THE INFLUENCE OF GLUCOSE CONCENTRATION IN THE DIALYSATE ON THE ELEcTroencePhaLograms Of URAEMIC PATIENTS

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It is well known that the EEG recordings of uraemic patients often deteriorate during extracorporeal haemodialysis [Peterson (1964); Stölzel (1962); Stölzel (1963); Falzone (1965); Bennhold (1965); Kennedy, Linton, Luke, Renfrew, Dinwoodie (1964a); Kennedy, Luke, Linton (1964b); Kennedy, Linton, Luke, Renfrew (1963)]. Less common are the signs and symptoms of cerebral dysfunction, such as headaches, agitation, confusion and numbness, and very seldom there are muscle twitching and convulsions. The EEG changes are non-specific and generalized, showing slow frequency waves, high voltage, dysrhythmia, and sharp waves. Occasionally spike and wave patterns are found. In most cases EEG ameliorations can be observed the day after haemodialysis.

Pathogenesis and prevention of these disturbances have been discussed frequently in recent times [Kennedy et al. (1964 a,b); Shackman, Chisholm, Holden, Pigott (1962); Peterson (1964)].

It is the purpose of this paper to survey how the EEG deterioration during extracorporeal haemodialysis can be influenced by the glucose concentration in the dialysate, and to find out what EEG changes occur—if any—immediately after maintenance haemodialysis using different bath-glucose concentrations.

Methods and material

EEG recordings have been conducted during 130 haemodialyses on 78 patients with severe renal failure (Group A) and during 50 maintenance haemodialyses on 3 patients (Group B). The following bath-glucose concentrations have been used:

| 0.5 g per 100 ml | 1.0 g per 100 ml | 1.5 g per 100 ml |

Three types of EEG have been employed: Schwarzer 2-channel; Schwarzer 4-channel, portable; Kofes 2-channel and 3 types of artificial kidneys: Alwall’s artificial kidney, Twin coil kidney (Travenol), Twin coil kidney (Freiburg). The EEG recordings were bipolar. The average dialysis time was 6 hours.

Results

Acute renal failure and acute deterioration of chronic renal insufficiency

<table>
<thead>
<tr>
<th>Bath-glucose concentration (g per 100 ml)</th>
<th>No. of cases</th>
<th>EEG-features</th>
<th>Amelioration or no change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Deterioration</td>
<td>20</td>
</tr>
<tr>
<td>0.5</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>64</td>
<td></td>
<td>37</td>
</tr>
<tr>
<td>1.5</td>
<td>28</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>
The above table shows the results of our EEG examinations during 130 haemodialyses of group A. Sixty-six EEG recordings show distinct deterioration. These alterations were not only noticed when the dialysate had a low or medium glucose concentration, but also fairly often, when the bath-glucose concentration was high.

Figure 1 shows a distinct deterioration of the EEG recordings in spite of a high glucose concentration in the dialysate. The general condition of this patient did not alter.

![Fig. 1](image)

*Fig. 1. Example of a considerable deterioration of the EEG recording during haemodialysis using a bath-glucose concentration of 1.5 g per 100 ml.*

20 hours following dialysis treatment the EEG pattern is so much improved that it is better than pre-dialysis.

However, we must emphasize that most of the very severe changes were observed when the bath-glucose concentration was low. These findings correspond with our clinical observations: From 1958 to 1962 we dialysed against a 1 g% glucose concentration as was recommended by Dr. Alwall. Within that time we have hardly ever seen patients suffering convulsions during haemodialysis. Later we used temporarily a dialysate with only 0.5 g% glucose concentration, and during that period a larger number of patients deteriorated acutely and showed severe signs and symptoms of cerebral dysfunction, even convulsions.

It is known that the urea clearance from the CSF is delayed in comparison with the urea clearance from the blood plasma [Kennedy, Linton, Eaton (1962); Scheitlin, Hunziker (1962)]. EEG changes and cerebral oedema occasionally observed during haemodialysis are supposed to be due to this reverse urea shift [Sitpria, Holmes (1962); Gilliland, Hegstrom (1963); Scribner (1962)]. Then the urea gradient between C.S.F. and plasma would determine the amount of oedema and thus the severity of the EEG changes. With the use of a high glucose concentration in the dialysing fluid the osmotic gradient will be markedly
Fig. 2. Maintenance haemodialysis with a bath-glucose concentration of 0.5 g per 100 ml, during which the EEG only shows theta-activity. Increasing EEG changes with high voltage theta waves only occurred after dialysis treatment.

Fig. 3. Maintenance haemodialysis with a bath-glucose concentration of 1.0 g per 100 ml. During dialysis there are no EEG changes. 20 minutes following dialysis there are high voltage slow frequency waves. 90 minutes following dialysis the slow activity pattern is even more marked.
reduced during haemodialysis. A high bath-glucose concentration however usually causes a steep post-dialysis fall of the blood sugar concentration, which corresponds with an increase of the osmotic gradient. Therefore the post-dialysis disequilibrium should be more marked now, rather than after the use of a lower bath-glucose concentration.

The fact that we found severe EEG alterations also after only slight reductions of the BUN concentrations, induced us to examine our 3 patients (group B), who undergo regular maintenance haemodialysis more specifically. And for the first time we also carried out on most patients several EEG recordings during the 90 minutes following dialysis treatment. We must mention the following facts: The average reduction of the BUN concentration was only from 30 to 50 mg%. The general condition of these ambulant patients was good before, during and after haemodialysis. There were no complications during any of these treatments.

In spite of these facts we found distinct EEG deteriorations in as many as 35 of 50 dialyses. These EEG changes were more marked after dialysis treatment, and in some cases they only occurred post-dialysis. There was no evidence that the bath-glucose concentration determined either the severity or the time of occurrence of these abnormal EEG patterns.

Figures 2-4 show examples of the deterioration of the EEG recordings during and after maintenance haemodialyses. It is shown that we used different bath-glucose concentrations.

Figure 5 shows that also when employing peritoneal dialysis resulting in a slow reduction of the BUN concentration, we occasionally observed severe EEG deteriorations.

In conclusion we wish to mention that the EEG of uraemic patients can be altered simply by an intravenous infusion of glucose without any dialysis treatment, sometimes giving rise to deterioration and sometimes to amelioration [Nogi, Uchihori, Kobota, Maeda (1959); Falzone (1965); Uchihori, Kobota, Nishioka (1957)].
Fig. 5. Example of an EEG deterioration during peritoneal dialysis. 2 days after treatment commencement there are slow waves (1-2 c/sec). 6 hours following dialysis a slight improvement can be detected. Further improvement can be seen 28 hours following dialysis.

Summary
1. In cases of severe renal failure most of the severe EEG deteriorations were found when the bath-glucose concentration was low (0.5 g per 100 ml).
2. A high bath-glucose concentration (1.5 g per 100 ml) however very often cannot prevent EEG alterations altogether, but here the deteriorations are much less frequent than with the use of a lower bath-glucose concentration (0.5 or 1.0 g per 100 ml).
3. Investigations of our maintenance haemodialysis patients—with a low BUN reduction—showed that the slightly impaired pre-dialysis EEG patterns deteriorated further during, and more grossly after dialysis. Some cases maintained the pre-dialysis EEG pattern throughout dialysis, and EEG changes only occurred post-dialysis. There is no evidence that the bath-glucose concentration influences these findings in any way.

REFERENCES


