Measuring Sodium in dialysis patients
sodium

Na-heparin sulphate  Na-dermatan sulphate  Na-chondroitin sulphate

Na-Sulfate  Na-Bicarbonate

plasma protein  Na-organic acid

Na-Chloride  Na-Citrate  Albumin  Na-Phosphate
Sodium binding

chemical
electrical
Sodium concentration vs activity

**concentration**
- total amount
- activity
- Exchangeable sodium
sodium

**Measurement**
- Indirect potentiometer
  - main laboratory analyzer
- Direct potentiometer
  - blood gas analyzer
- Flame photometer
- Ion electrophoresis
- Absorption spectroscopy
Measurement

- Indirect potentiometer
  - dilutes serum sample
  - measures electrical charge
  - compares with standard curve
    - Standards
      - protein content
      - lipid content
      - normal blood glucose
    - reports activity
- Estimates sodium concentration
  - assumption normal protein/lipid/glucose
**Measurement**

- **Direct potentiometer**
  - plasma sample
  - measures electrical charge
  - compares with standard curve
    - Standards
      - protein content
      - lipid content
      - normal blood glucose
  - reports activity
- **Estimates sodium concentration**
  - assumption normal protein/lipid/glucose
Sodium in fluids

Biological fluids

• Plasma
  ▪ Proteins
  ▪ Lipids
  ▪ Organic/non-organic acids

• Serum
  ▪ no clotting proteins

Qu does plasma sodium differ from serum sodium?
How reliable is your laboratory?
Sodium in fluids

Dialysis fluids
• Hemodialysis dialysate
  ▪ No Proteins
  ▪ No Lipids
  ▪ No organic acids
• contains
  ▪ bicarbonate
  ▪ chloride
  ▪ acetate/citrate
  ▪ glucose
Sodium in fluids

Dialysis fluids

- Hemodialysis dialysate
  - No Proteins
  - No Lipids
  - No organic acids

- contains
  - bicarbonate
  - chloride
  - acetate/citrate
  - glucose

- Peritoneal dialysate
  - No Proteins
  - No Lipids
  - No organic acids

- contains
  - lactate/bicarbonate
  - chloride
  - acetate/citrate
  - Glucose
  - iso-maltose
  - amino acids
  - GDPs
Sodium in fluids

Dialysis fluids
  • Hemodialysis dialysate
    ▪ No Proteins
    ▪ No Lipids
    ▪ No organic acids
  • contains
    ▪ bicarbonate
    ▪ chloride
    ▪ acetate/citrate
    ▪ glucose

• Peritoneal dialysate
  ▪ No Proteins
  ▪ No Lipids
  ▪ No organic acids
  ▪ contains
    ▪ lactate/bicarbonate
    ▪ chloride
    ▪ acetate/citrate
    ▪ Glucose
    ▪ iso-maltose
    ▪ amino acids
    ▪ GDPs

Qu does haemodialysis sodium differ from peritoneal dialysate sodium?
Can we simply use dialysate samples?

- indirect potentiometer
- direct potentiometer
  - proteins
  - lipids
  - organic/non-organic acids
- viscosity
  - need different standards
Indirect potentiometer

interference

• glucose
• lipids
• paraproteins
• icodextrin
Hemodialysis - dialysate composition

acid

RO water

bicarbonate

conductivity
conductivity

Measurement of electrical charge

- sodium
- chloride
- bicarbonate
- acetate
- citrate
- potassium
- calcium
- magnesium

Temperature
Check conductivity
• dialysis machine
• manufacturer
  ▪ single
  ▪ close range
  ▪ wider range
• acetate
Check conductivity

- dialysis machine
- manufacturer
  - single
  - close range
  - wider range
- acetate
Hemodialysis - dialysate composition

acid

RO water

bicarbonate

pH

conductivity
Increase dialysate sodium?
Increase dialysate sodium?

acid → RO water → bicarbonate

pH

conductivity
hemodialysis

acid

RO water

bicarbonate

pH

conductivity
conductivity
You sure the dialysate sodium was 138?

Reality check ...........

Difference Plot

- Identity
- Bias (-0.7)
- 95% Limits of agreement (-10.8 to 9.4)

You sure the dialysate sodium was 138?
Dialysate errors

acid concentrate

A fluid
Na+ = 102

bicarbonate

BiBag
Na+ = 35

dialysis water

conductivity cell
Dialysate errors

acid concentrate    dialysis water    bicarbonate

A fluid
Na+ = 102

BiBag
Na+ = 35

The “Base” Na therefore = (102 + 35) = 137mmol/l

The Assumption:

To reach a prescribed Na of 140mmol/l the dialysis machine will marginally increase the volume of A fluid in the mixture.
conductivity

MAP mmHg

** Pre  Post

post MAP

weekly

MAP

Jun Jly A1 A2 A3 A4 S1 S2 S3 S4 O1 O2 Nov

serum sodium mmol/l

***

post MAP w/hi

May Jun Jly Aug Sep Oct Nov

Weight kg

** Pre  Post

Jun Jly A1 A2 A3 A4 S1 S2 S3 S4 O1 O2 Nov

hypotensive episodes

Apr May Jun Jly Aug Sep Oct Nov
How do we get a 140 sodium?

The “Base” Na therefore =

\[(102 + 35) = 137 \text{mmol/l}\]

The Assumption:

To reach a prescribed Na of 140mmol/l the dialysis machine will marginally increase the volume of A fluid in the mixture.
**Renalyte Acid Concentrate**

For Bicarbonate Haemodialysis

<table>
<thead>
<tr>
<th>Ion</th>
<th>Concentration (mmol/l)</th>
<th>Composition (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>102.0</td>
<td></td>
</tr>
<tr>
<td>K⁺</td>
<td>1.00</td>
<td>Sodium Chloride</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>1.35</td>
<td>Potassium Chloride</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.500</td>
<td>Calcium Chloride 2H₂O</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>106.7</td>
<td>Magnesium Chloride 6H₂O</td>
</tr>
<tr>
<td>CH₃COO⁻</td>
<td>3.0</td>
<td>Acetic Acid</td>
</tr>
<tr>
<td>Glucose</td>
<td>1.0</td>
<td>Glucose Monohydrate</td>
</tr>
<tr>
<td>Α</td>
<td>223.1</td>
<td></td>
</tr>
</tbody>
</table>

The acid concentrate when diluted 1 part acid to 1.575 parts sodium bicarbonate 8.4% or equivalent powder bicarbonate to 42.425 parts purified water will contribute as above left to the final dialysate.

**Notes:** For safe use refer to the equipment manufacturer's instructions.

Use at other dilutions may result in patient injury. Use only clear solutions, do not use damaged containers. Always check the composition of the haemodialysis solution. Aluminium content of concentrate < 0.1 ppm. Unopened solution is non pyrogenic.

**Contraindications:** Hyperkalemia. Uncontrollable coagulation anomalies.

**Side Effects:** Hypotension, nausea, vomiting, muscle cramps, dizziness, headache and unconsciousness have been observed.
Renalyte Acid Concentrate for Bicarbonate Haemodialysis

**Composition (g/L):**

- Sodium Chloride: 268.2 g
- Magnesium Chloride $6\text{H}_2\text{O}$: 4.57 g
- Potassium Chloride: 3.35 g
- Acetic Acid: 8.11 g
- Glucose Monohydrate: 49.5 g
- $\Delta$: 223.1 mosm/l

The acid concentrate when diluted 1 part acid to 1.575 parts sodium bicarbonate 8.4% or equivalent powder bicarbonate to 42.425 parts purified water will contribute as above left to the final dialysate.

**Notes:**
- For safe use refer to the equipment manufacturer’s instructions.
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**Contraindications:**
- Hyperkalaemia: Uncontrollable coagulation anomalies.
- Side Effects: Hypotension, nausea, vomiting, muscle cramps, dizziness, headache and unconsciousness have been observed.

**Composition of ready-to-use haemodialysis solution**

1 part A/17 + 42.26 parts Purified Water + 1.72 parts $\text{NaHCO}_3$ 8.4% or equivalent

**Na**^+^ 138.0 mmol/l

**K**^+^ 1.00 mmol/l

**Ca**^{++} 1.00 mmol/l

**Mg**^{++} 0.50 mmol/l

**HCO_3^-** 35.0 mmol/l

**Cl**^-^ 104.0 mmol/l

**CH_3COO^-** 3.00 mmol/l

**Glucose** 1.0 g/l

**$\Delta$** 288 mosm/l

**Types of Application:** For extracorporeal bicarbonate haemodialysis or haemodialfiltration in combination with a ready to use 8.4% bicarbonate concentrate or bicarbonate in a dry form in the given dilution. Other dilutions can endanger patients.

**Contraindications:** Hyperkalaemia (for HD concentrates with a K^+ concentration on dilution of 4 mmol/l or higher), hypokalaemia (for HD concentrates with K^+ concentration on dilution of <3 mmol/l or lower). Uncontrollable coagulation anomalies.
CONCENTRATED HAEMODIALYSIS SOLUTION

A - Concentrate A330 BP2000

Composition in mmol/L in diluted solution

<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>103.9</td>
</tr>
<tr>
<td>Potassium</td>
<td>2.7</td>
</tr>
<tr>
<td>Chloride</td>
<td>6.615</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.1</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.5</td>
</tr>
<tr>
<td>Chlorate</td>
<td>1.0</td>
</tr>
<tr>
<td>Acetate</td>
<td>49.5</td>
</tr>
<tr>
<td>Glucose</td>
<td>6.626</td>
</tr>
</tbody>
</table>

Composition of ready-to-use haemodialysis solution

<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>138.0</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.00</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.00</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.50</td>
</tr>
<tr>
<td>Chloride</td>
<td>103.4</td>
</tr>
<tr>
<td>Chlorate</td>
<td>3.00</td>
</tr>
<tr>
<td>Acetate</td>
<td>3.00</td>
</tr>
<tr>
<td>Glucose</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Types of Application: For extracorporeal bicarbonate haemodialysis or haemodialfiltration in combination with a ready to use 8.4% bicarbonate concentrate or bicarbonate in a dry form in the given dilution. Other dilutions can endanger patients.

Contraindications: Hyperkalaemia (for HD concentrates with a K+ concentration on dilution of 4mmol/l or higher), hypokalaemia (for HD concentrates with K+ concentration on dilution of 3mmol/l or lower), uncontrollable coagulation anomalies.
The BiBag contains Sodium Bicarbonate (NaHCO3) powder and the default machine setting was 35 mmol/l of sodium bicarbonate solution.

**HOWEVER!**

The 3 mmol of acetic acid in the A fluid react with 3 mmol of NaHCO3 from the BiBag solution via the equation

$$3(\text{CH}_3\text{COOH}) + 3(\text{NaHCO}_3) \rightarrow 3(\text{NaCH}_3\text{COO}) + 3(\text{H}_2\text{O}) + 3(\text{CO}_2)$$

Therefore to achieve a final dialysis fluid bicarbonate level of 35mmol/l, it is necessary to produce 38mmol/l of sodium bicarbonate solution.
How many mmol/l of NaCl are there?

A/985: 268.2g of NaCl

\[
\text{RMM of NaCl} = (23 + 35.5) = 58.5
\]

\[
\frac{268.2 \times 1000}{58.3} = 4600.3 \text{ mmol/l in acid concentrate}
\]

This is diluted in a 1:44 ratio (or 1 in 45)

So the final concentration in our diluted A solution is

\[
\frac{4600.3}{45} = 102.2 \text{ mmol/l}
\]
How many mmol/l of NaCl are there?

A17: 263g of NaCl

\[
\text{RMM of NaCl} = (23 + 35.5) = 58.5
\]

\[
\frac{263 \times 1000}{58.5} = 4496 \text{ mmol/l in acid concentrate}
\]

This is diluted in a 1:44 ratio (or 1 in 45)

So the final concentration in our diluted A solution is

\[
\frac{4496}{45} = 100 \text{ mmol/l}
\]
Label for A17

Renalyte Acid Concentrate for Bicarbonate Haemodialysis

Composition (g/L)

- Sodium Chloride: 263.0 g
- Magnesium Chloride 6H2O: 4.57 g
- Potassium Chloride: 3.35 g
- Acetic Acid: 8.11 g
- Calcium Chloride 2H2O: 6.62 g
- Glucose Monohydrate: 49.5 g

Composition of ready-to-use haemodialysis solution

1 part A/17 + 42.28 parts Purified Water + 1.72 parts NaHCO3 8.4% or equivalent

<table>
<thead>
<tr>
<th>Ion</th>
<th>Concentration</th>
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</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>138.0 mmol/l</td>
</tr>
<tr>
<td>K⁺</td>
<td>1.00 mmol/l</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>1.00 mmol/l</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.50 mmol/l</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>35.0 mmol/l</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>104.0 mmol/l</td>
</tr>
<tr>
<td>CH₃C0O⁻</td>
<td>3.00 mmol/l</td>
</tr>
<tr>
<td>Glucose</td>
<td>1.0 g/l</td>
</tr>
</tbody>
</table>

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Contraindications: Hyperkalaemia (for HD concentrates with a K⁺ concentration on dilution of 4mmol/l or higher), hypokalaemia (for HD concentrates with K⁺ concentration on dilution of 2mmol/l or lower), Uncontrollable coagulation anomalies.
New Kimal concentrate

<table>
<thead>
<tr>
<th>Composition in mmol/L in diluted Solution</th>
<th>Dilution ratio 1:44</th>
<th>5 Litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>103 mmol/L</td>
<td></td>
</tr>
<tr>
<td>K⁺</td>
<td>1 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Ca⁺</td>
<td>1 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Mg⁺</td>
<td>0.5 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Cl⁻</td>
<td>107 mmol/L</td>
<td></td>
</tr>
<tr>
<td>CH₃COO⁻</td>
<td>3 mmol/L</td>
<td></td>
</tr>
<tr>
<td>Dextrose</td>
<td>1 gm/L</td>
<td></td>
</tr>
</tbody>
</table>
Dialysate composition

<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration</th>
<th>Dilution Factor</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>42.45</td>
<td>1:44 dilution</td>
<td>A/985</td>
</tr>
<tr>
<td>Purified water</td>
<td>1.575</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>1.72</td>
<td></td>
<td>A/17</td>
</tr>
<tr>
<td>Acid</td>
<td>42.45</td>
<td></td>
<td>A330</td>
</tr>
<tr>
<td>Purified water</td>
<td>1.575</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Dialysate errors
Sodium

Serum sodium
- Indirect potentiometer
- Direct potentiometer
  - glucose

- Dialysate sodium
  - Conductivity
  - Flame photometry
thank you for your attention!