Effects of Zinc-Containing Dialysis Membranes on Zinc Metabolism in Patients on RDT

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In a previous paper (Zazgornik et al., 1971) we reported that zinc was released both into the dialysis fluid and into the patient's blood, when haemodialysis was performed with cellophane membrane coils. With the introduction of the cuprammonium process a new type of dialysis membrane, the cuprophane membrane, has become available. The differences in the zinc and copper content of the two types of membranes prompted us to study the effects of regular haemodialysis on the patient's zinc metabolism by comparing the data obtained with cellophane and cuprophane membranes.

MATERIAL AND METHODS

In a first series of investigations routine haemodialysis was done in 9 patients (aged between 22 and 44 years) with the Twin-Coil-Travenol-system (cellophane membrane, membrane surface 19,000 cm²). In a second series haemodialysis was done in 10 patients (aged between 16 and 49 years) with cuprophane coils (SH 50 HF, cuprophane membrane, membrane surface 9,000 cm²). Dialysis was performed two to three times each week for 6 hours.

In both series of investigations pre- and post-dialysis zinc levels in the plasma and red cells were determined. To account for the net zinc movements during a single dialysis the dialysis fluid of 3 patients of each group was collected in 15-litre containers after passage through the RSP-dialysis system. Total zinc released into the dialysis fluid was calculated from zinc contents of single samples. Zinc was measured by atomic absorption spectrophotometry (Zazgornik et al., 1971)

RESULTS

Predialysis plasma zinc concentrations (Zn_p) were normal or increased when compared to a group of normal subjects (Table I). When using cellophane membranes the difference was found to be more pronounced (p < 0.005).
Table I. Zinc concentrations in plasma (ZnP) and red cells (ZnR) prior to and after 6-hour dialysis as well as net Zn loss to dialysis fluid during dialysis depending on membrane used

<table>
<thead>
<tr>
<th>Dialyser</th>
<th>ZnP µg/100 ml</th>
<th>n</th>
<th>ZnR µg/ml</th>
<th>n</th>
<th>Net/loss Zn mg</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCT® (series I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>membrane surface</td>
<td>261 ± 92</td>
<td>32</td>
<td>17.4 ± 1.4</td>
<td>10</td>
<td>42.9</td>
<td>3</td>
</tr>
<tr>
<td>19 x 10³ cm²</td>
<td>275 ± 88</td>
<td></td>
<td>15.6 ± 1.6</td>
<td></td>
<td>(33.7 - 48.0)</td>
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<tr>
<td>SP 50 HFR® (series II)</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>membrane surface</td>
<td>119 ± 25</td>
<td>33</td>
<td>15.0 ± 2.6</td>
<td>33</td>
<td>25.6</td>
<td>3</td>
</tr>
<tr>
<td>7 x 10³ cm²</td>
<td>132 ± 33</td>
<td></td>
<td>14.8 ± 3.4</td>
<td></td>
<td>(15.7 - 34.1)</td>
<td></td>
</tr>
<tr>
<td>Normal subjects</td>
<td>106 ± 20</td>
<td>30</td>
<td>12.0 ± 1.6</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-dialysed</td>
<td>120 ± 10</td>
<td>10</td>
<td>14.8 ± 1.2</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chronic uraemics</td>
<td></td>
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</tbody>
</table>

In both series the plasma zinc concentrations increased slightly towards the end of the dialysis. The increase was, however, statistically not significant. In both groups predialysis red cell zinc concentrations (ZnP) were higher than in the control group (p < 0.01 and p < 0.025). Again the difference was more pronounced in series I with cellophane than in series II with cuprophane membranes. During dialysis a statistically not significant drop of red cell zinc was observed in both groups. In spite of this drop mean values at the end of dialysis were still above normal.

In both series a significant rise of zinc concentrations in the dialysate was observed. When using cellophane membranes zinc losses into the dialysis fluid were more pronounced than during dialysis with cuprophane coils. (Figure 1)

**DISCUSSION**

As the data presented indicate, the zinc metabolism of our patients under-

![Figure 1](attachment:image.png)  
**Figure 1.** Zinc concentration in the dialysate during haemodialysis using coils with cellophane [ ] and cuprophane [ ] membrane (Pat. BA, 16a)
going regular dialysis is characterised by normal or increased plasma zinc concentrations - and by clearly raised red cell levels. If these results are interpreted in terms of a positive zinc balance, diminished renal elimination of zinc must be considered as a cause of the retention of this trace element. However, in normal subjects the major portion of ingested zinc, i.e. about 10 mg, is eliminated with the faeces and no more than 350 to 400 micrograms with the urine (Vallee et al., 1965).

Increased supply from exogenous sources, such as zinc-containing dialysers may play a much more important role (Blomfield et al., 1969; Zazgornik et al., 1971). In this context the reported decrease of $^{65}$ZnCl$_2$ radio-activity after washing the cellophane membrane is worth noting (Maher et al., 1965).

The actual zinc content of a dialyser is not only determined by the amount of zinc used during fabrication of the coil, but also by the size of the membrane surface.

This would explain why patients exposed to cellophane coils show a higher plasma and red cell concentration than those dialysed with cuprophane coils with smaller membrane surface. The total zinc balance during dialysis is accounted for by both the amount of zinc discharged from the membrane into the blood and the amount of zinc released from the blood into the dialysis fluid (Zazgornik et al., 1971).

Depending on the zinc content, the efficiency of the dialyser and the dialysis time in a given case, the postdialysis zinc balance can either be positive, normal or negative. This would explain the discrepancies between our findings and those of other authors (Mansouri et al., 1970; Condon & Freeman, 1970), who observed reduced and low normal plasma concentrations with increased red cell concentrations (Mansouri et al., 1970) and normal tissue levels in kidneys, heart and liver on plate dialysis. The amount of zinc recovered from the dialysis fluid amounts to 7 to 9 times the quantity normally absorbed per day. If a causal relationship between the zinc in the dialysis fluid and the dialyser is denied and if origin of this zinc is due to zinc depots in the body, it is inconceivable that plasma and red cell concentrations can be increased in spite of the loss of endogenous zinc.

Increased zinc concentrations have been shown to cause secondary copper, iron and calcium deficiencies with resultant anaemia and osteoporosis in animals owing to the antagonistic effect of zinc on other elements and electrolytes (Underwood, Van Reen; cited by Blomfield et al., 1969). Whether or not interactions between zinc and other elements also exists in humans has not been established.
ACKNOWLEDGMENT

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REFERENCES

Condon, C. J. and Freeman, R. M. (1970) Annals of Internal Medicine, 73, 531
Mansouri, K., Halsted, J. A. and Gombos, E. A. (1970) Archives of Internal Medicine, 125, 88
OPEN DISCUSSION

H C BURCK (Tubingen): Dr Schmidt, I have two questions and a comment. First, what kind of atomic absorption instrument did you use? Did you use the Unicam SP 90 or the Perkin-Elmer? I ask this because results obtained with the SP 90 show very large standard deviations, while the Perkin-Elmer instrument is much more accurate. If you used the SP 90, I doubt whether the differences you described are significant. Second, did you take trapped plasma into consideration for the red cell estimates? We have done some studies on zinc metabolism in red cells and found that the concentration of zinc in plasma is about twenty times that in cells: so, if you find a slight increase in plasma zinc concentration between the two groups, and an increase in red cell zinc, but do not take into consideration the trapped plasma, the apparent increase in the red cell zinc may only be due to the increase in the plasma level. We did not find any increase in red cell zinc during haemodialysis, or peritoneal dialysis. In contrast, we found that the zinc concentration was even lower in uraemic patients than in normal.

SCHMIDT: In answer to the first question, we used the second instrument you mentioned, the Perkin-Elmer. In reply to the second question, I must state that we didn't allow for plasma trapping. Our differences between the pre-dialysis and the post-dialysis values were not statistically significant and this was the same in all groups because there were always the same patients.