Determinants of outcome dialysis
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Chapter 3.1

Hemodialysis and peritoneal dialysis

Jager KJ, Merkus MP, Boeschoten EW, Dekker FW, Tijssen JGP, Krediet RT for the NECOSAD Study Group: What happens to patients starting dialysis in the Netherlands? (submitted for publication)
Abstract

Background and purpose. Despite improvements in dialysis technology, publications around 1990 showed increasing mortality rates in dialysis patients. The Dialysis Group of the Netherlands initiated the Netherlands Cooperative Study on the Adequacy of Dialysis (NECOSAD) to investigate the association of patient and therapy characteristics with outcome.

Methods. Two hundred and fifty patients were included in this prospective multicenter study 3 months after the start of dialysis. We used Cox regression to predict mortality and technique failure and repeated measures analysis of variance to study the time course of continuous parameters.

Results. There were considerable differences in patient populations among dialysis centers. Patient survival was 76% at two years. Technique survival was higher in hemodialysis. Hospitalization decreased from 25 days between 3 to 12 months to 19 days per patient year in the third year. Residual renal function decreased at a similar rate in both modalities, but blood pressure tended to increase in females receiving peritoneal dialysis. Outcome was predominantly dependent on patient characteristics.

Conclusions. In the light of the increasing age of patients starting dialysis, increasing mortality can be expected. Furthermore, if outcome is to play a role in the quality assessment of dialysis centers, it is essential to know the characteristics of their patient populations.
Introduction

For patients with end-stage renal disease (ESRD), dialysis treatment is the only option to survive as long as a donor kidney is not available. The number of dialysis patients has continued to increase since the treatment became available as an accepted therapy.\(^1\) At the beginning of the nineties, reports were published showing an increase in the mortality of US dialysis patients.\(^2\) Data from the Dutch renal replacement registry RENINE showed a similar trend for the Netherlands. Despite major improvements in dialysis technology, mortality rates had increased from 10.5 to 18.8% in the period between 1981 and 1992.\(^1\) Advanced age and increased comorbidity were the obvious causes for the increase in mortality, but a change in other patient characteristics or in treatment could not be excluded. Therefore, the Dialysis Group of the Netherlands (DGN), comprising all Dutch nephrologists involved in dialysis treatment, initiated the Netherlands Cooperative Study on the Adequacy of Dialysis (NECOSAD). The aim of this study was to investigate the association of patient and therapy characteristics with outcome. A first cohort of 250 patients was included from 1993 to 1995. This paper describes the clinical condition of these patients, their treatment and outcomes, such as hospitalization, technique failure and mortality.

Patients and methods

Patients and follow-up period

ESRD patients older than 18 years, who started chronic dialysis as their first renal replacement therapy and survived the first 3 months on dialysis, were eligible for the study. From 13 Dutch dialysis centers we included consecutive patients who started dialysis between October 1, 1993 and April 1, 1995. Informed consent was obtained from all patients. Measurements at three months after initiation of dialysis were taken as baseline. These patients were followed until July 1, 1997.

Data collection

In addition to demographic data we collected the following information. Primary renal disease was classified according to the codes of the European Renal Association-European Dialysis and Transplant Association (ERA-EDTA) Registry. Comorbidity present at the start of dialysis was scored.\(^3\) Laboratory blood investigations included hemoglobin, serum albumin, calcium and phosphate. In hemodialysis (HD), the blood samples were taken prior to a dialysis session. Blood pressure was measured before and after each session over a period of two weeks. These pressures were averaged. Blood pressure in peritoneal dialysis (PD) was measured at a routine visit in the outpatient clinic. Urine was collected during the
interdialytic interval in HD and during 24 hours in PD. From this we calculated residual GFR (rGFR), defined as the mean of the urea and creatinine clearances and expressed in ml/min/1.73m².

Total clearance of waste products (renal function plus dialysis) was expressed as total $K_t/V_{urea}$ (/week). For PD patients we also collected data on total creatinine clearance (liter/week/1.73m²). Data on medication use were obtained from the medical records. During follow-up dialysis related treatment characteristics were assessed for patients who received that dialysis modality at 12, 24 and 36 months after the start of dialysis.

Analytical methods

Patients were classified according to dialysis modality at baseline; i.e. start-on-HD and start-on-PD. Differences in baseline characteristics were analyzed with t-tests for continuous variables and with chi-square tests for categorical variables. A two sided P-value < 0.05 was considered statistically significant.

Statistical analysis of mortality and technique failure was performed by the Cox proportional hazards model. The influence of a baseline characteristic on the occurrence of an event was expressed in terms of the relative risk (RR), calculated as the hazard ratio from the Cox proportional hazards model. In the analysis of mortality the event was death, while transplantation was a censored observation. For the analysis of technique failure transfer to the other dialysis modality was the event, censored observations were death, and transplantation. In both analyses, the follow-up of patients alive and on dialysis on July 1, 1997 was censored at that date. The number of hospital admissions for the first 9 months and the third year were calculated per patient at risk at 3 and 24 months. Hospitalization rate was defined as the number of days in hospital divided by the number of days alive and on dialysis and expressed as hospital days per patient year.

Repeated-measures analysis of variance was used to assess the time course of continuous parameters. To investigate the effect of dialysis modality on the time course of continuous parameters, we used an intention to treat analysis with start-on-HD versus start-on-PD patients, irrespective of changes in treatment modality, transplants and deaths. The analysis was repeated in a per protocol manner for patients who stayed on their initial dialysis modality during follow-up, i.e. stay-on-HD and stay-on-PD patients to assess possible effects of patient drop out during follow-up.

Results

Patient characteristics

Of 267 patients who met the inclusion criteria, 250 were included in the study
(94%). Eleven patients refused to participate and the physical, psychological or social condition of six patients was so serious that collection of essential parameters, such as residual renal function or anthropometry, was not possible. Of the 250 patients participating in the study, 132 started on HD and 118 on PD. In 64% of the HD patients this modality was chosen for medical reasons, whereas in PD this was the case in 19%. Table 1 shows the baseline patient characteristics for the entire cohort and for the groups starting on HD and PD. Patients starting on HD were older and had more frequently suffered from malignant disease. They had higher systolic blood pressure values, lower diastolic pressures, lower hemoglobin levels and clinical parameters indicated a better nutritional status. In addition, their urine volume was lower.

Figure 1 shows the center variation in the percentage of patients of 65 years and older and the percentage of patients with comorbid conditions. The distribution of the rGFR at baseline is shown in Figure 2.

Therapy characteristics

Hemodialysis. At baseline, the mean total Kt/V_urea was significantly different among centers. The upper panel of Figure 3 demonstrates that the percentage of patients receiving at least three hemodialysis sessions per week and those receiving at least 3.6 Kt/V_urea per week almost doubled between 3 and 36 months.

Peritoneal dialysis. The penetration of PD at 3 months varied from 0 to 68% among centers. At baseline, 95% of the PD patients were treated by continuous ambulatory peritoneal dialysis (CAPD), but at 3 years this percentage was reduced to 74, due to an increase in automated PD. Other treatment characteristics of PD patients over time are shown in the lower panel of Figure 3. The percentage of CAPD patients receiving at least standard treatment of 8 liter per day showed only minor variation. Similar to HD, the mean total Kt/V_urea and total creatinine clearance differed among centers at baseline. The percentage of PD patients receiving at least 2.0 Kt/V_urea or 60 liter/1.73m² of creatinine clearance per week declined over time.

Medication. More than 95% of the patients used phosphate binders at baseline and during follow-up. At baseline, 64% used antihypertensive medication and 74% erythropoetin. At three years, these percentages were 38 and 87.

Mortality, technique failure and hospitalization

After a median follow-up time of 28 months (range, 4 to 44) there were 75 deaths: 27 cardio-cerebrovascular, 14 due to infection, 4 due to malignancies, 10 patients refused further treatment and 20 patients died of other causes. Two-year patient survival was 76% and three-year patient survival was 66%. In univariate analyses, a higher age and the presence of diabetes mellitus, cardiovascular disease and comorbidity according to the Davies risk score were associated with a higher
Table 1. Baseline characteristics of all patients and those starting on HD or PD (mean (SD) or %).

<table>
<thead>
<tr>
<th></th>
<th>all patients</th>
<th>start-on-HD</th>
<th>start-on-PD</th>
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</thead>
<tbody>
<tr>
<td>N</td>
<td>250</td>
<td>132</td>
<td>118</td>
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</table>

**Demographics and comorbidity**

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<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>mean (year)</td>
<td>57 (15)</td>
<td>59 (16)</td>
</tr>
<tr>
<td></td>
<td>≥ 65 years (%)</td>
<td>37</td>
<td>47</td>
</tr>
<tr>
<td>Sex (% male)</td>
<td></td>
<td>58</td>
<td>53</td>
</tr>
<tr>
<td>Primary renal disease (%)</td>
<td>renal vascular disease</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>diabetes mellitus</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>glomerulonephritis</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td>50</td>
<td>54</td>
</tr>
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<table>
<thead>
<tr>
<th>Comorbidity (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>18</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Malignancy</td>
<td>6</td>
<td>9</td>
<td>3*</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td></td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>ischemic heart disease</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>myocardial infarction</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>angina pectoris</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>congestive heart failure (NYHA III/IV)</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>peripheral vascular disease</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>grade I (no comorbidity)</td>
<td>49</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>grade II (intermediate comorbidity)</td>
<td>44</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>grade III (severe comorbidity)</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Davies risk score *</td>
<td></td>
<td>28</td>
<td>27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current smoker (%)</th>
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<th></th>
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**Hemodynamics**

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<tr>
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</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>145 (19)</td>
<td>148 (16)</td>
<td>143 (22)*</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>83 (10)</td>
<td>81 (9)</td>
<td>85 (11)*</td>
</tr>
</tbody>
</table>

**Laboratory blood investigations**

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<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin (mmol/l)</td>
<td>6.7 (1.0)</td>
<td>6.3 (0.9)</td>
<td>7.1 (0.9)*</td>
</tr>
<tr>
<td>Serum albumin (g/l)</td>
<td>36.9 (5.4)</td>
<td>37.8 (4.6)</td>
<td>36.0 (6.0)*</td>
</tr>
<tr>
<td>Calcium (mmol/l)</td>
<td>2.4 (0.2)</td>
<td>2.4 (0.2)</td>
<td>2.4 (0.2)</td>
</tr>
<tr>
<td>Phosphate (mmol/l)</td>
<td>1.8 (0.5)</td>
<td>1.9 (0.5)</td>
<td>1.7 (0.5)*</td>
</tr>
</tbody>
</table>
Hemodialysis and peritoneal dialysis

**Nutritional status and renal function**

<table>
<thead>
<tr>
<th></th>
<th>all patients</th>
<th>start-on-HD</th>
<th>start-on-PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea (mmol/l)</td>
<td>26.2 (7.2)</td>
<td>28.9 (6.2)</td>
<td>23.1 (7.0)*</td>
</tr>
<tr>
<td>Creatinine (µmol/l)</td>
<td>841 (223)</td>
<td>874 (227)</td>
<td>804 (215)*</td>
</tr>
</tbody>
</table>

**Therapy characteristics**

<table>
<thead>
<tr>
<th></th>
<th>all patients</th>
<th>start-on-HD</th>
<th>start-on-PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kt/Vurea (/wk)</td>
<td></td>
<td>3.4 (1.5)</td>
<td>2.1 (0.5)*</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>renal</td>
<td>renal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6 (0.5)</td>
<td>0.6 (0.5)</td>
</tr>
<tr>
<td>Creatinine clearance (l/wk/1.73m²)</td>
<td></td>
<td>83 (29)</td>
<td>40 (30)</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>renal</td>
<td>renal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 (32)</td>
<td>39 (34)</td>
</tr>
<tr>
<td>Fluid removal (ml/24 hr)</td>
<td></td>
<td>1547 (912)</td>
<td>771 (698)*</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>urinary</td>
<td>urinary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>674 (583)</td>
<td>584 (433)</td>
</tr>
<tr>
<td>Medication (%)</td>
<td></td>
<td>antihypertensive agents</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>erythropoetin</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>phosphate binders</td>
<td>95</td>
</tr>
</tbody>
</table>

Values are presented as % or means (SD);
* values may not total 100% because of rounding off;
vs. HD: *p < 0.01, *p < 0.05
Figure 1. Percentage of patients of ≥65 years of age and those with comorbidity according to the Davies risk score at the start of dialysis in the entire cohort (left bars) and in each of the 13 participating centers.

Figure 2. Percentage of patients with an rGFR of ≤2.5, >2.5 and ≤5, and >5 ml/min/1.73m² at the start of dialysis in the entire cohort (left bar) and in each of the 13 participating centers.
risk of death. Also a high systolic blood pressure, a low serum albumin and a low total urea appearance were univariately associated with a higher risk of mortality. The upper panel of Figure 4 shows that in univariate analysis the patient survival on both dialysis modalities was identical.

Table 2 shows that in multivariate analysis high age, the presence of comorbidity according to the Davies risk score, a high systolic blood pressure and a low serum albumin were risk factors for mortality. Comorbidity and serum albumin were more important risk factors in the patients starting HD, whereas systolic
Figure 4. *Upper panel,* patient survival in start-on-HD (-----) and start-on-PD (——) patients, crude. *Lower panel,* patient survival in start-on-HD (-----) and start-on-PD (——) patients, after adjustment for age, comorbidity, systolic blood pressure and serum albumin levels at baseline.

Blood pressure was only a determinant of death in the patients starting PD. The lower panel of Figure 4 shows that, also after adjustment for the factors included in the Cox model, dialysis modality was not a determinant of mortality (RR for PD, 1.15 (95% CI, 0.70 to 1.90)). Similarly, in the analysis of the entire cohort the clearance of waste products showed no association with mortality. However, a higher absolute quantity of small solutes removed was associated with a reduced risk of death in PD patients.
Table 2. Multivariate Cox proportional hazards model for patient survival.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Relative Risk</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (1 year)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.04</td>
<td>1.01 - 1.06</td>
</tr>
<tr>
<td>Comorbidity (present)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.58</td>
<td>1.43 - 4.67</td>
</tr>
<tr>
<td>Systolic blood pressure (10 mm Hg)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.15</td>
<td>1.03 - 1.29</td>
</tr>
<tr>
<td>Serum albumin (1 g/l)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.95</td>
<td>0.91 - 1.00</td>
</tr>
</tbody>
</table>

<sup>a</sup> P < 0.01; <sup>b</sup> P < 0.05

Seven patients who started on HD switched to PD: four because of vascular access problems, one because of frequent hypotensive periods and two because they preferred PD. Two-year technique survival on HD was 95% and three-year technique survival was 94%. The number of seven events was too low to analyze the determinants of HD technique survival.

During follow-up 44 patients were transferred from PD to HD, 39 of them for medical reasons, in more than half of the cases because of peritonitis. One patient was transferred for social reasons and one patient preferred HD. In three patients the reasons for technique change were unknown. On PD, two-year technique survival was 64% and three-year technique survival was 53%. The relative risk of technique failure in PD was higher in patients with high systolic blood pressure, low urine volume and low peritoneal ultrafiltration.

The left bars in Figure 5 show the hospitalization rate for all patients. From 3 to 12 months after the start of dialysis the hospitalization rate was 25 days (range, 0 to 365) per patient year, 5 of which were due to dialysis related problems and 3 to cardiovascular problems. These were due to 1.1 hospital admissions (range, 0 to 7) per patient with a mean duration of 12 days (range, 1 to 74). The hospitalization rate decreased over time to 19 days (range, 0 to 219), comprising 1.3 admissions (range, 0 to 7) with a mean duration of 13 days (range, 2 to 81) during the third year. However, the contributions of dialysis related and cardiovascular problems increased to 9 and 4 days.

Residual renal function and blood pressure over time

As other studies suggested an effect of dialysis modality on residual renal function we compared its time course between start-on-HD versus start-on-PD patients. Both groups had a similar rGFR at baseline. In start-on-HD patients it decreased to 1.1 ml/min/1.73m<sup>2</sup> at two years after the start of dialysis and in start-on-PD patients to 1.4 ml/min/1.73m<sup>2</sup>. Figure 6 demonstrates that, adjusted for the baseline value of rGFR, age, sex and diabetes mellitus, the decrease in rGFR was similar in both groups. The per protocol analysis, comparing patients staying on HD versus those staying on PD, provided similar decline rates for both groups, but stay-on-PD patients had a higher rGFR at baseline and this remained so over time.
Figure 5. Hospitalization rate per patient year in all patients (left bars) and in patients of 65 years or older (right bars) between 3-12 and 24-36 months after the start of dialysis.

Figure 6. Change over time in rGFR (ml/min/1.73m²) in start-on-HD (-----) and start-on-PD patients (——), after adjustment for the baseline value of rGFR, age, sex and diabetes mellitus.
Blood pressure showed an initial dip in both start-on-HD and start-on-PD patients with a slight increase thereafter. Subgroup analyses showed a different time course of blood pressure values in start-on-PD females, compared to start-on-PD males and start-on-HD patients. Figure 7 shows that, adjusted for baseline blood pressure values, age, diabetes mellitus and rGFR, the increase in blood pressure was higher in PD females: 15 mm Hg (95% CI, 11 to 24) for systolic and 5 mm Hg (95% CI, 0.3 to 9) for diastolic pressure.

Patients of 65 years of age or older

Seventy percent of the patients starting dialysis in this age group (N=93) had comorbid conditions according to the Davies risk score. The prevalence of diabetes mellitus was 28% and that of cardiovascular disease 51%. Their rGFR at 3 months was 2.6 (2.1) ml/min/1.73m². The distribution of total Kt/Vurea in the elderly was similar to that in younger patients in both dialysis modalities.

Figure 8 shows that the survival in these patients was lower than in the younger age category with a two-year survival of 62% and three-year survival of 52% (RR for 65 years or older, 2.5 (95% CI, 1.5 to 3.9)). In the first 9 months of follow-up they were admitted 1.4 times (range, 0 to 7) per patient with a mean duration of 15 days (range, 1 to 74) per admission. The right bars in Figure 5 show that this
resulted in a hospitalization rate of 43 days (range, 0 to 365) per patient year, 9 of which were due to dialysis related problems and 7 to cardiovascular morbidity. In the third year on dialysis there were 1.5 admissions (range, 0 to 5) per patient with a mean hospital stay of 16 days (range, 2 to 81). The hospitalization rate decreased to 26 days (range, 0 to 365) per patient year with 9 due to dialysis related and 7 to cardiovascular problems.

Discussion

This analysis of the results of chronic dialysis treatment in the Netherlands has shown that the morbidity and mortality in the dialysis population is high. Outcome was predominantly dependent on patient characteristics. There was no difference in mortality between patients starting HD and PD, but a large difference in technique failure. The decrease in residual renal function over time was similar in both modalities, but blood pressure tended to increase in female PD patients. These findings will be discussed in the following paragraphs.

Patient and therapy characteristics

The case-mix differences in the patient populations of the participating dialysis centers with respect to important outcome predictors, such as age, comorbidity and residual renal function were considerable. There were also differences between the patient groups starting on HD and on PD, reflecting the process of patient selection for dialysis modality.
The increase in HD frequency over time demonstrates the nephrology practice

to increase the number of sessions per week along with the decrease in residual

renal function. The concurrent increase in the total Kt/V_{urea} suggests that in HD it
was possible to provide a large majority of the patients for over a period of three

years with a dialysis dose, that was defined as adequate in the US.4 Our data also
suggest that this was much more difficult in CAPD, where a decreasing renal

function was associated with a decrease in the percentage of patients meeting the
US recommendations for total Kt/V_{urea} and creatinine clearance.5 This may explain
the increasing use of automated PD.

Outcome in the entire cohort

Age, comorbidity and serum albumin levels have shown to be important risk

factors of death in dialysis.36-9 We have previously reported the importance of
systolic blood pressure and the removal of small solutes as risk factors of death
among patients starting PD.10 In our cohort the determinants of death were
different between patients starting different dialysis modalities. More studies are
needed to substantiate and clarify this finding. We found a similar patient survival
in patients starting HD and PD. Also others did not find clinically relevant
differences, provided appropriate correction for case-mix differences had been
made.11,12 Some studies reported an overall survival advantage for HD13 or PD,14
but recently it was suggested that these differences in study results were greatly due
to differences in statistical methodology.15 However, elderly, especially female,
diabetics seem to be at a somewhat higher death risk when treated with PD,12,16,17
whereas younger nondiabetics seem to have a slight survival advantage.17 This
indicates that in general patient survival is similar in HD and PD, but that
differences may exist in subgroups.

We found that technique failure was much higher in PD, compared to HD.
This confirms the findings of others.11,18,19 A low urine volume, a low peritoneal
ultrafiltration and a high systolic blood pressure were associated with an increased
technique failure in PD. In these patients, especially a combination of the first two
may lead to overhydration. This indicates that in addition to peritonitis,16,11 the
inability to maintain fluid balance is a criterion in the decision for transfer to HD.

Our hospitalization rates were similar to6 or slightly higher 25-22 than those in
other studies comprising patients of similar age. Hospitalization for dialysis related
and cardiovascular problems became increasingly important over time, whereas
hospitalization for other conditions decreased, possibly because the patients
suffering of those conditions died early in the course of treatment.

Others have shown that residual renal function decreases at a faster rate in HD
than in PD.23-25 The cause of this more rapid decline in HD is not quite clear, but
hypotensive periods occurring during HD sessions might contribute to the effect.
Our stay-on-PD patients did have a higher rGFR at 3 months compared to stay-
on-HD patients, but the decline rates were similar. Recent work by our group suggests that the increased loss of renal function is an early effect of HD taking place in the first three months on dialysis [abstract; Jansen M, Perit Dial Int 2000;20:128]. Furthermore, another study has shown that the renal function loss in HD was accelerated by the use of bio-incompatible cellulose hemodialysis membranes. All our HD patients used cellulose derivatives and synthetic dialysis membranes. This may be an additional explanation as to why we did not find a difference in decline, whereas others did.

In HD patients, the decrease in the use of antihypertensive medication without a rise in blood pressure over time may indicate an increasing success to remove fluid by the dialysis procedure itself. An early decrease in blood pressure in PD patients has also been reported by other investigators. The rise we found thereafter in PD females may reflect overhydration due to a decreasing residual renal function over time. Moist et al. found that females were at a higher risk with respect to the loss of renal function than males. We did not find a sex difference in the loss of rGFR or urine volume and also the increase of peritoneal fluid removal over time was similar in both sexes. Therefore, a potential different time course of blood pressure in females receiving PD requires further study.

**Patients of 65 years or older**

At 3 months after the start of dialysis both the residual renal function in the elderly and the provided dialysis dose in terms of \( \text{Kt/V}_{\text{urea}} \) were similar to those in other patients. This suggests that the higher prevalence of comorbid conditions is an important cause of the higher mortality and hospitalization rates within this group. A study from the US reported a hospitalization rate of approximately 16 days per patient year, whereas in a joint Canada-USA study the elderly patients stayed in hospital for 29 days per year. It seems likely that differences in health care and health insurance systems contribute to these differences in hospital stay.

**Conclusion**

This study provides insight in what happened to patients, who started dialysis in the Netherlands in the middle of the nineties. Thus far, there are no indications that there are large differences in clinical outcome between hemodialysis and peritoneal dialysis, with the exception of a difference in technique survival in favor of HD. An association of the dialysis dose with the risk of death could only be demonstrated in PD and, so far, not in HD patients. Despite a decrease over time, the hospitalization rate remained substantial in the third year on dialysis with 19 days per patient in the entire cohort and 26 days per patient in the elderly. In the light of increasing numbers of patients starting dialysis and their increasing age, not only higher mortality rates are to be expected, but also a growing need for hospital back-up facilities. The latter has to be taken into account, when planning new
dialysis centers or extending existing ones. Furthermore, this study has shown that dialysis outcome is largely dependent upon patient characteristics at the start of dialysis. If outcome is to play a role in the quality assessment of dialysis centers, it is essential to have information on the characteristics of their patient populations.

References

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