Changes in Middle Cerebral Artery Blood Velocity in Uremic Patients After Hemodialysis

Alfredo Postiglione, MD; Fulvio Faccenda, MD; Giovanni Gallotta, MD; Paolo Rubba, MD; and Stefano Federico, MD

Background and Purpose: Strokes are a frequent complication in uremic patients on dialysis. We wanted to evaluate the effect of this treatment on cerebral hemodynamic parameters, particularly those of patients with carotid stenosis, who are at higher risk for atherothrombotic ischemic events.

Methods: We used transcranial Doppler ultrasonography to evaluate blood velocity of the middle cerebral artery in 18 uremic patients before and after hemodialysis. Carotid stenosis was evaluated by echo-Doppler investigation. Six patients were also studied before and after recombinant human erythropoietin treatment.

Results: Dialysis treatment decreased mean blood velocity in all patients (p<0.001). Eight of 18 patients (44%) with mild (16–50%), moderate (51–80%), or severe (>80%) carotid stenosis had lower velocity than patients with normal carotid arteries (p<0.01), and they experienced a further decrease to even lower levels after hemodialysis (p<0.05). In patients treated with recombinant human erythropoietin, hematocrit increased from 28±8% to 37±5% (p<0.001), and blood velocity had a further decrease by 11%. All changes were associated with modifications toward normality of pH, Paco₂, and hematocrit.

Conclusions: Transcranial Doppler ultrasonography represents a useful method for monitoring cerebral circulation of uremic patients, especially of those at possible risk for ischemia.

(Stroke 1991;22:1508–1511)
Hemodialysis treatment was performed for 4 hours in each patient using a capillary filter with an effective surface area of 1 m² and a wall thickness of 8 μm. The dialysate flow was 500 ml/min, and blood flow was 280 ml/min. The dialyzer was prefilled with a large volume of saline solution (1500 ml) before each treatment. The dialysis was performed for 4 hours with a blood flow rate of 500 ml/min and a dialysate flow rate of 280 ml/min. The dialysate contained (meq/l): Na⁺ 139, K⁺ 2, Ca²⁺ 3.5, Mg²⁺ 1.5, Cl⁻ 108, acetate⁻ 38, and glucose 1 g/l. If hypotension occurred during the dialysis, it was treated by saline infusion, but never by hypertensive drugs.

We evaluated extracranial and intracranial arteries by echo-Doppler and TCD, respectively. Echo-Doppler examination of the carotid arteries was performed with a duplex scanner (ATL, USA) and included common carotid artery, bulb, and internal carotid artery. The diagnosis was based on the spectral analysis of the pulsed Doppler signal. With the subject in a supine position, we performed TCD before and within 60 minutes after the hemodialysis in a quiet room under constant environmental conditions at 22°C, using a 2-MHz pulsed-wave Doppler instrument (model SD1000, Vingmed, Norway) with on-line spectrum analysis. The probe was placed over a temporal bone “window” to insonate MCA. Because the Doppler window was not adequate in six of the 36 hemispheres of the patients investigated, a total of 30 hemispheres were studied. Blood velocity was measured at a standardized depth of 45 mm. Mean velocity (time-averaged maximum velocity over the cardiac cycle) was expressed in centimeters per second. Pulsatility (Pj) and resistance (Ri) indexes were calculated from the Doppler spectrum as follows: Pj=systolic velocity—diastolic velocity/mean velocity; Ri=systolic velocity—diastolic velocity/systolic velocity. These indexes represent an estimate of vascular compliance.

Arterial tension of carbon dioxide (Paco₂) and oxygen (PaO₂) and pH were measured simultaneously with TCD by conventional methods before and after the dialysis; hematocrit and other biochemical parameters, such as plasma urea and creatinine concentrations, total plasma protein, and albumin levels, were also evaluated.

Mean blood velocity and pulsatility and resistance indexes were compared before and after hemodialysis by paired and unpaired Student's t test. Statistical significance was set at p<0.05.

### Results

All patients underwent dialysis treatment without any side effects and without any significant episodes of arterial hypotension. Neurological examinations that followed the treatment were unchanged in all patients. Echo-Doppler investigation in 10 patients showed both carotid arteries patent or with small wall irregularities (stenosis ≤15%). Three patients had a mild stenosis (16–50%) and five a moderate-to-severe stenosis (>50%) of at least one carotid artery.

Table 1 shows biochemical parameters before and after hemodialysis, which were all changed toward normality. Body weight was reduced after treatment.

Table 2 shows the effects of hemodialysis on blood velocity and P in the MCA ipsilateral to patent or stenotic carotid arteries. Blood velocity ipsilateral to mild stenosis (16–50%) or severe stenosis (>80%) of at least one carotid artery.

### Table 1. Effects of Hemodialysis on Blood Pressure and Blood Parameters in 18 Uremic Patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before Hemodialysis</th>
<th>After Hemodialysis</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAM (mm Hg)</td>
<td>119±13</td>
<td>107±19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>pH</td>
<td>7.301±0.08</td>
<td>7.369±0.08</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Paco₂ (mm Hg)</td>
<td>36.1±3</td>
<td>33.2±3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>10.3±2</td>
<td>5.0±1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Urea (mg/dl)</td>
<td>177±38</td>
<td>65±19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>26±5</td>
<td>30±6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>64±9</td>
<td>61±9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum protein (g/dl)</td>
<td>6.7±0.5</td>
<td>7.8±0.7</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Values are mean±SD.

### Table 2. Changes in Middle Cerebral Artery Mean Blood Velocity and Pulsatility Index After Hemodialysis, According to Carotid Stenosis, in 18 Uremic Patients

<table>
<thead>
<tr>
<th>Degree of stenosis (%)</th>
<th>n</th>
<th>Velocity (cm/sec)</th>
<th>Pulsatility index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>0–15</td>
<td>20</td>
<td>61±17</td>
<td>51±19*</td>
</tr>
<tr>
<td>16–50</td>
<td>5</td>
<td>44±12†</td>
<td>39±11*</td>
</tr>
<tr>
<td>&gt;50</td>
<td>5</td>
<td>45±14†</td>
<td>41±18</td>
</tr>
<tr>
<td>All stenoses</td>
<td>10</td>
<td>44±12†</td>
<td>40±14§</td>
</tr>
</tbody>
</table>

* p<0.05, † p<0.001 before vs. after dialysis by Student's t test.

† p<0.05, † p<0.01 stenosis vs. normal by Student's t test.

Values are mean±SD; 30 middle cerebral arteries were evaluated.
In conclusion, uremic patients on chronic hemodialysis have a high prevalence of carotid arteriosclerosis. Dialysis decreased MCA blood velocity in all patients, especially in those with carotid stenosis. Human recombinant erythropoietin treatment increased hematocrit levels, but slightly decreased MCA velocity. Transcranial Doppler ultrasonography represents a reliable and suitable method for monitoring the hemodynamic features of uremic patients under dialysis, especially those at risk for cerebral events induced by low blood flow. The results of TCD examination might indicate that some uremic patients need more intensive efforts, including drug therapy, to prevent acute cerebral ischemia.

References


**KEY WORDS** • cerebral ischemia • hemodialysis • ultrasonics • uremia
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