SIDE EFFECTS IN BICARBONATE DIALYSIS
DUE TO LOW DIALYSATE pH

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Summary

In six commercially available bicarbonate containing dialysates pH and pCO₂ were determined. Side effects resulted from low pH and high pCO₂. Use of two of the six dialysates was associated with fatigue, muscle cramps and somnolence.

Introduction

Recent studies have demonstrated that bicarbonate dialysis is superior to acetate dialysis with regard to frequency of intradialytic and interdialytic symptoms in haemodialysis patients [1, 2]. During the past four years bicarbonate dialysis machines of various types have been developed and many concentrates of various compositions have become commercially available, generating specific problems (Figure 1). This study assesses the influence of a low dialysate pH and a correspondingly high pCO₂ (Henderson-Hasselbalch equation) on specific symptoms during haemodialysis treatment.

Material and methods

Two thousand one hundred and five bicarbonate dialyses in 25 patients were evaluated. pH and pCO₂ were measured using ABL 2 (Radiometer Kopenhagen); total CO₂ was determined with Titroprocessor 636 (Metrohm). The following dialysers were used: Gambro Optima, Major, Fiber GF 120; Salvia KF 1.2; Terumo Citrans TH 15, TE 15.

Dialysis machines and bicarbonate concentrates examined are listed in Table I. The composition of acetate containing dialysate was: Na 140mmol/L, K 2mmol/L, Ca 1.5mmol/L, Mg 1mmol/L, acetate 35mmol/L, glucose 100mg/dl.
TABLE I. Characteristics of various bicarbonate dialysates

<table>
<thead>
<tr>
<th>Concentrate (each n = 5)</th>
<th>pH</th>
<th>pCO₂ (mmHg)</th>
<th>T CO₂* (mmol/L)</th>
<th>Acetate† (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1¹</td>
<td>7.348 ± 0.057</td>
<td>45.5 ± 3.2</td>
<td>33.73 ± 0.84</td>
<td>2.1</td>
</tr>
<tr>
<td>2²</td>
<td>7.368 ± 0.048</td>
<td>43.8 ± 3.5</td>
<td>33.73 ± 0.85</td>
<td>2.1</td>
</tr>
<tr>
<td>3³</td>
<td>7.136 ± 0.036</td>
<td>84.4 ± 10.9</td>
<td>30.7 ± 0.3</td>
<td>10.0</td>
</tr>
<tr>
<td>4⁴</td>
<td>7.478 ± 0.019</td>
<td>41.8 ± 2.8</td>
<td>34.25 ± 0.42</td>
<td>7.5</td>
</tr>
<tr>
<td>5⁵</td>
<td>7.109 ± 0.018</td>
<td>96.6 ± 3.8</td>
<td>35.04 ± 1.02</td>
<td>8.0</td>
</tr>
<tr>
<td>6⁶</td>
<td>7.508 ± 0.028</td>
<td>45.4 ± 3.9</td>
<td>36.65 ± 0.85</td>
<td>5.8</td>
</tr>
</tbody>
</table>

* Titroprocessor 636 (Metrohm)
† According to the producer’s information

¹ Salvia KB 102 + SV 090/DMS 5
² Salvia KB 104 + SV 090/DMS 5
³ Belloco BL 185 B/Belloco Unimat
⁴ Belloco BL 185 E/Belloco Unimat
⁵ Schiwa SW 56 A + SW 56 BC/Extracorporeal
⁶ Schiwa SW 58 A + SW 56 BC/Extracorporeal

Concentrates of Gambro (+ AK10) and Fresenius (+ MTS) are examined presently.
Results

The characteristics of the six bicarbonate dialysates examined are shown in Table I. Significant differences were seen in pH and pCO\textsubscript{2}. Despite a low pH (7.0–7.2) and a high pCO\textsubscript{2} (80mmHg) in bicarbonate dialysates generated from

![Graph showing blood pCO\textsubscript{2} distribution]

Figure 2. Bicarbonate dialysis (pH 7.0–7.2/pCO\textsubscript{2} > 80mmHg). 48 dialysis (16 patients)

Patient: I. M. Φ, age 54

![Graphs showing pH, pCO\textsubscript{2}, and HCO\textsubscript{3}⁻ levels during dialysis]

Figure 3. --- --- Bicarbonate dialysis (pH 7.1/pCO\textsubscript{2} 99.2mmHg/HCO\textsubscript{3}⁻ 33mmol/L) n = 2.
--- Bicarbonate dialysis (pH 7.48/pCO\textsubscript{2} 44.0mmHg/HCO\textsubscript{3}⁻ 34mmol/L) n = 3.
--- --- Acetate dialysis (pH 6.94/pCO\textsubscript{2} 8.4mmHg/CH\textsubscript{3}COO⁻ 35mmol/L) n = 3
concentrates number 3 and number 5 the majority of 16 patients during 48 treatments did not develop hypercapnia. In only five treatments pCO\(_2\) rose above 60mmHg with a maximum of nearly 100mmHg (Figure 2). Nevertheless no signs of dyspnoea occurred. But, as expected, no increase in respiratory rate was observed. In all instances an increase of blood-pCO\(_2\) was accompanied by fatigue. Patient I.M. (Figure 3) in addition suffered from severe leg muscle cramps and developed somnolence. This patient was subjected to an intra-individual comparison in three successive dialyses using a bicarbonate dialysate with pH 7.48, no side effects occurred.

Patients generating symptoms during high pCO\(_2\) bicarbonate dialysis remained free of symptoms when dialysed against a low pCO\(_2\) dialysate. In Figure 4 a summary of side effects during bicarbonate dialyses (pH 7.3–7.6) is demonstrated.

![Figure 4. Bicarbonate dialysis (pH 7.3–7.6/pCO\(_2\) < 50mmHg). Blood pCO\(_2\) < 50mmHg during entire dialysis](image)

**Discussion**

The importance of a low pH and a high PCO\(_2\) in commercially available bicarbonate concentrates have not been recognised until recently, as the majority of patients are capable of eliminating the increased amount of CO\(_2\) via respiration [3]. In patients with metabolic acidosis treatment with bicarbonate containing dialysate is followed by increased CO\(_2\) generation in blood, which has to be compensated for by increased respiratory activity. In this situation the continued passage of CO\(_2\) [4] from dialysate to blood may lead to respiratory decompensation, particularly in patients with lung function impairment, or with decreased sensitivity of the respiratory centre (perhaps caused by tranquillisers or hypnotics),

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with subsequent CO₂ accumulation. Consequences may be: 1) worsening of acidosis; 2) development of latent or overt CO₂ intoxication; 3) acid-base dysequilibrium, i.e. difference of pCO₂ between blood and cerebrospinal fluid [5].

These considerations in connection with our data demonstrate, that the pH and pCO₂ of bicarbonate containing dialysates have to be in a physiological range in order to prevent possible side effects.

References

1 Van Stone JC. Dial Transpl 1979; 8: 703
2 Samar RE. Cont Dial Aug 1981: 10

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