Renal physiology III

Quantification of renal function

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Transport rate

Transport maximum ($T_m$) is transport rate at saturation.

Saturation occurs.

Renal threshold is plasma concentration at which saturation occurs.
Handling of glucose

(a) Filtration rate of glucose (mg/min)

(b) Reabsorption rate of glucose (mg/min)

(c) Excretion rate of glucose (mg/min)

(d) Filtration, reabsorption, and excretion rates of glucose (mg/min)

Plasma glucose (mg/100 mL plasma)

Approximate normal range

Tm

Transport maximum

Renal threshold

Renal threshold
Threshold concentration

- plasma concentration of a solute at which it begins to appear in the urine
- characteristic of each substance
- for glucose: threshold concentration is 11 mmol/l
- glucosuria at plasma glucose concentration > 11 mmol/l (diabetes mellitus)
- $T_m$ glucose = 16 mmol/l
Renal transport maximum ($T_m$)

- maximal amount of a substance that can be transported over tubular epithelium/min
- no $T_m$: inulin (not reabsorbed), or sodium – no upper limit
- high $T_m$: glucose (16 mmol/min)
Clearance is a non-invasive way of measuring GFR

Definition:
The amount of plasma in ml passing through the kidneys that have been cleared of a substance in a given amount of time

\[
\text{ Clearance } = \frac{\text{ urinary excretion rate of substance (mg/min) }}{\text{ plasma concentration of the substance (mg/ml) }}
\]

where the urinary excretion rate is calculated by:

\[
\text{ urinie flow rate x urine concentration of the substance}
\]

\[
\text{Clearance}_{\text{substance}} = V(\text{urine flow rate}) \times \frac{[U]_{\text{substance}}}{[P]_{\text{substance}}}
\]
Measuring clearance with inulin

- Inulin is a polysaccharide that comes from the dahlia root
- Inulin is freely filtered and neither reabsorbed nor secreted by the nephron
- Thus, inulin clearance is 125 ml/min = GFR

Example:

\[ U_{IN} = 35 \text{ mg/ml} \]
\[ V = 0.9 \text{ ml/min} \]
\[ P_{IN} = 0.25 \text{ mg/ml} \]
\[ C_{IN} = U_{IN} \times \frac{V}{P_{IN}} \]
\[ = 35 \times \frac{0.9}{0.25} \]
\[ C_{IN} = 126 \text{ ml/min} \]
Creatinine clearance

- injections are not necessary as with inulin
- routinely used to assess GFR
- plasma concentrations do not vary much
- a small amount is secreted by the proximal tubule
Determination of renal blood flow

- plasma load = total amount of substance in plasma which circulates through kidneys/min
- \[ \text{plasma load} = \text{effective renal plasma flow (ERPF in l/min)} \times \text{[substance]}_{\text{plasma}} \text{ (mmol/l)} \]
- use clearance of a substance that is cleared from the plasma in one circulation through the kidneys by filtration AND SECRETION
- \text{PAH (para-aminohippuric acid) or diodrast}
- effective renal plasma flow \[ = \left[ U \right]_{\text{PAH}} \times V/\left[ P \right]_{\text{PAH}} \]
- renal blood flow = renal plasma flow \times 1/1-\text{haematocrit}
Renal blood flow determination using clearance of PAH (para-amino hippuric acid)

Renal plasma flow = clearance of PAH

= $[U]_{PAH} \times \frac{V}{[P]_{PAH}}$

= 14 mg/ml x 0.9 ml/min/0.02 mg/ml

= 630 ml/min

Average PAH extraction ratio = 0.9

= 630/0.9

Renal plasma flow = 700 ml/min

Renal blood flow = RPF x 1/1-Hct

= 700 x 1/0.55

= 1273 ml/min
<table>
<thead>
<tr>
<th>Substance</th>
<th>[ ] filtrate</th>
<th>mmol/24h filtered</th>
<th>mmol/24h reabsorbed</th>
<th>% reabsorbed</th>
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<tr>
<td>Water</td>
<td>180 l</td>
<td>178,5 l</td>
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<tr>
<td>Na⁺</td>
<td>142</td>
<td>26 000</td>
<td>25 850</td>
<td>99</td>
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<td>560</td>
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<td>17 750</td>
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<td>100</td>
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<td>Creatinine</td>
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<td>0</td>
<td>0,0</td>
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