Lymphocyte subsets in dialyser eluates: a new parameter of bioincompatibility?

M. P. C. Grooteman1, M. J. Nube1, J. van Limbeek2, M. Schoorl1 and A. J. van Houte1

'Medical Center Alkmaar, Departments of Nephrology and Immuno-haematology, Alkmaar; 2Municipal Health Center, Department of Social and Psychiatric Epidemiology, Amsterdam, The Netherlands

Abstract

Introduction. During haemodialysis (HD), several adverse reactions in peripheral blood can occur, which have been attributed to the bioincompatibility of the dialyser membrane. Utilizing a dialyser elution technique, we have demonstrated that polymorphonuclear cells (PMN) manifested non-membrane dependent signs of activation during HD with cellulose triacetate (CTA), cuprammonium (CU) and polysulphone (PS) membranes. In the present study, we employed this elution technique to investigate the influence of HD with these membranes on lymphocytes.

Methods. Eight patients were studied during HD with CTA, CU, and PS dialysers in a randomized crossover design. Dialyser elution was performed after 3 h of HD. Besides total leukocyte count and differentiation, lymphocyte subpopulations and activation status in peripheral blood and dialyser eluates were analysed by flow cytometry.

Results. Only with CU was a significant leukocyte decrease observed in peripheral blood at 30 min (P<0.001). Neither the total number of lymphocytes nor the proportion of T(CD3+) and B(CD19+) cells had markedly changed after HD with either membrane. Meanwhile, all membranes induced a relative decline in natural killer cells -NK(CD3-/CD16+/56+)- at the end of dialysis, although this was only significant for CTA (P=0.04). As for T-lymphocyte subsets, the proportion of CD4+ cells had markedly increased after three hours of HD with all three dialysers, CTA and PS being significant (P<0.05). Dialyser eluates contained 33.8-82.2 x 10^6 cells, CTA yielding the highest cell counts. The majority (81–91%) of the eluted cells consisted of PMN (dialyser eluates versus peripheral blood: P<0.05), whereas only few lymphocytes were found (4–13%, absolute 2.6 x 10^6). Lymphocyte subpopulations in dialyser eluates were comparable to peripheral blood at t=180 min in case of CTA and CU. In contrast PS eluates contained significantly fewer T-cells (37%), but more B-cells (22%) and NK-cells (30%) in comparison with peripheral blood at 180 min (peripheral blood: 79, 6 and 16% respectively; P<0.05). The expression of activation markers on T-cells (HLA-DR, CD25) in dialyser eluates was comparable with peripheral blood.

Conclusion. The absolute number of lymphocytes in dialyser eluates of CTA, CU, and PS dialysers was low (mean 2.6 x 10^6) in comparison with peripheral blood (mean 1.4 x 10^9/l). Whereas non-selective adhesion occurred in CU and CTA dialysers, a selective adhesion pattern of lymphocyte subpopulations was observed in case of PS, suggesting a difference in bioincompatibility. Apparent T-cell activation was not noted, either in peripheral blood or in dialyser eluates. Because PMN in the dialyser eluates of three different membranes showed similar activation patterns in a previous study, we hypothesize that eluted lymphocytes, rather than PMN, represent a preferable parameter of bioincompatibility.

Key words: bioincompatibility; elution; haemodialysis; lymphocyte subpopulations; lymphocyte activation

Introduction

Various abnormalities of the immune system have been demonstrated in patients on maintenance haemodialysis (HD). Although defects occur in both the humoral and cellular response, the major defects are observed in cell-mediated immunity. The immunodeficient state is manifested by prolonged survival of skin allografts, increased susceptibility to viral infections, an abnormal high incidence of malignant tumours, anergy in cutaneous hypersensitivity testing, and defective responses to T-cell-dependent antigens such as influenza and hepatitis B virus (reviewed in [1]). However, despite this clinically evident immune deficiency state, recent studies suggest the paradoxal activation of various cell types during HD. In the past decade it has been demonstrated that dialysis sessions trigger neutrophil [2,3], monocyte [4], and lymphocyte

Correspondence and offprint requests to: M. P. C. Grooteman MD, Medical Center Alkmaar, Departments of Nephrology and Immuno-haematology, Wilhelminalaan 12, 1815 JD Alkmaar, The Netherlands.

© 1996 European Dialysis and Transplant Association–European Renal Association
employed in a randomized crossover fashion, each for 1 h.

Water purified by reversed osmosis was used for dilution of 40 ml/h/mmHg respectively. None of the dialysers was ETO-sterilized (Table 1). The last dialysis of each week was used for all experiments. First-use CTA (CT 150 G, Baxter, Osaka, Japan), CU (AM-UP-75, Asahi, Tokyo, Japan), and PS (F 60 S, Fresenius, Bad Homburg, Germany) were pre-rinsed with 1000 ml NaCl 0.9%, containing 3000 IU heparin. For dialyse preparation tap water purified by reversed osmosis was used for dilution of the concentrated bicarbonate solutions. Blood flow rates were kept constant at 200–250 ml/min, and the dialyse flow was 300 ml/min. The UF rate varied individually from 300 to 1000 ml/h. Anticoagulation was achieved by heparin, with a priming dose of 1250–5000 IU and 250–1500 IU/h continuously (both UF rate and heparin dose were constant for each individual patient).

Analytical methods

Blood samples were drawn from the afferent line before the start of the dialysis procedure (t0), and from the efferent line after 30 min (t30) and at the end of HD (t180). Leukocyte counts were determined in blood samples drawn in tripotassium EDTA, as well as in dialyser eluates, using a Sysmex NE-8000 cell analyser (TOA Medical Electronics Co., Kobe, Japan). Leukocyte differentiation of PB and eluates was performed by light microscopy (×630) after May–Grünewald–Giemsa staining of smears.

Lymphocytes were identified by flow cytometry (FACScan, Becton Dickinson, San Jose, California, USA) using their morphological characteristics (forward versus side scatter). Lymphocyte subclasses were identified using direct two-colour immunofluorescence on tripotassium EDTA blood samples immediately after sampling, as well as on eluate cell suspensions. The cells were enumerated with a panel of monoclonal antibodies (Immunotech, Marseille, France) against T(CD3+) cells, B(CD19+) cells, activated T(CD3+/CD25+) and CD3+/HLA-DR+, helper/inducer (CD3+/CD4+) and suppressor/cytotoxic (CD3+/CD8+) T-cells, and natural killer (NK, CD3-/CD16+/CD56+) cells. Data acquisition and analysis were performed using Simulset software (Becton Dickinson).

Dialyser elution

As has been described before [8], our elution technique could effectively differentiate between circulating peripheral blood leukocytes residing temporarily in the dialyser after HD, and leukocytes sticking to the membrane (adherent cells). To summarize, after disconnecting the patient from the extracorporeal circuit, the dialyser was emptied. Then the system was filled with 200 ml phosphate-buffered saline (PBS, pH 7.4), containing 3 mMol EDTA. After recirculation for 20 min, the drainage fluid was poured into polystyrene bottles and processed immediately. Samples were centrifuged and washed three times with PBS/BSA (bovine serum albumin, final concentration 0.5%). The final sediment was denoted ‘dialyser eluate’ (DE).
Statistical analysis

Data are expressed as mean ± SD, or median and range when appropriate. Analysis was performed with the SPSS/PC+ software system, using multivariate analysis of variance (MANOVA) and Student's t test (paired). Differences were considered statistically significant at *P* < 0.05.

Results

Total cell counts and differentiation

Peripheral blood (*t*0, *t*30 and *t*180)

In contrast to HD with CTA and PS membranes, only CU dialysers induced a significant drop in the number of leukocytes at *t*30 (DF(12,2); *F* = 25.05; *P* < 0.001), Figure 1. The decrease was mainly due to a decline in the number of PMN. Neither CTA nor PS induced changes in microscopic differentiation throughout dialysis (data not shown).

Eluates (*t*180)

The mean number of leukocytes in DE was 53 × 10⁶, PS and CU dialysers yielding comparable amounts. CTA eluates contained most cells (Figure 1 and Table 2), whereas only the difference between CTA and CU was significant (P = 0.048).

The composition of DE differed significantly from PB at *t*180 in case of CTA and PS, consisting mainly of PMN (PB 68–69%, DE 88–91%; CTA *t* = −10.72; DF = 7; *P* < 0.001, and PS *t* = −7.28; DF = 7; *P* < 0.001). Only a few lymphocytes, DE 3–5% versus PB 23–24% (CTA *t* = 8.07, DF = 7; *P* < 0.001, and PS *t* = 11.09; DF = 7; *P* < 0.001) were found (Table 2). In case of CU, the discrepancy between PB at *t*180 and DE was less pronounced (PMN: PB 68 and DE 82%, *t* = −2.51; DF = 7; *P* = 0.041; lymphocytes PB:24%, DE 13%, *t* = 2.27; DF = 7; *P* = 0.057). In these eluates, however, a few erythrocytes were also detected, suggesting contamination with PB, which might explain the higher lymphocyte counts.

Lymphocytes

Peripheral blood (*t*0 and *t*180)

Both the total number of lymphocytes and the proportion of T (CD3+) and B (CD19+) cells remained unchanged after HD with either membrane. As for NK-cells (CD3-/CD16+/56+), all membranes induced a relative decline at the end of dialysis, which was only significant with CTA (CTA *t* = 2.5; DF = 7; *P* = 0.04; CU *t* = 2.08; DF = 7; *P* = 0.08; PS = n.s.), see Table 3 for data, illustrated in Figure 2.

With respect to T-lymphocyte subsets, the proportion of CD4+ cells had markedly increased after 3 h of HD with all three dialysers, CTA and PS being significant (CTA *t* = −2.41; DF = 7; *P* = 0.047, PS *t* = −2.65; DF = 7; *P* = 0.03). Furthermore the proportion of CD8+ cells tended to decrease at *t*80 after CTA and CU dialysis (CTA: *t* = 2.36; DF = 7; *P* = 0.05; CU = n.s.), but remained constant after PS dialysis (Table 3).

Concerning T-lymphocyte activation, none of the three membranes induced obvious changes in the peripheral expression of CD3/25 and CD3/HLA-DR at *t*180 in comparison with *t*0 (Figure 3, Table 3).

Table 2. Eluate cell counts and differentiation (Mean (SD))

<table>
<thead>
<tr>
<th>Count (x10⁶)</th>
<th>CTA</th>
<th>CU (14.6)**</th>
<th>PS (22.1)</th>
<th>PB*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differentiation (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutrophils</td>
<td>90.5 (6.7)</td>
<td>81.5 (13.6)</td>
<td>88.0 (2.9)</td>
<td>68.6 (5.3)***</td>
</tr>
<tr>
<td>lymphocytes</td>
<td>3.6 (4.5)</td>
<td>13.1 (13.3)</td>
<td>4.6 (3.5)</td>
<td>23.7 (5.2)****</td>
</tr>
<tr>
<td>monocytes</td>
<td>3.1 (5.3)</td>
<td>2.6 (5.9)</td>
<td>4.4 (5.5)</td>
<td>4.8 (0.9)</td>
</tr>
<tr>
<td>basophils</td>
<td>2.4 (2.7)</td>
<td>0.1 (0.4)</td>
<td>0.4 (0.7)</td>
<td>1.2 (0.7)</td>
</tr>
<tr>
<td>eosinophils</td>
<td>0.4 (0.7)</td>
<td>2.6 (2.3)</td>
<td>2.5 (3.3)</td>
<td>1.7 (0.8)</td>
</tr>
</tbody>
</table>

*differentiation in peripheral blood at *t*180, mean value of all three experiments.

**t* test CTA vs CU: P < 0.05.

***t* test PB vs eluates: CTA and PS *P* < 0.001, CU *P* < 0.05.

****t* test PB vs eluates: CTA and PS *P* < 0.001, CU *P* = 0.057.

---

Fig. 1. White blood cell (WBC) counts (x 10⁹/l, left Y axis) in peripheral blood during 180 min of HD with CTA, PS, and CU dialysers, and WBC counts (x 10⁶ cells, right Y axis) in dialyser eluates. A significant leukocyte dip in PB was noted only during CU dialysis at *t*30 (****P < 0.001). The mean WBC count in all eluates was 53 × 10⁶ cells. The difference between CTA and CU was significant (**P < 0.05).
Fig. 2. Lymphocyte subsets (percentage: T cells (CD3+), B cells (CD19+), and NK cells (CD3−/CD16+/56+)) in peripheral blood before (t0) and after HD (t180), as well as in eluates of CTA, CU, and PS dialysers. A relative decline in NK cells was noted at the end of HD with all membranes (significant only for CTA. *P = 0.04). PS eluates differed markedly from peripheral blood at t180 (**P < 0.05) and the eluates of CTA and CU.

Table 3. Lymphocyte counts and subpopulations in peripheral blood and dialyser eluates

<table>
<thead>
<tr>
<th>Lymphocyte subset</th>
<th>Blood t0</th>
<th>Blood t180</th>
<th>Eluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose triacetate</td>
<td>1.15*** (0.5)</td>
<td>1.33*** (0.5)</td>
<td>2.44*** (2.9)</td>
</tr>
<tr>
<td>CD3</td>
<td>70.1 (14.8)</td>
<td>67.5 (28.6)</td>
<td>70.0 (11.8)</td>
</tr>
<tr>
<td>CD19</td>
<td>5.5 (3.1)</td>
<td>5.5 (2.7)</td>
<td>5.6 (4.1)</td>
</tr>
<tr>
<td>CD16/56</td>
<td>21.5 (11.5)</td>
<td>13.8 (6.3)</td>
<td>16.9 (8.3)</td>
</tr>
<tr>
<td>CD4</td>
<td>46.4 (9.3)</td>
<td>57.8 (9.8)</td>
<td>43.7 (18.0)**</td>
</tr>
<tr>
<td>CD8</td>
<td>29.0 (7.7)</td>
<td>23.1 (4.4)</td>
<td>25.7 (5.9)</td>
</tr>
<tr>
<td>CD3/25</td>
<td>16.0 (10.1)</td>
<td>16.9 (10.1)</td>
<td>13.9 (7.5)</td>
</tr>
<tr>
<td>CD3/HLA-DR</td>
<td>12.9 (6.9)</td>
<td>17.1 (10.1)</td>
<td>9.3 (5.8)**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Polyacrylamide</th>
<th>Blood t0</th>
<th>Blood t180</th>
<th>Eluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphocyte count</td>
<td>1.44*** (0.5)</td>
<td>1.24*** (0.4)</td>
<td>2.13*** (2.3)</td>
</tr>
<tr>
<td>CD3</td>
<td>72.0 (17.4)</td>
<td>78.5 (13.5)</td>
<td>36.9 (26.2) **</td>
</tr>
<tr>
<td>CD19</td>
<td>5.5 (2.3)</td>
<td>5.6 (2.6)</td>
<td>22.1 (20.0)**</td>
</tr>
<tr>
<td>CD16/56</td>
<td>19.5 (13.9)</td>
<td>16.4 (10.5)</td>
<td>29.8 (22.9)**</td>
</tr>
<tr>
<td>CD4</td>
<td>48.8 (13.7)</td>
<td>54.3 (11.7)</td>
<td>24.5 (16.7)**</td>
</tr>
<tr>
<td>CD8</td>
<td>27.4 (6.8)</td>
<td>27.9 (6.0)</td>
<td>24.0 (7.9)</td>
</tr>
<tr>
<td>CD3/25</td>
<td>11.1 (11.9)</td>
<td>15.0 (14.7)</td>
<td>6.4 (10.5)**</td>
</tr>
<tr>
<td>CD3/HLA-DR</td>
<td>14.3 (14.8)</td>
<td>13.6 (12.1)</td>
<td>7.2 (5.2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cuprammonium</th>
<th>Blood t0</th>
<th>Blood t180</th>
<th>Eluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphocyte count</td>
<td>1.33*** (0.6)</td>
<td>1.50*** (0.6)</td>
<td>3.44*** (2.5)</td>
</tr>
<tr>
<td>CD3</td>
<td>76.1 (10.6)</td>
<td>79.4 (8.6)</td>
<td>64.3 (25.0)</td>
</tr>
<tr>
<td>CD19</td>
<td>5.8 (2.4)</td>
<td>5.6 (2.4)</td>
<td>7.3 (8.2)</td>
</tr>
<tr>
<td>CD16/56</td>
<td>17.1 (10.2)</td>
<td>12.9 (7.2)</td>
<td>17.6 (14.6)</td>
</tr>
<tr>
<td>CD4</td>
<td>52.1 (14.7)</td>
<td>58.3 (8.9)</td>
<td>45.6 (18.5)</td>
</tr>
<tr>
<td>CD8</td>
<td>27.4 (6.1)</td>
<td>23.8 (7.0)</td>
<td>23.6 (8.0)</td>
</tr>
<tr>
<td>CD3/25</td>
<td>15.9 (12.2)</td>
<td>20.0 (13.5)</td>
<td>11.8 (7.6)</td>
</tr>
<tr>
<td>CD3/HLA-DR</td>
<td>13.6 (6.8)</td>
<td>13.0 (6.4)</td>
<td>14.9 (8.5)</td>
</tr>
</tbody>
</table>

*PB t0 vs t180, P < 0.5.
**PB t180 vs eluate, P < 0.5.
Lymphocyte counts in peripheral blood (×10⁷/l) and dialyser eluates (×10⁴/absolute count. ×10³, and lymphocyte subpopulations CD3+ cells: T cells, CD19+: B cells, CD16/56−/NK cells, CD4+: T-helper cells, CD8+: T-suppressor cells, CD16+/56+CD25+ and CD3/HLA-DR+: activated T cells (mean % (SD)).

CU dialysis was similar. However, in PS eluates proportionally fewer T cells (t = 5.58; DF = 7; P = 0.001) and more B (t = −2.47; DF = 7; P = 0.043) and NK-cells (t = −2.8; DF = 7; P = 0.027) were found than in PB (Figures 2 and 4, and Table 3). As for CD4+ cells, CU of all three dialysers showed a lower proportion than PB, whereas CD8+ cell numbers were similar.

No signs of activation were noted in eluted T lymphocytes. In comparison with PB at t180, the proportion of both CD3+/HLA-DR− and CD3+/CD25+ lymphocytes was even lower in DE from all three dialysers (CD3+/HLA-DR: CTA t = 3.42; DF = 5; P = 0.02; CD3/25: PS t = 6.56; DF = 5; P = 0.001). Figure 3.

Discussion
In a previous study, we described an elution technique which could effectively separate adherent cells, sticking
Subpopulations of lymphocytes in dialyser eluates: new parameter of bioincompatibility?

To the dialyser membrane after HD, from passen
gear cells residing temporarily in the dialyser [8].

Subsequently, various aspects of eluted PMN were
described [9]. In the present study lymphocytes were
analysed, both in dialyser eluates and in PB, in a
randomized crossover comparison between CTA,
CU, and PS.

In the peripheral blood, only CU induced a signifi-
cant leukopenia, without influencing the absolute
number of lymphocytes. As far as dialyser eluates were
concerned, the total number of eluted cells (mean
5.3 x 10^8) was small in comparison with the number
of lymphocytes in the blood (mean 5.5 x 10^9/l). In concor-
dance with our previous findings [8], the vast majority
of the eluted cells of the three dialysers turned out to
be PMN (81–91%). Only a small percentage consisted
of lymphocytes (4–13%), the absolute numbers varying
between 2.1 and 3.4 x 10^6, which is about 2.5 x 10^4
of the number of circulating lymphocytes, and only
2.5 x 10^−6 of the total body-pool [12]. Hence it seems
highly unlikely that the chronic peripheral blood
lymphopenia and the chronic immunodeficient state,
as described in HD patients [13,15], are due to
sequestration of lymphocytes within the dialyser.

The percentages of T(CD3+), B(CD19+) and
NK(CD3+/CD16+/56+) cells in the eluates of CTA,
CU, and PS dialysers. PS eluates contained markedly more B
and NK cells, but fewer T cells in comparison with peripheral blood
and the cellulose based dialysers (CTA and CU). For PS, the
difference between PB and DE was significant (*P<0.05).

Although significant differences between the dia-
lysers could be demonstrated in this respect, the
sequestration of lymphocyte subsets was negligible in
relation to the total body-pool, as stated before. Hence
it is hardly conceivable that the dissimilar trapping of
lymphocyte subpopulations, as observed in this study,
duces membrane-dependent changes in the immune
status of HD patients. Therefore, in our opinion, not
the trapping of lymphocytes itself, but dialyser-specific
changes in the functioning of lymphocytes seem funda-
mental for the various alterations in the immune
response after HD. According to reports on this sub-
ject, cellulose materials induce more interference than
synthetic substances [1,15–18].

As far as the peripheral blood was concerned, all
three membranes induced a relative increase in
CD3+/CD4+ cells, as has been described before
[13,19]. In addition, NK-cells tended to decrease at
the end of HD, confirming not only a previous study
from our centre [19], but also other published data
[13,18,20]. However, only in case of PS dialysers, was
the decline in NK-cells in peripheral blood accompa-
nied by a relatively high proportion of NK-cells in
the eluates, indicating that sequestration might underlie
this process to some extent.

In contrast to the activated state of eluted PMN, as
demonstrated in a previous study [9], expression of
T-cell activation markers appeared generally lower in
eluates than in peripheral blood at t180, but only
significant for CTA in the case of HLA-DR, and for
PS in the case of CD25.

Furthermore, although HD-induced T-cell (pre)ac-
tivation has been described both in vivo [6,15] and in vitro [5], T-cell activation, as indicated by an increased
expression of CD25 and/or HLA-DR, was not
observed in blood samples taken during HD with
either membrane in this study. Nevertheless, dialyser-
induced lymphocyte activation either in peripheral
blood and/or eluates cannot be totally excluded in the
present study, as besides expression of early activation-
markers (CD25, HLA-DR) [6,21], the appearance of
late surface markers (VLA-1) has also been described
[20].

As mentioned, lymphocyte subsets in dialyser eluates
have been analysed by Castiglione and co-
workers [10,11]. However, the latter studies were per-
formed only in a limited number of patients in a non-
randomized fashion. In addition, as published else-
where [8], we showed that the analysis of dialyser
eluates is markedly influenced by the elution technique
itself, which was not described in detail in the afore-
mentioned reports. Consequently it may not be surpris-
ing that the previous data are somewhat conflicting
with ours. First, in that study the amount of eluted
cells showed a respectable variation (9–88 x 10^6).
Second, a proportional increase in B cells was observed
in the eluates of both CU and PS, whereas only PS
dialysers showed a preferential sequestration of B cells
in our study. Third, selective trapping of NK cells was

![Fig. 4. Lymphocyte subsets (percentage; T-cells (CD3+), B cells (CD19+) and NK cells (CD3+/CD16+/56+)) in the eluates of CTA, CU and PS dialysers.](https://academic.oup.com/ndt/article-abstract/11/6/1073/1819411/1616703/1818491)
found not only in case of PS, as demonstrated in the present analysis, but also in case of modified cellulosic membranes [11]. Hence, further elution studies with different membranes and a standardized elution method might be of interest.

To summarize, the numbers of lymphocytes eluted from all three membranes were modest in comparison with granulocytes. In addition, the absolute amount of lymphocytes was negligible in comparison with the total body pool. Therefore, dialyserspecific mechanisms other than lymphocyte sequestration seem to be involved in the immune-deficient state of HD patients. In contrast to PMN, eluted lymphocytes displayed a proportionally low expression of activation markers. In case of the cellulosic-derived membranes (CU and CTA), lymphocyte subset adherence appeared non-selective. In contrast, PS eluates showed significant selectivity for B lymphocytes and NK cells at the expense of T lymphocytes. Based on the striking dissimilarities between the lymphocyte subsets in the eluates of CU and CTA on the one hand, and PS on the other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences other, it is tempting to speculate that eluted lymphocytes, rather than eluted PMN [9], represent differences

Acknowledgements. We wish to thank Prof. Dr A. J. M. Donker, Dr J. A. van Geelen and Dr P. M. ter Wee for their critical reading of the manuscript; Anja Bijpost, Gerard Loot, Irene Slaman, Astrid Smit, Mirjam Verhey, Paula Zuurker, and the staff of the dialysis department for their invaluable support and enthusiasm, and Stichting OMCA (Research Fund Medical Center Alkmaar), Stichting Diafoon and Fresenius BV for financial support.

References


Received for publication: 18.9.95
Accepted in revised form: 15.1.96