ADEQUATE DIALYSIS? MEASUREMENT OF KT/V IN A PEDIATRIC PERITONEAL DIALYSIS POPULATION

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Objective: To measure the urea and creatinine kinetics in a pediatric population

Patients and Methods: In 19 children treated with peritoneal dialysis (PD) KT/V, urea and creatinine clearances (Ccr) were measured. Thirteen children were on continuous ambulatory peritoneal dialysis (CAPD) and 6 on nightly intermittent peritoneal dialysis (NIPD).

Results: Mean KT/V per week was 2.31 ± 0.78 and mean creatinine clearance 74 ± 47 L/week/1.73 m². There was no difference in dialytic KT/V between patients treated with CAPD and NIPD (1.75 ± 0.21 vs 1.76 ± 0.50). The correlation between KT/V urea and creatinine clearance was 0.9 (p<0.001). There was a clear relationship of these parameters with residual renal function, but not with age or blood urea level. A weak positive correlation was found with serum albumin and protein intake.

Conclusions: Mean KT/V in this patient group was higher than the values reported for most adult patient groups. Residual renal function considerably contributes to this high KT/V. It is not clearly defined which KT/V should be aimed for, since criteria for adequate dialysis are multifactorially determined and therefore difficult to interpret.

KEY WORDS: Adequacy, urea kinetics, children.

Adequate dialysis is crucial for the well-being of patients with end-stage renal disease. The traditional approach in assessing adequacy has been clinical. The standardized therapy prescription is traditionally adjusted on the basis of clinical signs and symptoms of under-dialysis such as anorexia, nausea, vomiting and poor blood pressure control. Therapy based only on serum measurements such as urea nitrogen and creatinine may be misleading as patients on dialysis may be in a catabolic phase or have a decreased muscle mass. Also, peritoneal protein losses and glucose absorption may suppress appetite and will increase the risk of growth failure which already exists on the basis of chronic renal failure (1). It therefore seems important, especially in children, to quantitate adequacy of therapy. Urea kinetic modeling is now an accepted tool for defining the adequacy of therapy prescription. KT/V urea represents the urea clearance normalized for distribution volume. The concept of KT/V (K being the clearance of urea, T the duration of dialysis treatment, and V the volume of urea distribution) as developed by Gotch and Sargent (2), is nowadays used as a model to quantitate therapy prescription based on urea removal. For adult peritoneal dialysis (PD) patients KT/V urea or creatinine clearance are advocated as parameters suitable for quantifying the amount of dialysis and for optimizing the prescription of treatment.

A weekly KT/V of 1.7 or more or a creatinine clearance (Ccr) exceeding 50 L/week/1.73 m² are generally considered sufficient (3,4), although higher values have recently been advocated (5). For the pediatric population such guidelines are still scarce. Few publications have examined PD therapy in children (6,8). This study aims to measure the urea and creatinine kinetics in a pediatric population.

PATIENTS AND METHODS

Measurements were performed in 19 children on PD (median age 9 years; range 0.4–17; SD 4.44). Thirteen of these children were treated with continuous ambulatory peritoneal dialysis (CAPD), 6 with nightly intermittent peritoneal dialysis (NIPD). Seven children were anephric, whereas 12 had some residual renal function (Ccr < 10 mL/min/1.73m²). The choice between NIPD and CAPD was essentially made by the parents of the patients. No studies were performed in patients within the month following an episode of peritonitis. Patients were treated with 35 mL dialysis fluid/kg body weight. The volumes are rounded to the nearest commercially available
amount. In this study the patients on CAPD were treated with four daily exchanges of 37±5 mL dialysis fluid/kg body weight (mean ± SD), and the patients on NIPD with nightly exchanges of 32.4 ± 3 mL/kg with a 60–90 minute dwell period per cycle.

Weekly KT/V urea and Ccr were calculated from 24-hour urine and dialysate specimens, and a blood sample taken early in the morning after the collection of 24-hour urine and dialysate. Serum albumin was measured by a dye-binding method using bromcresol green on a Hitachi 747 auto-analyzer, Boehringer Mannheim, Germany. Protein intake was derived from dietary history and prescription in those 12 patients with a known protein intake. KT/V was calculated according to Keshaviah and Nolph (3). The distribution volume (V) was calculated according to the formula for pediatric patients by Friis-Hansen (9). Ccr was calculated on total urinary creatinine and dialysate creatinine corrected for glucose concentrations and body surface area according to Dubois and Dubois, and expressed as L/week/1.73 m² (10).

RESULTS

Measured weekly dialytic and renal KT/V and dialytic and renal Ccr are presented in Tables 1 and 2 for patients on NIPD and CAPD, respectively. Mean total KT/V of all patients was 2.31 per week. Mean Ccr was 74 L/week/1.73 m². The correlation coefficient between weekly KT/V urea and Ccr was 0.90 (p<0.001).

For the children with residual renal function, KT/V was separated into dialytic and renal clearances. Dialytic KT/V in these patients was 1.70±0.23, which was similar to the value reached in children without residual renal function (1.84±0.46). The higher mean KT/V total of the children with renal function was caused by the residual renal function.

There was no difference in dialytic KT/V between the patients treated with CAPD and NIPD (1.75 ±0.21 vs 1.76 ±0.50). A weak, but not significant, positive correlation between KT/V urea and serum albumin concentration was established (Figure 1; r=0.4; p=0.1). There was no correlation of weekly KT/V and Ccr with age of the patient or blood urea level.

In those 12 children with a known protein intake, mean daily dietary protein intake (DPI) was 1.59 g/kg ± 0.41; (medium 1.48; range 1.20–2.50). There was a weak correlation between KT/V urea and dietary protein intake (Figure 2; r=0.7; p=0.009). There was no difference in weekly KT/V and Ccr with age of the patient or blood urea level.

Table 1—Relation between KT/V and serum albumin in patients on PD (r=0.4, p=0.1). Three patients with nephrotic syndrome are excluded because of severe renal protein loss.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Weight (kg)</th>
<th>Duration of PD (months)</th>
<th>Dialysis prescription</th>
<th>KT/V urea total</th>
<th>KT/V urea dialytic</th>
<th>KT/V urea renal</th>
<th>Ccr total (L/week/1.73 m²)</th>
<th>Ccr dialytic (L/week/1.73 m²)</th>
<th>Ccr renal (L/week/1.73 m²)</th>
<th>Serum albumin (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>14.2</td>
<td>5</td>
<td>8 x 500 mL</td>
<td>1.92</td>
<td>1.45</td>
<td>0.47</td>
<td>54.5</td>
<td>31.2</td>
<td>23.3</td>
<td>36.1</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>37.2</td>
<td>3</td>
<td>5 x 1200 mL</td>
<td>2.81</td>
<td>1.16</td>
<td>1.65</td>
<td>112.2</td>
<td>33.6</td>
<td>78.6</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>0.4</td>
<td>5.1</td>
<td>3</td>
<td>8 x 170 mL</td>
<td>2.65</td>
<td>2.66</td>
<td>-</td>
<td>30.1</td>
<td>30.1</td>
<td>-</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>17.4</td>
<td>5</td>
<td>6 x 600 mL</td>
<td>1.69</td>
<td>1.69</td>
<td>-</td>
<td>39.6</td>
<td>39.6</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>21.7</td>
<td>32</td>
<td>7 x 700 mL</td>
<td>1.41</td>
<td>1.41</td>
<td>-</td>
<td>37.0</td>
<td>37.0</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>39.7</td>
<td>7</td>
<td>7 x 1050 mL</td>
<td>2.24</td>
<td>2.24</td>
<td>-</td>
<td>55.2</td>
<td>55.2</td>
<td>-</td>
<td>39</td>
</tr>
<tr>
<td>mean</td>
<td>7.9</td>
<td>22.6</td>
<td>9.2</td>
<td></td>
<td>2.12</td>
<td>1.76</td>
<td>1.06</td>
<td>54.8</td>
<td>37.8</td>
<td>50.9</td>
<td>37</td>
</tr>
<tr>
<td>SD</td>
<td>6.1</td>
<td>12.3</td>
<td>10.3</td>
<td></td>
<td>0.50</td>
<td>0.50</td>
<td>0.59</td>
<td>27.2</td>
<td>8.4</td>
<td>27.7</td>
<td>4</td>
</tr>
<tr>
<td>median</td>
<td>6.0</td>
<td>19.6</td>
<td>5</td>
<td></td>
<td>2.08</td>
<td>1.57</td>
<td>1.96</td>
<td>47.1</td>
<td>35.3</td>
<td>50.9</td>
<td>37</td>
</tr>
</tbody>
</table>

PD = Peritoneal dialysis; CAPD = continuous ambulatory peritoneal dialysis; NIPD = nightly intermittent peritoneal dialysis; KT/V = fractional urea clearance per week; Ccr = creatinine clearance (L/week/1.73 m²).
no correlation between Ccr and DPI (r=0.03, not significant).

**DISCUSSION**

Definition of adequacy of PD is difficult. The parameters of weekly KT/V and Ccr are both used for defining adequacy. The discussion on the proper clearance of urea and creatinine to be achieved in adult PD patients is not yet closed (5,11). For pediatric patients, data are scarce (6–8). The establishment of normal values for KT/V is hampered by the difficulty in finding quantitative outcome parameters. Outcome parameters like mortality, morbidity, nutritional state, growth and quality of life are multifactorially determined and not influenced by adequacy of dialysis alone. Much attention has been paid to the serum albumin concentration (12–15). Struijk et al. (15) observed a higher mortality in CAPD patients with a serum albumin level below 30.9 g/L. None of the patients in the present study had a serum albumin below 30.0 g/L.

Although a weak positive correlation between weekly KT/V urea and serum albumin concentration was observed, using the serum albumin concentration as an outcome parameter does not seem to be justified, especially since the groups studied were small.

The intermittent nature of NIPD may impair dialysis adequacy. NIPD, however, has the advantage of the empty abdomen during daytime, with its positive influence on nutrition (1). Schaefer et al. observed a significantly higher KT/V urea in patients treated with continuous cycling peritoneal dialysis (CCPD) with small dialysis volumes during the daytime (50–70% of the normal fill volume) than in patients treated with CAPD (8). In CCPD patients, total KT/V was 2.45±0.84, in CAPD patients, 1.75±0.7. Remarkably, this difference was not caused by a lesser residual renal function in children on CAPD.

![Figure 2—Relation between KT/V and dietary protein intake in 12 patients with a known protein intake on PD (r=0.7, p=0.009).](image-url)
The larger absolute volume of PD fluid in CCPD and NIPD, together with the rapid equilibration of urea and creatinine in children, was responsible for this phenomenon (7,16,17). Interestingly, no differences in adequacy parameters were found between CAPD and NIPD patients in our study.

Protein catabolic rate was not measured in the present study. Protein intake was calculated from dietary history and prescription. The relatively high KT/V urea reported in this study as compared to most studies in adult patients may be the result of the relatively high dialysate volume in children.

The important contribution of residual renal function is obvious from this study, as it is from a number of papers on adult patients (18,19). It has been stated that in large adult patients PD might not be an appropriate mode of therapy after loss of residual renal function, for reasons of adequacy (20). The cross-sectional nature of the present study does not provide sufficient data for this conclusion; additional longitudinal studies in children are needed and ongoing.

The present cross-sectional study is not able to provide guidelines for adequate PD in pediatric patients, for the reasons described above. It is, however, necessary to perform calculation of urea and creatinine kinetics on a regular basis, to relate adequacy parameters to the overall judgement of a pediatric PD patient's condition.

REFERENCES

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