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ORIGINAL RESEARCH ARTICLE

# Health-Related Quality of Life in Patients Treated with Continuous Ambulatory Peritoneal Dialysis and Automated Peritoneal Dialysis in Singapore

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**Abstract**

*Objective* This study aimed to compare the health-related quality of life (HRQOL) in patients with end-stage renal disease (ESRD) treated with continuous ambulatory peritoneal dialysis (CAPD) and automated peritoneal dialysis (APD) in Singapore.

*Methods* The data used in this study were from two cross-sectional surveys of ESRD patients. HRQOL was assessed using the Kidney Disease Quality of Life (KDQOL) instrument. Socio-demographic characteristics and clinical data were collected. The physical component summary (PCS) and mental component summary (MCS) scores, kidney disease component summary (KDCS) score and its three scales (symptoms, effects, burden), and one health utility score [EuroQol 5-dimension (EQ-5D)] were calculated and compared between CAPD and APD using multivariate linear regression.

*Results* In total, 266 patients were included, with 145 on CAPD (mean age 60.8 years) and 121 on APD (mean age 57.4 years). After adjustment for all variables collected, APD patients had significant higher scores in PCS and KDQOL symptoms than CAPD patients, suggesting that APD was associated with better physical health and milder dialysis-related symptoms.

*Conclusion* The HRQOL of CAPD and APD patients was largely equivalent in Singapore, but APD patients seemed to experience better physical health and be less bothered by dialysis-related symptoms.

**Key Points for Decision Makers**

Peritoneal dialysis (PD) has been used as a practical and widespread alternative to conventional hemodialysis (HD) for end-stage renal disease (ESRD).

There are two forms of PD, continuous ambulatory PD (CAPD) and automated PD (APD). It has been shown that the clinical outcomes for these two PD modalities are comparable, so evidence on health-related quality of life (HRQOL) is important in guiding nephrologists and patients in their choice of PD modality.

The HRQOL of CAPD and APD patients was largely equivalent in Singapore, but APD patients seemed to experience better physical health and be less bothered by dialysis-related symptoms.

## 1 Introduction

Peritoneal dialysis (PD) has been used as a practical and widespread alternative to conventional hemodialysis (HD) for end-stage renal disease (ESRD) because of its

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advantages over HD, e.g., lower costs [1] and increased flexibility in lifestyle [2]. But it remains largely underutilized in most settings [3].

There are two forms of PD, continuous ambulatory PD (CAPD), which involves performing the PD exchanges manually, and automated PD (APD), which refers to all forms of PD using a mechanical device to assist the delivery and drainage of dialysate. It has been shown that the clinical outcomes for these two PD modalities are comparable [4, 5], so evidence on health-related quality of life (HRQOL) is important to contribute to guiding nephrologists and patients in their choice of PD modality. In the provision of healthcare, HRQOL is commonly evaluated, as it provides a good measure of treatment effectiveness by revealing how well an individual is functioning upon treatment [6]. For ESRD patients, HRQOL is an important predictor of clinical outcomes, and poor HRQOL could independently predict death and hospitalization of dialysis patients [7, 8]. As the majority of old and frail patients undergoing dialysis are unlikely to receive kidney transplantation and would most likely remain in dialysis until the end of life, the importance of evaluating HRQOL is even more salient [9]. However, previous work of HRQOL outcomes for PD modalities has produced mixed evidence [10–12]. Furthermore, although there has been an exponential increase in HRQOL research in PD patients with Asian origin or in an Asian setting, most work has mainly compared PD with HD and has not been across PD modalities [2, 13, 14].

Therefore, this study aimed to evaluate HRQOL between PD modalities and to explore factors which could affect their HRQOL.

## 2 Methods

### 2.1 Patients and Data

Data used in this study were from two cross-sectional surveys, conducted between 2009 [15] and 2013 [16]. Participants were recruited from the PD center of Singapore General Hospital between 2009 and 2011 and from the renal center of the National University Hospital between 2012 and 2013. In both surveys, patients were approached by trained interviewers while awaiting consultation with a nephrologist. HRQOL data were collected using the kidney disease-specific HRQOL instrument Kidney Disease Quality of Life-Short Form (KDQOL-SF) in the first survey and its abridged version, the 36-item KDQOL (KDQOL-36), in the second survey, respectively. Socio-demographic characteristics were self-reported, and clinical data including co-morbidities measured using the Charlson Comorbidity Index (CCI), serum albumin and hemoglobin, dialysis vintage (i.e., time on dialysis), dependency status (i.e., self-care/assisted) and dialysis adequacy (i.e., Kt/V) were retrieved from medical records. Patients were included if they were aged $\geq$ 21-year-old, on PD $\geq$ 3 months, and able to communicate verbally and provide informed consent. This study was approved by the Institutional Review Board of the National University Health System, Singapore.

### 2.2 Measures

KDQOL-SF and KDQOL-36 are two commonly used instruments developed specifically for individuals with kidney disease and on dialysis [17]. Both instruments have been validated in ESRD patients in Singapore [18, 19]. KDQOL-SF includes Short Form-36 (SF-36) and 43 kidney disease-specific items; the KDQOL-36 contains a subset of the KDQOL-SF items, with Short Form-12 (SF-12) and 24 disease-specific items. Two summary scores, physical component summary (PCS) and mental component summary (MCS), can be calculated from SF-12, and the disease-specific part generates three kidney disease-specific scales, i.e., symptoms, effects, and burden, and a kidney disease component summary (KDCS) score by averaging the three disease-specific subscales [20]. The EuroQol 5-dimension (EQ-5D) health utility score can be obtained from SF-12 using an established mapping function [21], and it has been demonstrated to be valid and sensitive in Singaporean dialysis patients [16]. For summary scores and health utility, higher scores represent better HRQOL, and for disease-specific scales, higher scores represent fewer/milder symptoms, effects or burden due to kidney disease and dialysis.

### 2.3 Statistical Analysis

The socio-demographic and clinical characteristics were compared first, and then the three summary scores (PCS, MCS, and KDCS), three disease-specific scales and one health utility score (EQ-5D) were compared between patients with CAPD and those with APD. In the subsequent multivariate linear regression, all factor variables were coded into categorical variables in case the association was not linear and then entered into seven models, one for each of the HRQOL scores, regardless of their statistical significance. All analyses were performed using STATA 14.0, with $p < 0.05$ being considered significant.

## 3 Results

A total of 266 patients were included, with 145 on CAPD and 121 on APD. Patients' mean [standard deviation (SD)] age was 59.3 (12.5) years, with 45.5% male, 74.4%

Chinese, 80.8% having secondary or lower education, 71.1% married, and 88.3% living in a public residence. The mean (SD) CCI was 5.08 (1.67), and mean (SD) serum albumin and hemoglobin levels were 30.3 (5.6) g/l and 10.9 (1.69) g/dl, respectively. For dialysis parameters, the mean (SD) dialysis vintage was 3.55 (3.28) years, and the mean (SD) Kt/V value was 2.33 (0.88) per week.

No significant difference was observed in gender, ethnicity, marital status, housing type, co-morbidity, albumin level, hemoglobin level, and dialysis adequacy between CAPD and APD patients. But APD patients were younger than CAPD patients (mean age 57.4 vs. 60.8 years) and there were more individuals with high education, undergoing assisted dialysis, and with shorter dialysis vintage in the APD group. There was no significant difference in the QOL scores, with the exception that APD patients had higher KDQOL symptoms scores than CAPD patients (76.0 vs. 69.8). Full characteristics and QOL scores are shown in Table 1.

In multivariate analyses, APD was significantly associated with higher PCS and KDQOL symptoms scores, indicating patients had better physical health and milder dialysis-related symptoms (Table 2). We also found the following factors significantly associated with higher HRQOL scores (Table 2): young or old age, high albumin level, self-care dialysis and low dialysis adequacy.

## 4 Discussion

In view of the lack of clear evidence showing the advantage of one PD modality in clinical outcomes, a comparison of HRQOL between CAPD and APD patients would contribute to guiding the patient's choice and provide evidence for future cost-effectiveness assessment of PD treatments. Few studies have investigated this topic, and results are conflicting. De Wit et al. observed better mental health in APD patients [10], while Bro et al. found no difference in both physical and mental health [12]. Regarding the kidney disease-specific QOL, one previous study of incident PD patients showed that APD had advantages in KDQOL symptoms at 1 month, but significance disappeared at 12 months [22]. In our study, the HRQOL of CAPD and APD were almost equivalent, but physical health and KDQOL symptoms were in favor of APD.

The better physical health and fewer/milder symptoms of APD patients may be mainly explained by the nature of each PD modality. CAPD typically requires patients to manually perform exchanges of dialysate fluid four to five times a day, whereas APD is usually applied at night when the patient is asleep using an automated machine. The great time requirements of manual CAPD exchanges and additional abdominal weight due to dwelling dialysate in between the CAPD exchanges may be more likely to cause discomfort and more interruptions to daily activities, hence impacting HRQOL. In contrast, APD being an overnight procedure entails no dialysate weight bearing and allows more flexibility during the day for patients to pursue work, family and daily activities [23], which would be associated with better HRQOL. Also, compared to the manual exchanges in CAPD, the use of a dialysis machine in APD may lead to increased compliance with the prescribed PD regime and hence better disease management, which may in turn contribute to higher physical HRQOL. On the other hand, we could not rule out the possibility that the study participants may have been self-selected for better outcomes such as milder dialysis-related symptoms since our study cohort comprised prevalent PD patients with a mean dialysis vintage over 3 years. The health utility measured by the EQ-5D index showed a very small difference between CAPD and APD patients, suggesting that the relative cost-effectiveness of these two PD modalities in Singapore would be mainly determined by their survival outcomes and associated costs.

We also observed the impact of demographic, clinical and dialysis-related characteristics rather than PD modality itself on HRQOL. First, the impact of age on physical health was non-linear, with the middle-aged showing worse QOL, but old patients reporting comparable results to the young. A similar trend has been observed in previous studies [2, 24]. This may be due to the greater adaptation to chronic dialysis and old patients' lower expectations regarding their health. Second, high albumin level was associated with higher scores in PCS, MCS, KDQOL effects and health utility index. These associations make good sense from the clinical perspective. A low albumin may reflect malnutrition, and it is known to be strongly related to higher risk for mortality and morbidity in dialysis patients [2, 25]. Thus, it would be expected to be associated with poorer HRQOL. Third, self-care patients reported better physical health and better health utility measured using EQ-5D, in line with the previous study [9]. This result was not surprising because patients having physical difficulties such as decreased vision and strength would be more likely to use assisted PD; however, the impact of these physical difficulties cannot be adjusted by the analyses of this study. Last, higher dialysis adequacy was associated with lower QOL scores, different from the previous study showing the positive correlation of Kt/V and HRQOL [26]. In clinical practice, a dialysis adequacy target value is set to reduce the mortality risk [27], but to reach this target, patients might experience adverse effects and the increased amount of time needed to perform the exchanges is less acceptable to patients [27]. These factors might adversely affect QOL in PD patients.

**Table 1** Socio-demographic, clinical, dialysis characteristics and the HRQOL scores of the patients

| | Total ($n = 266$) | CAPD ($n = 145$) | APD ($n = 121$) | $p$ value |
|---|---|---|---|---|
| Socio-demographic | | | | |
| Age, mean (SD) | 59.3 (12.5) | 60.8 (11.4) | 57.4 (13.6) | 0.03* |
| Young (45 years) | 33 (12.4%) | 15 (10.4%) | 18 (14.9%) | 0.13 |
| Middle-aged (45–60 years) | 90 (33.8%) | 44 (30.3%) | 46 (38.0%) | |
| Old (>60 years) | 143 (53.8%) | 86 (59.3%) | 57 (47.1%) | |
| Gender | | | | 0.99 |
| Male | 121 (45.5%) | 66 (45.5%) | 55 (45.5%) | |
| Female | 145 (54.5%) | 79 (54.5%) | 66 (54.5%) | |
| Ethnicity | | | | 0.76 |
| Chinese | 198 (74.4%) | 109 (75.2%) | 89 (73.6%) | |
| Malay/Indian/others | 68 (25.6%) | 36 (24.8%) | 32 (26.4%) | |
| Educational level | | | | 0.02* |
| Low (no/primary/secondary) | 215 (80.8%) | 125 (86.2%) | 90 (74.4%) | |
| High (tertiary/above) | 51 (19.2%) | 20 (13.8%) | 31 (25.6%) | |
| Marital status | | | | 0.99 |
| Married | 189 (71.1%) | 103 (71.0%) | 86 (71.1%) | |
| Other | 77 (28.9%) | 42 (29.0%) | 35 (28.9%) | |
| Housing type | | | | 0.13 |
| Private residence | 31 (11.7%) | 13 (9.0%) | 18 (14.9%) | |
| Public residence | 235 (88.3%) | 132 (91.0%) | 103 (85.1%) | |
| Clinical | | | | |
| CCI | 5.08 (1.67) | 5.19 (1.48) | 4.95 (1.87) | 0.24 |
| Albumin (g/l) | 30.3 (5.6) | 29.9 (5.2) | 30.8 (6.0) | 0.20 |
| Hemoglobin (g/dl) | 10.9 (1.69) | 10.9 (1.67) | 11.0 (1.71) | 0.78 |
| Dialysis | | | | |
| Dependency status | | | | <0.01** |
| Self-care | 164 (61.6%) | 102 (70.3%) | 62 (51.2%) | |
| Assisted | 102 (38.4%) | 43 (29.7%) | 59 (48.8%) | |
| Dialysis vintage (years) | 3.55 (3.28) | 4.50 (3.68) | 2.42 (2.26) | <0.001*** |
| Dialysis adequacy | | | | |
| Kt/V (per week) | 2.33 (0.88) | 2.28 (0.72) | 2.40 (1.04) | 0.26 |
| QOL scores | | | | |
| PCS | 37.1 (9.8) | 36.2 (9.6) | 38.1 (9.7) | 0.10 |
| MCS | 46.6 (11.1) | 46.7 (11.2) | 46.4 (11.1) | 0.80 |
| KDCS | 58.7 (18.0) | 57.6 (19.0) | 60.0 (16.7) | 0.29 |
| Symptoms | 72.6 (18.4) | 69.8 (18.6) | 76.0 (17.7) | <0.01** |
| Effects | 69.1 (21.0) | 67.9 (21.4) | 70.5 (20.4) | 0.31 |
| Burden | 34.4 (26.9) | 35.2 (27.8) | 33.5 (25.8) | 0.62 |
| EQ-5D | 0.59 (0.21) | 0.58 (0.21) | 0.60 (0.22) | 0.35 |

*APD* automated peritoneal dialysis, *CAPD* continuous ambulatory peritoneal dialysis, *CCI* Charlson Comorbidity Index, *EQ-5D* EuroQol 5-dimension, *HRQOL* health-related quality of life, *KDCS* kidney disease component summary, *MCS* mental component summary, *PCS* physical component summary, *QOL* quality of life, *SD* standard deviation

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

This study has several limitations. First, the HRQOL data were from two different versions of the KDQOL, which may influence patients' responses due to context effect [28]. Second, analyses were based on cross-sectional data, and hence causal inferences cannot be made. Third, the EQ-5D was based on mapping, which is suboptimal compared to the direct use of a preference-based measure.

**Table 2** Coefficients of the independent predictor variables for HRQOL scores in peritoneal dialysis patients

| Independent variable | Dependent variable | | | | | | |
|---|---|---|---|---|---|---|---|
| | Component summary score | | | KDCS subscale | | | Health utility |
| | PCS | MCS | KDCS | Symptoms | Effects | Burden | EQ-5D |
| Young (45 years) | Ref. | | | | | | |
| Middle-aged (45–60 years) | −5.31** | 0.58 | −2.44 | −6.30 | −2.46 | 1.44 | −0.088 |
| Old (>60 years) | −2.81 | 2.69 | 4.58 | 0.95 | 6.97 | 5.83 | −0.022 |
| Male | Ref. | | | | | | |
| Female | 0.61 | −1.01 | 1.97 | 0.33 | 3.39 | 2.18 | −0.003 |
| Chinese | Ref. | | | | | | |
| Malay/Indians/others | −2.56 | 0.77 | −1.42 | −0.81 | −4.11 | 0.65 | −0.039 |
| Low education (no/primary/secondary) | Ref. | | | | | | |
| High education (tertiary/above) | −1.10 | 2.31 | −1.49 | −2.36 | −4.42 | 2.32 | 0.007 |
| Non-married | Ref. | | | | | | |
| Married | 1.23 | −1.61 | −2.90 | −1.38 | −3.81 | −3.50 | 0.002 |
| Housing type, public residence | Ref. | | | | | | |
| Housing type, private residence | 0.80 | 0.08 | 2.13 | 2.89 | −3.01 | 9.10 | 0.006 |
| Low CCI (<5) | Ref. | | | | | | |
| High CCI (≥5) | −0.95 | −1.32 | −5.75 | −2.28 | −4.59 | −10.4 | −0.029 |
| Low albumin level (<37 g/l) | Ref. | | | | | | |
| High albumin level (≥37 g/l) | 5.75** | 4.90* | 6.38 | 7.52 | 10.7* | 0.90 | 0.146** |
| Low hemoglobin level (<11 g/dl) | Ref. | | | | | | |
| High hemoglobin level (≥11 g/dl) | 1.70 | 0.62 | 2.47 | 2.33 | 1.97 | 3.12 | 0.037 |
| CAPD | Ref. | | | | | | |
| APD | 2.81* | −0.56 | 2.63 | 6.90** | 4.78 | −3.78 | 0.039 |
| Dependency status, assisted | Ref. | | | | | | |
| Dependency status, self-care | 5.12*** | −0.20 | 2.79 | 4.50 | 6.03 | −2.16 | 0.085** |
| Short dialysis vintage (<3.5 years) | Ref. | | | | | | |
| Long dialysis vintage (≥3.5 years) | 0.02 | 0.42 | −0.97 | −1.66 | 0.31 | −1.55 | 0.011 |
| Low dialysis adequacy (<2.0/week) | Ref. | | | | | | |
| High dialysis adequacy (≥2.0/week) | −1.63 | −2.74 | −1.69 | −0.85 | −2.53 | −1.69 | −0.065* |
| Total $R^2$ | 0.17 | 0.05 | 0.06 | 0.09 | 0.08 | 0.04 | 0.15 |

All $p$ values for a given independent variable are controlled for all other independent variables in the model

*APD* automated peritoneal dialysis, *CAPD* continuous ambulatory peritoneal dialysis, *CCI* Charlson Comorbidity Index, *EQ-5D* EuroQol 5-dimension, *HRQOL* health-related quality of life, *KDCS* kidney disease component summary, *MCS* mental component summary, *PCS* physical component summary

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

## 5 Conclusion

The HRQOL of CAPD and APD patients was largely equivalent in Singapore, but APD patients seemed to experience better physical health and be less bothered by dialysis-related symptoms. In the context of increasing advocacy for expanding PD utilization, more work is necessary to evaluate the outcomes of PD modalities to inform modality selection and guide healthcare resource allocation.

**Author Contributions** FY designed the study, analyzed the data and drafted the article. KG and NL contributed to study design and the critical revision of the article draft. TL and MF provided medical information. ZY helped with the original data collection. All authors read and approved the final manuscript.

**Compliance with Ethical Standards**

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**Conflict of interest** Fan Yang, Nan Luo, Titus Lau, Zhenli Yu, Marjorie Wai Yin Foo, and Konstadina Griva have no conflicts of interest.

**Data availability statement** The data that support the findings of this study are available from the corresponding author upon reasonable request.

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