Survival Rate of Renal Replacement Therapy Patients in Charoenkrung Pracharak Hospital

Kamonrat Chongthanakorn MD[1]

[1] Nephrology Unit, Department of Medicine, Charoenkrung Pracharak Hospital, Bangkok Metropolitan Administration, Bangkok, Thailand.

* Corresponding author, e-mail address: kamonratmed@gmail.com

Vajira Med J. 2018;62(1): 9-20

http://dx.doi.org/10.14456/vmj.2018.6

Abstract

Objective: This study aimed to analyze survival data and the factors associated with treatment outcomes in end-stage renal disease (ESRD) patients.

Methods: This was a retrospective analysis of survival data in a single-center cohort of 337 ESRD patients between 2009 and 2015. The database of medical records such as baseline demographics, comorbidities and mortality data were analyzed by cox-regression analysis and Kaplan-Meier analysis.

Results: One hundred seventy-four (51.6%) patients were male and 163 (48.4%) patients were female. 181(53.7%) patients were on continuous ambulatory peritoneal dialysis (CAPD), 156 (36.3%) patients were on hemodialysis (HD), 153 (45.4%) patients started renal replacement therapy (RRT) at eGFRs between 3.01-5.99 cc/min/1.73m^2, 130 (38.6%) patients started RRT at eGFR more than 6 cc/min/1.73m^2, and 54 (16%) patients started RRT at eGFR below 3 cc/min/1.73m^2. As for laboratory results, hematocrit level was 29 ± 5.4%, serum calcium was 8.7 ± 1.3 mg/dL, serum phosphate was 4.5 ± 2.8 mg/dL, and intact parathyroid was 464.4 ± 556.8 pg/mL. The average duration of treatment in HD patients (773.8 ± 544.8 days) was statistically significantly higher than the average duration of treatment in CAPD patients (567.5 ± 556.8 days); the risk of death was higher in patients initiating dialysis with CAPD than those initiating dialysis with HD (hazard ratio (HR) = 7.86; 95% confidence interval (CI) 2.56–21.13; p<0.001). Patients over 60 years old had a higher risk of death compared to those younger than 60 (HR = 3.32; 95% CI 1.23-8.91; p<0.05).

Conclusion: ESRD patients, initiating dialysis with HD had better survival outcomes than those initiating dialysis with CAPD. These findings were potentially confounded by many factors. Randomized controlled trials should be conducted as well as matching in subjects should be carried out to answer this question.

Keywords: hemodialysis, continuous ambulatory peritoneal dialysis, survival analysis, dialysis modality

อัตราการรอดชีวิตในผู้ป่วยไตวายเรื้อรังระยะสุดท้าย ที่ได้รับการบำบัดทดแทนไต ณ โรงพยาบาลเจริญกรุงประชารักษ์

กมลรัชฎ์ จงธนากร พ.บ.[1]

[1] หน่วยโรคไต โรงพยาบาลเจริญกรุงประชารักษ์ สำนักการแพทย์ กรุงเทพมหานคร ประเทศไทย

* ผู้ติดต่อ, อีเมล์: kamonratmed@gmail.com

Vajira Med J. 2018; 62(1): 9-20

http://dx.doi.org/10.14456/vmj.2018.6

บทคัดย่อ

วัตถุประสงค์: การบำบัดทดแทนไตเป็นวิธีมาตรฐานในการรักษาผู้ป่วยไตวายเรื้อรังระยะสุดท้าย การศึกษานี้ทำการวิเคราะห์เพื่อทราบถึงอัตราการรอดชีวิตของผู้ป่วยไตเรื้อรังที่รับการบำบัดทดแทนไตและปัจจัยที่มีผลต่อผลสำเร็จของการรักษาของผู้ป่วยไตเรื้อรังที่รับการบำบัดทดแทนไตของโรงพยาบาลเจริญกรุงประชารักษ์

วิธีดำเนินการวิจัย: การศึกษานี้เป็นการศึกษาย้อนหลังในกลุ่มผู้ป่วยที่ได้รับการวินิจฉัยเป็นไตวายเรื้อรังระยะสุดท้ายและได้รับการบำบัดทดแทนไต จำนวน 337 ราย โดยใช้ข้อมูลพื้นฐาน โรคร่วมของผู้ป่วย ระยะเวลาเริ่มการบำบัดทดแทนไต และผลการบำบัดทดแทนไต มาวิเคราะห์ปัจจัยที่มีผลต่อความอยู่รอดของผู้ป่วย ใช้วิธี Cox regression analysis และเปรียบเทียบระยะเวลาการรอดชีวิตของผู้ป่วยโดยใช้ Kaplan-Meier analysis

ผลการวิจัย: ผู้ป่วยจำนวน 174 รายเป็นเพศชาย (51.6%) และจำนวน 163 รายเป็นเพศหญิง (48.4%) ผู้ป่วยจำนวน 181 รายได้รับการล้างไตทางช่องท้อง (53.7%) และผู้ป่วยจำนวน 156 รายฟอกเลือดด้วยเครื่องไตเทียม (36.3%) ผู้ป่วยมีระดับความเข้มข้นเลือดเฉลี่ย ร้อยละ 29 ± 5.4 ระดับแคลเซียม 8.7 ± 1.3 มก.ต่อดล. ระดับฟอสฟอรัส 4.5 ± 2.8 มก.ต่อดล. ระดับพาราไทรอยด์ฮอร์โมน 464.4 ± 511.9 พก.ต่อดล.ผู้ป่วยไตวายเรื้อรังที่ได้รับการฟอกเลือดด้วยเครื่องไตเทียมมีระยะเวลาการรักษาเฉลี่ย 773.8 ± 544.8 วัน ซึ่งสูงกว่าระยะเวลาการรักษาเฉลี่ยของผู้ป่วยไตวายเรื้อรังที่ได้รับล้างไตทางช่องท้องที่ 567.5 ± 556.8 วัน อย่างมีนัยสำคัญทางสถิติ พบว่าผู้ป่วยไตวายเรื้อรังที่ได้รับการล้างไตทางช่องท้องมีความเสี่ยงต่อการเสียชีวิตสูงกว่าอย่างมีนัยสำคัญทางสถิติ โดยมีค่า hazard ratio (HR) 7.86 (95%CI 2.56–21.13) และผู้ป่วยอายุมากกว่า 60 ปีมีความเสี่ยงต่อการเสียชีวิตสูงกว่าอย่างมีนัยสำคัญทางสถิติ โดยมีค่า HR 3.32 (95%CI 1.23-8.91)

วิจารณ์ การศึกษานี้พบว่าผู้ป่วยไตวายเรื้อรังที่ได้รับการฟอกเลือดด้วยเครื่องไตเทียมมีอัตราการเสียชีวิตมากกว่าผู้ป่วยไตวายเรื้อรังที่ได้รับการฟอกไตทางช่องท้อง ทั้งนี้มีปัจจัยต่าง ๆ ที่ส่งผลต่อผลอัตราการเสียชีวิตของผู้ป่วย เพื่อตอบคำถามนี้ควรทำการศึกษาเพิ่มเติมโดยออกแบบการศึกษาให้มีการควบคุมปัจจัยต่าง ๆ ของผู้ป่วยไตวายเรื้อรังทั้งสองกลุ่ม เพื่อลดความลำเอียงของการวิจัยจะทำให้ทราบความแตกต่างของผลการรักษาทั้งสองวิธี

Introduction

End-stage renal disease (ESRD) has become a significant and growing public health problem worldwide. The global average prevalence of ESRD patients on dialysis was 215 per million population[1]. The prevalence of chronic kidney disease (CKD) is high in Thailand. Awareness of CKD in the general Thai population is quite low[2], leading to the prevalence of end stage renal disease (ESRD) in Thailand[3]. Continuous ambulatory peritoneal dialysis (CAPD), and Hemodialysis (HD) are standard treatments in this group of patients[4]. Many factors play roles that are associated with patient outcomes[5-9]: age, gender, race, comorbid disease, complications of treatment, and mode of dialysis. Two modes of dialysis are CAPD and HD. The mortality of ESRD patients who are treated with these two modalities has been investigated in numerous studies[10-25]. It is still not clear which dialysis modality performs better to prolong life of ESRD patients. Some studies showed HD had superior outcomes to CAPD mode[10-14], whereas others demonstrated that CAPD was equivalent to HD[15-19], or CAPD had a better outcome[5,20-22]. There are other benefits of CAPD such as the economic aspect; CAPD is a cost saving therapy compared to HD[23-25]. There is still a lack of survival data about treatment in this group of patients in Thailand.

Charoenkrug Pracharak Hospital is a tertiary hospital affiliated with Bangkok Administration. The hospital provides treatment to ESRD patients by performing both dialysis modalities, CAPD and HD. In this study, we aimed to find the factors associated with treatment outcomes in ESRD patients.

Methods

We performed a retrospective analysis of medical data of ESRD patients, aged > 15-years-old, who started RRT in Charoenkrug Pracharak Hospital from 1st October 2009 to 31st December 2015. CAPD time was counted after patients started full dose of 4 cycles of dialysis/day. HD time was counted after first hemodialysis was performed. Patients were followed up for a maximum of 6 years. We excluded the patients who received a kidney transplant (5 patients), changed mode of dialysis (22 patients), or who withdrew from dialysis during the studying period (2 patients). We recorded baseline demographic characteristics: age, gender, payment; co-morbidity conditions at dialysis initiation such as diabetes mellitus (DM), hypertension, hyperlipidemia, history of myocardial infarction or established coronary artery disease, cerebral vascular disease; laboratory tests at dialysis initiation time, blood urea nitrogen (BUN) level, serum creatinine (Cr), and estimated glomerular filtration rate (eGFR) by using CKD-EPI equation[26]. Patients who had a history of myocardial infarction or established coronary artery disease, or coronary heart disease (CHD) risk equivalents,[27] such as diabetes, cerebral vascular disease (either ischemic or hemorrhagic stroke) were defined as having high risk of cardiovascular disease in this study. Laboratory and clinical outcomes, hematocrit, calcium, phosphate, intact parathyroid hormone (iPTH), adequacy of RRT, hospitalization, and mortality were recorded. Information about death (died/living and date of death) were obtained from medical records review, and survival status was confirmed by using official death registration documents. In this study blood testing was completed by laboratories certified by The Medical Technology Council Organization, while data was collected from the hospital's computer. The study protocol was approved by Bangkok Administration Human Research Ethical Committees.

Statistical analysis

Categorical variable data such as gender, mode of dialysis, renal replacement therapy, reimbursement type, comorbidities, eGFR at starting renal replacement therapy, and adequacy of dialysis were summarized as a proportion. Continuous variable data such as age, duration of treatment, number of admissions, and laboratory measurements such as hematocrit, serum calcium, serum phosphate, and intact parathyroid level were summarized by mean with standard deviation or

median with range. Differences between categorical variables were evaluated by chi-squared test. Survival analysis and difference of survival outcomes among treatments and subgroups were completed by using Kaplan-Meier analysis and Log-rank test. Multivariate Cox proportional hazard regression model was employed to examine the effect of mode of treatment and covariates on survival status. Statistical significance was considered only if $p < 0.05$.

Results

Demographic data

Three hundred thirty-seven ESRD patients were enrolled in this study, 174 (51.6%) were male and 163 (48.4%) were female. 181 (53.7%) patients were on CAPD, 156 (36.3%) patients were on HD. The baseline characteristics of the included patients are presented in Table 1. Laboratory and clinical outcomes of patients, duration of treatment, number of hospitalizations, laboratory tests, and adequacy of RRT are presented in Table 2.

Table 1:

Baseline characteristics of patients

Variable	mean ± SD	n	%
Age (years)	59.9 ± 14.1	337/337	100.0
Comorbidity			
• Hypertension	-	223/336	96.1
• DM	-	177/337	52.5
• Hyperlipidemia	-	143/337	42.4
• CAD	-	88/337	26.1
• Stroke	-	35/337	10.4
• CGN	-	25/337	7.4
• Gout	-	25/337	7.4
• ADPKD	-	7/337	2.1
• Renal stone	-	5/337	1.5
Renal replacement therapy reimbursement type			
• UCS	-	233/337	69.1
• Self-payment	-	50/337	14.8
• SSS	-	34/337	10.1
• Civil Servant Medical Benefit Scheme	-	20/337	6.0
eGFR at start of renal replacement therapy (cc/min/1.73m^2)			
• <=3.00	2.55 ± 0.49	54/337	16.0
• 3.01-5.99	4.52 ± 0.86	153/337	45.4
• >=6.00	8.1 ± 4.1	130/337	38.6

Table 2:

Clinical and laboratories outcome of patients

Laboratories	Mean ± SD	x	%
Duration of treatment (days)	678.3 ± 559.1		
Number of admissions per 1 year	5.4 ± 28.8		
Hematocrit (%)	29.1 ± 5.4		
Serum Calcium (mg/dL)	8.7 ± 1.3		
Serum Phosphate (mg/dL)	4.5 ± 2.8		
Intact parathyroid hormone (pg/mL)	464.4 ± 511.9		
Adequacy of renal replacement therapy			
• Inadequate	-	40/281	14.2
• Adequate	-	241/281	85.8

Comparison of mode of renal replacement therapy

The average duration of treatment in HD patients (773.8 days) was statistically significantly higher than CAPD patients (567.5 days). The hematocrit in HD patients (30.5%) was statistically significantly higher than in CAPD patients (27.5%), serum calcium was statistically significantly higher in HD patients than CAPD patients: 9.0mg/dL and 8.4mg/dL respectively. Intact parathyroid levels were statistically significantly higher in HD patients than CAPD patients: 581(pg/mL) and 293 (pg/mL) respectively. There were no statistically significant differences in serum Phosphate in both groups (See Table 3).

Fig. 1 shows Kaplan-Meier actuarial survival. Fifty percent of patients in this study had a survival rate with 1,528 days of treatment. The poor survival rate was recognized in CAPD patients, patients over 60 years old, DM patients, patients at high risk of cardiovascular disease, patients who started RRT at eGFR below 3 cc/min/1.73m^2, patients who received inadequate renal replacement therapy parameters with significant statistical analysis, as in Figure 2. There were no statistical significant differences in survival of genders, and the frequencies of hospitalizations.

To determine the hazard ratio, Cox-regression analysis is shown in Table 4. Factors relating to survival rates in this study were CAPD, age over 60 years old, and lower serum Calcium were significant independent predictors for mortality. Hazard ratios were 7.9, 3.3, and 0.6 respectively with statistical significance of p<.01, <.05, and <.01 respectively. Gender, comorbidities, adequacy of treatment, eGFR at start of RRT, hematocrit, serum Phosphate, and intact parathyroid were not significant independent predictors of survival in this study.

Table 3:

Comparison of outcomes between modes of renal replacement therapy

Variable	PD	HD	P_value
	mean ± SD	mean ± SD	
Duration of treatment (days)[a]	567.5 ± 556.8	773.8 ± 544.8	0.001**
Hematocrit (%)[a]	27.5 ± 5.4	30.5 ± 4.9	<0.001**
Serum calcium (mg/dL)[a]	8.4 ± 1.5	9.0 ± 1.0	<0.001**
Serum PO_4 (mg/dL)[a]	4.6 ± 3.8	4.5 ± 1.5	0.787ns
Intact parathyroid (pg/mL)[a]	293.2±243.4	581.2±606.4	<0.001**

a = t-test **=highly significantly different ns = no significantly different

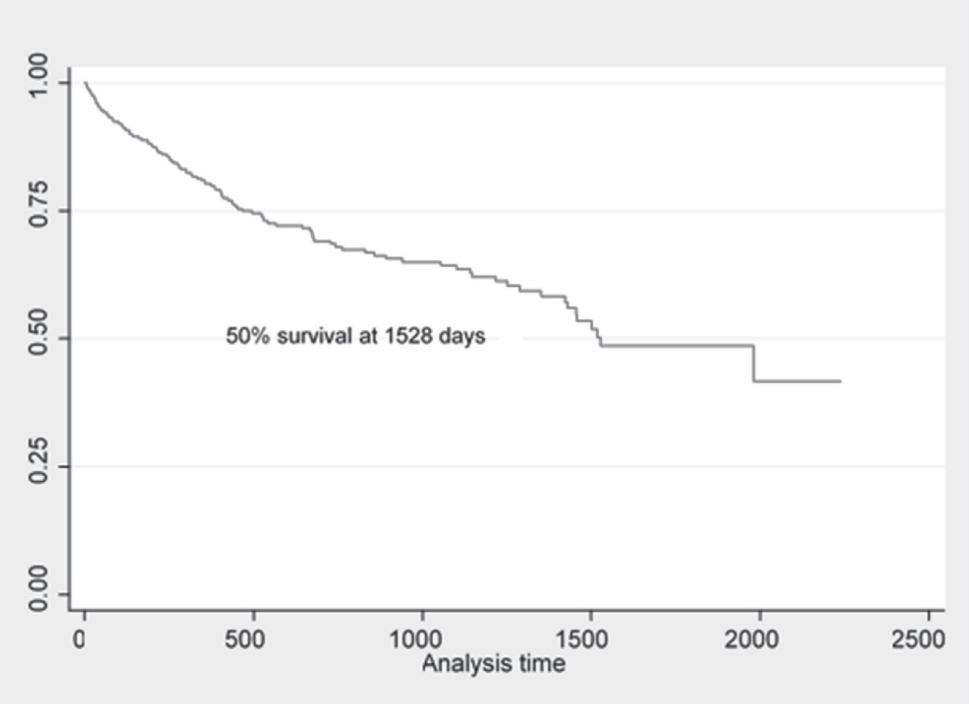

Figure 1: Kaplan-Meier survival estimates total times of ESRD patients.

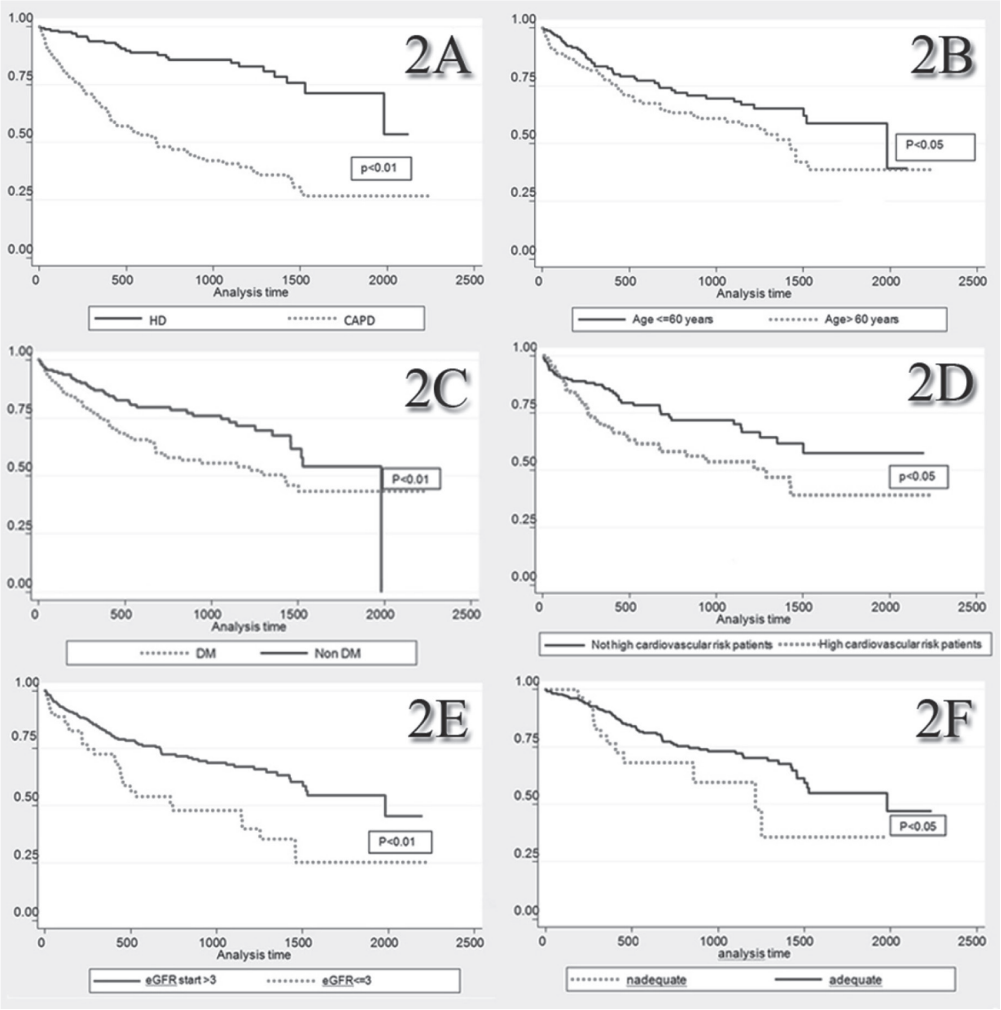

Figure 2: Kaplan-Meier survival estimates mode of renal replacement therapy; HD compared to CAPD (A), age of patients; over 60 year old patients compared to 60 or lower 60 year old patients (B), DM compared to non DM patients (C), high risk of cardiovascular disease compared to not high risk of cardiovascular disease patients (D), time to starting RRT at eGFR =3 or <3 cc/min/1.73m^2 compared to eGFR >3cc/min/1.73m^2 (E), adequate and inadequate RRT dose patients(F).

Table 4:

Hazard ratios for risk of death for patients initiating CAPD compared with those initiating HD

Variable	Hazard ratio	95%CI	P-VALUE
CAPD modality	7.86	2.57- 24.13	0.000*
Age >60 years	3.32	1.23-8.90	0.017$^+$
Serum Calcium	0.61	0.44-0.88	0.007*

*P<0.01 +p<0.05; HR: hazard ratio, HD: hemodialysis, CAPD: continuous ambulatory peritoneal dialysis

Discussion

In this study, we evaluated survival rates in ESRD patients initiating dialysis at Charoenkrug Pracharak Hospital. 50% of patients survived more than 4 years after initiation of dialysis. We showed that HD would lead to better survival rates compared to CAPD. This issue is controversial, depending on many factors. Many studies have shown the benefit in survival of HD[10-14] as in this study. On the other hand, many studies have shown the benefit of CAPD or reported the equal outcome of both modalities[15-22]. The inconstancy of CAPD and HD outcomes has been debased in many studies. Many factors have contributed to this effect. Comorbidity was one of the biggest factors associated with the outcome of renal replacement therapy. The data from the Choices for Healthy Outcomes in Caring for ESRD (CHOICE) cohort study,[21] which showed a better outcome in CAPD group would simply reflect the self- or physician-directed selection of healthier patients to CAPD. There was a report from Canada, which showed a survival advantage with peritoneal dialysis due to lower comorbidity.[22] This data was emphasized in a report from an South-East Asian country. In that study CAPD was the modality that nephrologists tended to recommend for patients with severe comorbidities such as weak cardiac function, or for patients with poor performance status, such as assisted activities of daily living or inability to ambulate[14]. Therefore, the outcome of HD was reported as the modality that had a better outcome than CAPD. As in this present study, we could not summarize that HD had a greater survival benefit than CAPD. The ideal way to compare the difference through a randomized controlled trial (RCT) with well controlled confounding factors should be done in the future. It is not surprising that patients over 60 years old had poor outcomes in this study. Patients aged over 60 had a hazard ratio of 3.32, which was statistically significant. This trend of bad outcomes was consistent with that in previous studies. The risk of death with modality varied with age[17]. Dialysis had a relatively increased mortality in older and younger patients, respectively[13]. In the Kaplan-Meier survival curve, comorbidities, especially Diabetes mellitus and cardiovascular risk equivalent, Diabetes mellitus was a disease in which many systems were involved including inflammatory pathways as well as glucose and lipid metabolism. Furthermore, diabetes mellitus was associated with infectious complications and cardiovascular complication. As in patients with a history of cardiovascular disease, stroke, or coronary artery disease, it also showed the poor survival in both groups. This result was confirmed through data from prior studies, which showed the worsening outcome in patients with this comorbidity[5,17,22]. There was also reduced residual renal function at the time of starting renal replacement therapy; more than 60% of patients in this study started RRT at eGFR below 6 cc/min/1.73m^2, and 16% of patients had severe renal failure and started RRT at eGFR below 3 cc/min/1.73m^2. For this reason, CAPD seemed to have bad survival rates compared to HD in this study. The residual renal function has been associated with a lower risk of death among CAPD patients. In a previous study, there were some benefits from CAPD in the first few years compared with HD[28]. This advantage seemed to change risk over time, with an increase in the mortality risk of CAPD compared with HD. Better preservation of residual renal function was associated with CAPD[29]. The benefit of CAPD in the first few years was not observed in our report. There would have been less residual renal function at the time of starting renal replacement therapy. Hence, the low number of residual renal function patients, or eGFR below 3 cc/min/1.73m^2, would be not suitable for CAPD modalities. HD would be the preferred modality for this group of patients. Inadequate dose of renal replacement therapy also showed poor survival in this study. We performed spKt/V and URR as measures of urea kinetic modeling to quantify the delivery of hemodialysis.

As recommended by the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines[30], target spKt/V and URR were 1.2 and 65% respectively for HD patients receiving dialysis 3 times a week. Target spKt/V was 1.8 for HD patients receiving dialysis twice a week[31]. Total Kt/V was 1.7 for CAPD patients[32]. There were better outcomes in patients who reached this target.

We found that HD patients had higher hematocrit levels than CAPD patients. The use of erythropoietin in Thai ESRD patients was recommend and could be reimbursed for all types of patients. The maximum doses permitted were 32,000 units monthly for Universal Coverage Scheme (UCS) reimbursement patients, and 48,000 units monthly for Social Security Scheme (SSS) reimbursement patients. However, for self-paying patients, and Civil Servant Medical Benefit Scheme patients, doses of erythropoietin were adjusted depending on the target hemoglobin level. In prior studies there were no significant differences in hemoglobin level in CAPD and HD patients. But the PD group consumed a lower dose of erythropoietin stimulating agents[33]. A meta-analysis from Japan showed that there were no significant differences in levels of hemoglobin between 2 renal replacement therapy modalities[34]. Lower hematocrit levels the in CAPD group would be from the lower dose of EPO in UCS patients, mainly in CAPD mode.

Chronic kidney disease-mineral bone disorder (CKD-MBD) correlated with morbidity and mortality in ESRD patients[35]. The biochemical assessment f or mineral and bone disorder in our study showed that HD patients had significantly higher mean levels of serum calcium and parathyroid hormone, but there were no significant differences in serum phosphate between modality in this study. Our data, in accordance with previous evidence, showed that patients on CAPD tended to have lower bone turnover and were relatively more hypoparathyroid than those on HD[36]. Many studies showed that high serum calcium was associated with an increased risk of death in dialysis patients[37,38]. But this was not in our data. Lower serum calcium had a significantly higher mortality risk compared to higher serum calcium (hazard ratio was 0.6); this could be due to the fact that the mean serum calcium in all patients, CAPD, and HD patients was 8.7, 8.4 and 9.0 mg/dl respectively. This seemed to be below normal level in CAPD patients and in all patients. The COSMOS study has shown that high and low serum calcium was associated with higher risks of death in dialysis patients[39]. Hence, the lower serum calcium in this study was associated with a worse outcome. This paper did not aim to answer the CKD-MBD disorder; for this question further studies should be done.

There are some limitations in the outcome of our studies. The majority of CAPD patients are in UCS reimbursement, but HD patients are in self-payment, SSS, and Civil Servant Medical Benefit Scheme. This inequality is related to other health factors, such as income of patients, knowledge, and socioeconomic status. This could lead to poor survival rates in the CAPD group. For a better outcome of RRT, an optimal strategy could be an integrated-care approach in which incident dialysis patients initially undergo peritoneal dialysis, transferring to hemodialysis once complications ensue with peritoneal dialysis. HD should be performed for patients with less amount of residual renal function.

Conclusion

Many factors led to poor survival status in the CAPD group in this study, such as reimbursement type, socioeconomic status and the delay of starting RRT. But for evaluating the survival rates between 2 modalities, a randomized controlled trial should be conducted, and subject matching should be done to answer this question.

Acknowledgments

I would like to take this opportunity to acknowledge the contributions of the following individuals to this study: Dr. Patchara Tanateerapong, the nurses and all member in the Dialysis Center at Charoenkrung Pracharak Hospital. I would especially like to thank Dr. Sirasanpang Yodavudh, Chief of the Department of Pathology at Charoenkrung Pracharak Hospital, who provided me with advice on statistics. This work was supported by a grant from Charoenkrung Pracharak Hospital.

Disclosure

The authors declare that there is no conflict of interest in this research.

References

1. Letsios A. The effect of the expenditure increase in the morbidity and the mortality of patients with end stage renal disease: the USA case. Hippokratia. 2011; 15 (Suppl 1): 16–21. Epub 2011/09/08. PMID:21897753; PubMed Central PMCID: PMC3139673
2. Ingsathit A, Thakkinstian A, Chaiprasert A, Sangthawan P, Gojaseni P, Kiattisunthorn K; theThai-SEEK Group. Prevalence and risk factors of chronic kidney disease in the Thai adultpopulation: Thai SEEK study. Nephrol Dial Transplant. 2010; 25: 1567-75.
3. TRT registry sub-committee, The nephrology society of Thailand. Thailand renal replacement therapy registry: Annual report 2014.
4. Fleming GM. Renal replacement therapy review past, present and future. Organogenesis 2011; 7(1): 2-12.
5. United States Renal Data System 2009. Chapter 6: Morbidity and Mortality. [internet]. [Cited 2007 July 20], Available from http://www.usrds.org/adr.htm
6. Collins AJ, Hao W, Xia H, Ebben JP, Everson SE, Constantini EG, Ma JZ. Mortality Risks of Peritoneal Dialysis and Hemodialysis. Am J Kidney Dis. 1999;36:1065-74.
7. Jaar BG, Coresh J, Plantinga LC, Fink NE, Klag MJ, Levey AS, et al. Comparing the Risk for Death with Peritoneal Dialysis and Hemodialysis in a National Cohort of Patients with Chronic Kidney Disease. Ann Intern Med. 2005; 143: 174-83.
8. Chung SH, Han DC, Noh H, Jeon JS, Kwon SH, Lindholm B, et al. Risk factors for mortality in diabetic peritoneal dialysis patients. Nephrol Dial Transplant, 2010;25(11): 3742-8.
9. Murthy B, Molony D, Stack A. Survival Advantage of Hispanic Patients Initiating Dialysis in the United States Is Modified by Race. J Am Soc Nephrol. 2005;16: 782-90.
10. McDonald SP, Marshall MR, Johnson DW, Polkinghorne KR. Relationship between dialysis modality and mortality. J Am Soc Nephrol. 2009; 20(1):155–63.
11. Jaar BG, Coresh J, Plantinga LC, Fink NE, Klag MJ, Levey AS, et al. Comparing the risk for death with peritoneal dialysis and hemodialysis in a national cohort of patients with chronic kidney disease. Ann Intern Med. 2005; 143(3):174–83.
12. Termorshuizen F, Korevaar JC, Dekker FW, Van Manen JG, Boeschoten EW, Krediet RT. Hemodialysis and peritoneal dialysis: comparison of adjusted mortality rates according to the duration of dialysis: analysis of The Netherlands Cooperative Study on the Adequacy of Dialysis 2. J Am Soc Nephrol. 2003; 14(11):2851–60.
13. Kim H, Kim KH, Park K, Kang SW, Yoo TH, Ahn SV, et al. A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. Kidney Int. 2014; 86(5):991–1000.
14. Yang F, Khin LW, Lau T, Chua HR, Vathsala A, Lee E, et al. Hemodialysis versus Peritoneal Dialysis: A Comparison of Survival Outcomes in South-East Asian Patients with End-Stage Renal Disease. PLoS One. 2015;10(10):e0140195
15. Chang YK, Hsu CC, Hwang SJ, Chen PC, Huang CC, Li TC, et al. A comparative assessment of survival between propensity score-matched patients with peritoneal dialysis and hemodialysis in Taiwan. Medicine. 2012; 91(3):144–51.

16. Huang CC, Cheng KF, Wu HDI. Survival analysis: Comparing peritoneal dialysis and hemodialysis in Taiwan. Periton Dial Int. 2008; 28:S15–S20.
17. Maiorca R, Vonesh EF, Cavalli P, De Vecchi A, Giangrande A, La Greca G, et al. A multicenter, selection-adjusted comparison of patient and technique survivals on CAPD and hemodialysis. Perit Dial Int. 1991;11(2):118-27.
18. Locatelli F, Marcelli D, Conte F, D'Amico M, Del Vecchio L, Limido A, et al. Survival and development of cardiovascular disease by modality of treatment in patients with end-stage renal disease. J Am Soc Nephrol. 2001;12(11):2411-7.
19. Yeates K, Zhu N, Vonesh E, Trpeski L, Blake P, Fenton S. Hemodialysis and peritoneal dialysis are associated with similar outcomes for end-stage renal disease treatment in Canada. Nephrol Dial Transplant. 2012;27(9): 3568-75.
20. Heaf JG, Lokkegaard H, Madsen M. Initial survival advantage of peritoneal dialysis relative to haemodialysis. Nephrol Dial Transplant. 2002; 17(1):112–7.
21. Miskulin DC, Meyer KB, Athienites NV, Martin AA, Terrin N. Comorbidity and other factors associated with modality selection in incident dialysis patients: the CHOICE Study. Choices for Healthy Outcomes in Caring for End-Stage Renal Disease. Am J Kidney Dis. 2002;39(2): 324-36
22. Murphy SW, Foley RN, Barrett BJ, Kent GM, Morgan J, Barré P, et al. Comparative mortality of hemodialysis and peritoneal dialysis in Canada. Kidney Int. 2000;57(4):1720-6.
23. Just PM, Riella MC, Tschosik EA, NoeL L, Bhattacharyya SK, de Charro F. Economic evaluations of dialysis treatment modalities. Health Policy. 2008; 86:163-80.
24. Liu FX, Quock TP, John B, Noe L, Inglese G. Economic evaluations of peritoneal dialysis and hemodialysis: 2004-2012. F1000 Res. 2013;2:273.
25. Klarenbach S, Manns B. Economic evaluation of dialysis therapies. Semin Nephrol. 2009;29: 524-32.
26. Levey AS, Stevens LA, Schmid CH, Zhang Y, Castro III AF, Feldman HI, et al. A new equationto estimate glomerular filtration rate. Ann Intern Med. 2009; 150: 604-12.
27. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001; 285: 2486–97.
28. McDonald SP, Marshall MR, Johnson DW, Polkinghorne KR. Relationship between dialysis modality and mortality. J Am Soc Nephrol. 2009;20(1):155-63.
29. Heaf JG, Løkkegaard H, Madsen M. Initial survival advantage of peritoneal dialysis relative to haemodialysis. Nephrol Dial Transplant. 2002; 17(1):112-7.
30. Hemodialysis Adequacy 2015 Work group. KDOQI clinical practice guideline for hemodialysis adequacy: 2015 update. AM J Kidney Dis 2015;66(5): 884-930
31. Krairittichai U, Supaporn T, Aimpun P. Thailand registry patient survival report on chronic hemodialysis. J Am Soc Nephrol. 2005; 16:292A.
32. Lo WK, Barkman JM, Burkart J, Krediet RT, Pollock C, Kawanishi H, et al. ISPD guilelines0 Recommendation: Guideline on targets for solute and fluid removal in adult patients on chronic peritoneal dialysis. Perit Dial Int. 2006; 26:520-2
33. Snyder JJ, Forley RN, Gilberton GT, Vonesh EF, Collins AJ. Hemoglobin levels and erythropoietin doses in hemodialysis and peritoneal dialysis patients in the United States. J Am Soc Nephrol. 2004; 15:174-79
34. Wang WN, Zhang WL, Sun T, Ma FZ, Su S, Zu ZG. Effect of peritoneal dialysis versus hemodialysis on renal anemia in renal in end-stage disease patients: a meta-analysis. Renal Fail. 2015;39(1):59-66

35. Kidney Disease: Improving Global Outcomes (KDIGO) CKD-MBD Work Group. KDIGO clinical practice guideline for the diagnosis, evaluation, prevention, and treatment of chronic kidney disease-mineral and bone disorder (CKD-MBD). Kidney Int. 2009; 76(Suppl 113): S1-S130.
36. Andress DL. Adynamic bone in patients with chronic kidney disease. Kidney Int. 2008; 73: 1345-54.
37. Liu CT, Lin YC, Lin YC, Kao CC, Chen HH, Hsu CC, et al. Roles of Serum Calcium, Phosphorus, PTH and ALP on Mortality in Peritoneal Dialysis Patients: A Nationwide, Population-based Longitudinal Study Using TWRDS 2005–2012. Nature. 2017; 33:1-9.
38. Tentori F, Blayney MJ, Albert JM, Gillespie BW, Kerr PG, Bommer J et al. Mortality risk for dialysis patients with different levels of serum calcium, phosphorus, and PTH: the Dialysis Outcomes and Practice Patterns Study (DOPPS). Am J Kidney Dis 2008; 52:510-30.
39. Fernández-Martín JL, Martínez-Camblor P, Dionisi MP, Floege J, Ketteler M, London G, et al. Improvement of mineral and bone metabolism markers is associated with better survival in haemodialysis patients: the COSMOS study. Nephrol Dial Transplant. 2015; 30: 1542–51.