun Tsai [1], Kwan-Dun Wu [1], Jung-Der Wang [1, 2, 3]

[1] Department of Internal Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei - Taiwan
[2] Institute of Occupational Medicine and Industrial Hygiene, National Taiwan University College of Public Health, Taipei - Taiwan
[3] Department of Environmental and Occupational Medicine, National Taiwan University Hospital, Taipei - Taiwan

Abstract

Background: **Expected years of life lost (EYLL) in dialysis patients are rarely discussed. This study compared life expectancy, EYLL and survival between hemodialysis (HD) and peritoneal dialysis (PD) patients.**
Methods: **Adults who underwent maintenance dialysis at National Taiwan University Hospital from 1995 to 2006 were followed up until December 2007. Kaplan-Meier analysis and a constant excess hazard model were used to estimate and project long-term survival. EYLL was calculated by subtracting the life expectancy of patients from that of age- and sex-matched referents. HD patients were then matched with PD patients on age, sex and diabetes mellitus (DM). Life expectancy, EYLL and survival between the 2 groups were compared. Mortality risks were determined by the Cox model.**
Results: **Before matching, the 305 HD patients were older than the 428 PD patients (62.4 ± 13.7 vs. 53.1 ± 16.7 years; p<0.0001). More HD patients had DM (HD vs. PD, 29.2% vs. 20.6%; p=0.0072). Life expectancy and EYLL of HD patients were 8.8 and 11.5 years, compared with those of PD patients (19.9 and 7.4 years). After matching, life expectancy (p=0.790) and EYLL (p=0.793) of both groups (236 patients each) were similar. Age (adjusted hazard ratio [AHR] = 1.07; 95% confidence interval [95% CI], 1.05-1.09) and DM (AHR=3.81; 95% CI, 2.28-6.36) were independent mortality predictors. For diabetic patients who underwent HD, a better survival rate was observed (AHR=0.24; 95% CI, 0.11-0.53).**
Conclusions: **After matching, HD and PD patients had similar life expectancy and EYLL. Survival was better for diabetic patients if they received HD.**

Key words: *Hemodialysis, Life expectancy, Peritoneal dialysis, Survival*

Introduction

End-stage renal disease (ESRD) has been recognized as an emerging clinical problem all over the world. In Taiwan, the incidence rate increased from 375 per million population (PMP) in 2004 to 404 PMP in 2005, whereas the prevalence rate increased from 1,706 PMP in 2004 to 1,830 PMP in 2005 (1). Under the new policy of cost containment of the National Health Insurance of Taiwan, peritoneal dialysis (PD) has been promoted mainly due to its lower expenditure compared with hemodialysis (HD). PD may also be superior to HD in other aspects. PD preserves residual renal function better (2-4) and is associated with higher scores for quality of life (5, 6). In terms of survival, however, the results seem inconsistent. Some studies suggested a survival advantage of PD over HD (7, 8), but others reported that HD patients lived longer than PD patients (9, 10). Similarity in survival was seen in some investigations (11, 12); yet another analysis showed that PD survival was better only at an earlier stage of the dialysis course (13). Although there was a previous study with a big sample size conducted in Taiwan (14), neither that study nor the above-mentioned ones were randomized clinical trials. As choice of renal replacement therapy often depends on the decision of both patients and medical staff, and thus involves an unavoidable selection bias, more outcome studies with longer follow-up periods are needed to draw any conclusion.
Prevention over treatment is not generally practiced. For example, despite the evidence of health benefit from early referral of chronic kidney disease patients to nephrologist care (15), such practice is limited. As the lifelong costs of renal replacement therapy for ESRD patients are

tremendous (16), the estimation of expected years of life lost (EYLL), which is useful for the quantification of potential health benefits gained by prevention, becomes of utmost importance. Moreover, the data of EYLL can be integrated into the cost-effectiveness analysis of both proactive and reactive preventions of ESRD. The purpose of this study was to determine the life expectancy, EYLL and survival between HD and PD patients treated at a tertiary medical center where, theoretically, the best medical care has been given to ESRD patients.

Subjects and methods

ESRD patients registered at the National Taiwan University Hospital from 1995 to 2006 were included. Patients who were younger than 18 years of age or had received dialysis for fewer than 3 months were excluded. Basic demographic characteristics were identified. All patients were followed up until the end of 2007 and linked to the National Mortality Database. In the analysis of patient survival, only death was considered as a final event. Patients who dropped out due to other reasons were censored.

Baseline characteristics between HD and PD patients were compared using the independent *t*-test for continuous variables and the chi-square test for categorical variables. A 2-sided p of 0.05 was the cutoff value for statistical significance. The follow-up data were analyzed by the Kaplan-Meier method (17) to yield the estimated survival functions for both HD and PD patients. A constant excess hazard model was used to project the long-term survival of these patients via a newly developed semiparametric method of linear extrapolation from a logit-transformed curve of the survival ratio between HD/PD patients and their age- and sex-matched reference populations. The survival functions of the reference populations generated by the Monte Carlo method (18) were based on the 2005 Life Table of Taiwanese Population (19). Life expectancy was estimated by extrapolating the survival curves to 50 years after the initiation of dialysis, while EYLL was calculated by subtracting the life expectancies of PD/HD patients from those of their corresponding age- and sex-matched general populations. The methodological details have been described previously (20), and the computer software can be freely downloaded (21).

We then matched our HD patients with PD patients on age (±2 years), sex and diabetic status. Life expectancy, EYLL and survival of the 2 groups were re-compared after matching. Cox model analysis and log-rank test were performed to determine the predictors of mortality.

All analyses were conducted using the SAS system, version 9.1 (SAS Institute, Inc., Cary, NC, USA), and the study was approved by the institutional review board of the hospital.

TABLE I
DEMOGRAPHIC CHARACTERISTICS OF STUDY SUBJECTS ON MAINTENANCE HEMODIALYSIS (HD) OR PERITONEAL DIALYSIS (PD), BEFORE AND AFTER MATCHING FOR AGE, SEX AND COMORBID DIABETES MELLITUS (DM)

Characteristics	HD	PD	p Value
Part A. Before matching			
Number	305	428	
Age, years, mean ± SD	62.4 ± 13.7	53.1 ± 16.7	<0.001
Male sex (%)	161 (52.8%)	200 (46.7%)	0.11
Cause of renal failure, number (%)			
Non-DM	216 (70.8%)	340 (79.4%)	<0.01
DM	89 (29.2%)	88 (20.6%)	
Part B. After matching			
Number	236	236	
Age, years, mean ± SD	60.0 ± 13.8	60.0 ± 13.9	0.9
Male sex (%)	111 (48.3%)	111 (48.3%)	1.0
Cause of renal failure, number (%)			
Non-DM	171 (72.5%)	171 (72.5%)	1.0
DM	65 (27.5%)	65 (27.5%)	

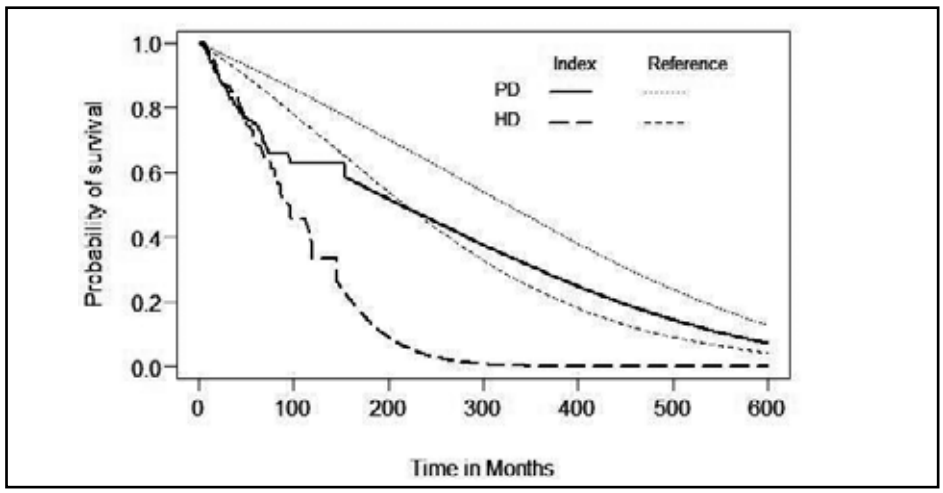


Fig. 1 - Comparison of lifetime survival curves between cohorts of hemodialysis (HD) and peritoneal dialysis (PD) and their respective reference populations before matching.

Results

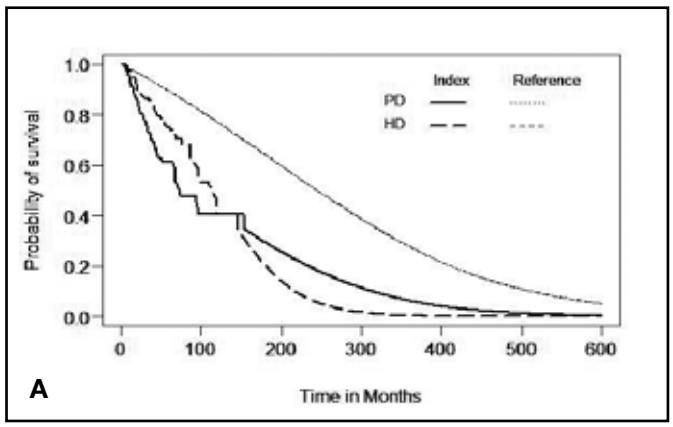
The underlying demographic characteristics of all eligible patients before matching are summarized in Table I (part A). There were 305 HD patients and 428 PD patients. All HD patients received conventional hemodialysis, and most PD patients (around 90%) received continuous ambulatory peritoneal dialysis. The HD patients (mean age 62.4 ± 13.7 years) were older than the PD patients (mean age 53.1 ± 16.7 years) (p<0.001); and more of the HD patients had diabetes mellitus (DM) (29.2% of HD patients vs. 20.6% of PD patients, p<0.01). The 2 groups had similar sex distributions, were in general adequately dialyzed and had mean hemoglobin levels more than 9.5 g/dL.

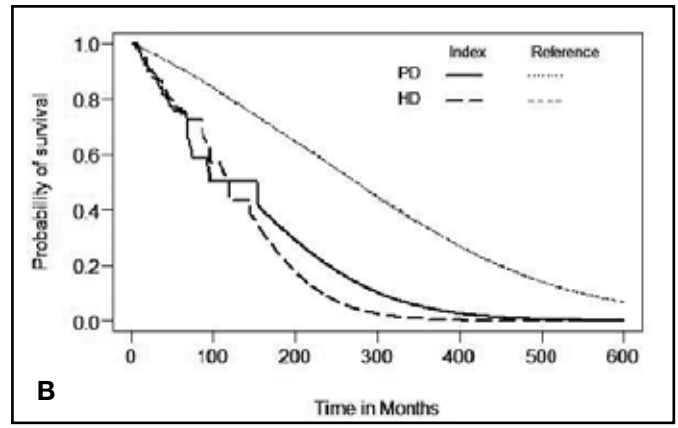
Before matching, as shown in Table II (part A), the life expectancy of HD patients was shorter than that of PD patients (8.8 ± 0.8 years vs. 19.9 ± 2.7 years, p<0.001), while a similar EYLL was found in the 2 groups (HD vs. PD: 11.5 years vs. 7.4 years, p=0.21). Life expectancies of both HD and PD patients were markedly shorter than their age- and sex-matched referents. As shown by the Kaplan-Meier curves in Figure 1, the long-term survival of HD patients was demonstrated to be worse than that of PD patients before matching.

After matching, 236 pairs of HD and PD patients were generated (Tab. I, part B). No statistical difference in life expectancy (HD vs. PD: 9.9 ± 2.1 years vs. 10.9 ± 2.6 years, p=0.79) or in EYLL (HD vs. PD: 12.0 years vs. 11.1 years, p=0.79) was found between the 2 groups (Tab. II,

TABLE II
COMPARISON OF LIFE EXPECTANCY AND EXPECTED YEARS OF LIFE LOST (EYLL) BETWEEN PATIENTS ON MAINTENANCE HEMODIALYSIS (HD) AND THOSE ON PERITONEAL DIALYSIS (PD), BEFORE AND AFTER MATCHING

	HD	PD	p Value
Part A. Before matching			
Number	305	428	
Life expectancy (years)	8.8 ± 0.8	19.9 ± 2.7	<0.001
Life expectancy of referents (years)	20.3 ± 0.05	27.3 ± 0.05	
Expected years of life lost (EYLL)	11.5	7.4	0.21
Part B. After matching			
Number	236	236	
Life expectancy (years)	9.9 ± 2.1	10.9 ± 2.6	0.79
Life expectancy of referents (years)	22.0 ± 0.05	22.0 ± 0.046	
Expected years of life lost (EYLL)	12.0	11.1	0.79





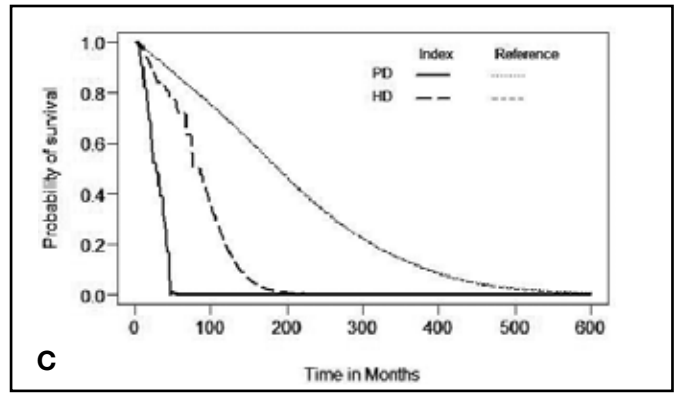


Fig. 2 - Comparison of lifetime survival curves between cohorts of hemodialysis (HD) and peritoneal dialysis (PD) patients and their respective reference populations after matching for age, sex and comorbid diabetes mellitus (DM) in all patients studied (A), and between only those patients without DM (B) and only those with DM (C).

part B). The Kaplan-Meier survival curves for both HD and PD patients after matching are illustrated in Figure 2A. These 2 curves crossed each other at the time point of 120 months. There was an initial survival advantage of HD patients over PD patients ($p<0.01$) before the crossing point, whereas PD patients showed better survival after that point. When long-term survivals up to 600 months extrapolated by the Monte Carlo method were compared, no statistical difference was observed between HD and PD patients. Similarly, when only those patients without DM were compared, there was no survival difference between the 2 groups (Fig. 2B). However, if the patients had DM, those treated with HD exhibited better survival than those with PD (Fig. 2C). As expected, both HD and PD patients had worse survival than their respective referents before (Fig. 1) and after matching (Fig. 2).

Table III shows the impact of age, sex, DM and dialysis

TABLE III
IMPACT OF AGE, SEX, DIABETES MELLITUS (DM) AND DIALYSIS MODALITY ON SURVIVAL OF OUR DIALYSIS PATIENTS

	Adjusted hazard ratio (95% CI)	p Value
Age	1.07 (1.05-1.09)	<0.001
Sex, male/female	0.81 (0.56-1.17)	0.26
Cause of renal failure DM versus no DM	3.81(2.28-6.36)	<0.001
HD versus PD	0.73 (0.45-1.17)	0.19
Interaction HD*DM	0.24 (0.11-0.53)	<0.001

HD = hemodialysis; PD = peritoneal dialysis.

modality on survival of our dialysis patients. Age (adjusted hazard ratio [AHR] = 1.07; 95% confidence interval [95% CI], 1.05-1.09) and DM (AHR=3.81; 95% CI, 2.28-6.36) were significant predictors of mortality. For patients with DM, survival was better if they received HD rather than PD (AHR=0.24; 95% CI, 0.11-0.53).

Discussion

As dialysis imposes a financial burden, policy makers must be informed about the cost-effectiveness of PD versus HD, especially when universal coverage is sought (22). Whether HD or PD is better in terms of patient survival has long been under debate because all previous results were not produced from large randomized clinical trials. Different combinations of potential confounders that influence the validity of comparison were also questioned. It is difficult to conduct long-term randomized controlled studies because the choice of dialysis modality depends not only on the wish of the patients, but also on the preference of the caretakers, the expertise of the attending physicians, the accessibility of the dialysis centers and the policy of the government. In this study, we initially demonstrated that the life expectancy of PD patients was statistically longer than that of HD patients. The difference disappeared when we limited the comparison to 236 matched pairs of patients. That indicated that the initial difference was related to confounding factors, especially age and DM.

To solve the aforementioned problems, we utilized the methods of matching and extrapolation and accomplished a 13-year follow-up. First of all, the patients were matched on age, sex and DM, as these factors significantly affect the survival of dialysis patients (23-25). Secondly, the Monte Carlo method of EYLL estimation incorporated real mortality data of the general population based on vital statistics, instead of assuming an arbitrarily chosen potential limit of life such as 65 years, to ensure more accurate estimates (26). Thirdly, this semiparametric method employed has been proven to give more robust extrapolations than, for example, the Weibull model (27). As our follow-up period was longer than that of previous investigations (7-14), and the comparison was performed with controls for major confounding factors, the results of our study are valid and reliable. We concluded that life expectancy and EYLL for HD and PD patients were not significantly different in Taiwan. Ways to further prolong life expectancy of dialysis patients should be sought in the future, but screening for solid organ cancers in those patients with a life expectancy of 10 years or longer is suggested (28).

This study first provides evidence for life-years gained from successful prevention of ESRD through a long-term follow-up plus a novel extrapolation method. The outcome factually indicates that compared with his/her age- and sex-matched referents, a patient on maintenance dialysis will lose 11-12 life-years on average. Future studies can focus on the exact costs for the prevention of ESRD. Comparison of costs per life-year or quality-adjusted life-year of these patients may also be performed.

By using the Cox model and Kaplan-Meier curves, we demonstrated that for DM patients, HD was superior to PD in terms of survival benefit. There were 2 possible reasons. Firstly, control of DM was more difficult for PD patients due to the elevation of blood sugar caused by peritoneal glucose absorption from glucose-based dialysate (29). That was especially true in previous years when icodextrin dialysate was seldom used in our hospital. Secondly, as HD patients receive dialysis treatment 3 times a week, they usually get more intensive medical care than PD patients. More patient education and earlier correction of other medical problems in diabetic HD patients probably contributed to their longer survival (30, 31). Future improvements in care of diabetic PD patients might reduce such a gap.

Our study had some limitations. As other studies, ours was not a randomized clinical trial, and its control of confounding was limited to prognostic factors that were known previously. Moreover, our patient number might not be large enough. To avoid potential confounding, we treated any switch of renal replacement therapy as censored, which limited the proportion of study patients. A larger cohort is indicated to corroborate our findings in the future.

In conclusion, life expectancy and EYLL were similar between matched HD and PD patients in Taiwan. Age and DM were predictors of mortality. For patients with DM, survival was better if they received HD. On average, 11-12 life-years could be gained from successful prevention of a case of ESRD.

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Address for correspondence:
Prof. Jung-Der Wang
Institute of Occupational Medicine and Industrial Hygiene
College of Public Health
National Taiwan University
No. 17, Shiujou Road
Taipei 100, Taiwan
jdwang@ntu.edu.tw

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