Renal Reabsorption & Secretion

Topics for today:

• Nephron processing of filtrate
• Control of glomerular filtration
• Reabsorption and secretion
• Examples of solute clearance rates
• Hormones affecting kidney function
• Counter current concentration mechanism

Renal Processing of Plasma:
(Amounts of filtrate and urine formed per day)

• Renal blood flow: ~24% of cardiac output
  (1.2 L/min)
• Renal plasma flow: ~700 ml/min
• Glomerular filtration rate: ~125 ml/min
  (or 180 L/day ... ~3x body mass)
• Reabsorption percent = about 99% (average)
• Urine formation: ~1.25 ml/min
  (~1.8 L/day)
Location of nephron functions

**Clearance** involves three essential renal processes:

- **Filtration** - a function of the glomerulus
- **Reabsorption** - a function of the kidney tubule
- **Secretion** - a function of the kidney tubule

Monitors input pressure; triggers release of local factors (bradykinin and endothelin) and systemic factors (renin); these local and systemic factors affect blood pressure to modulate glomerular filtration rate.

Autoregulation of Glomerular filtration rate (via control of renal blood flow)

Main site of much of the filtrate processing
Ultrastructure of tubular cell
(TEM view of prox. conv. tubule; longitudinal section)

Ultrastructure is designed for absorption

Active/passive reaborption
Various substances are actively transported across the apical surface. Many other substances move from the lumen into the tubular epithelial cells by passive transport processes. These substances move across the tubule cells into the interstitial fluid.

**active transport** (examples):
- glucose
- phosphate
- sodium

**passive reabsorption** (examples):
- water
- urea
- chloride

Renal reabsorption of glucose

*all glucose filtered can be reabsorbed up to ~ 200 mg%*
Active secretion

Various substances are actively transported across the basal surface. Organic substances are transported via organic anion transporter or organic cation transporter. These substances are then secreted at the apical surface into the lumen of the tubule.

- Organic anions secreted (examples):
  - penicillin
  - creatinine
  - diodrast
  - phenol red

- Organic cations secreted (examples):
  - histamine
  - norepinephrine
  - quinine

Secretion of potassium ions*

A process coupled with active reabsorption of Na occurs mainly in the distal convoluted tubule.

*Prevents disruption of heart EKG rhythm

Clearance function of kidney

The main function of the kidney is clearance, process by which the kidney removes ("clear") harmful substances from the plasma.

\[ C_X = \frac{(U_x)(V)}{P} \]

\( C_X \) = clearance
\( V \) = rate of plasma flow
\( P \) = rate of fluid flow

\( U_x \) = concentration of the substance in the urine

Plasma in (with harmful solutes)
Plasma out (minus harmful solutes)
Urine out (with harmful solutes)
Examples of clearance

Plasma clearance rates, ml/min

<table>
<thead>
<tr>
<th>Substance</th>
<th>Clearance Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>glucose</td>
<td>0 ml/min</td>
</tr>
<tr>
<td>amino acids</td>
<td>1-4 &quot;</td>
</tr>
<tr>
<td>Na⁺</td>
<td>0.5 &quot;</td>
</tr>
<tr>
<td>K⁺</td>
<td>15 &quot;</td>
</tr>
<tr>
<td>PO₄⁻³</td>
<td>21 &quot;</td>
</tr>
<tr>
<td>urea</td>
<td>60 &quot;</td>
</tr>
<tr>
<td>uric acid</td>
<td>6 &quot;</td>
</tr>
<tr>
<td>creatinine</td>
<td>150 &quot;</td>
</tr>
</tbody>
</table>

Cₜ = \frac{U_x V}{P_x} = \frac{\text{mg/ml x ml/min}}{\text{mg/ml}}

Renal Activation of Vitamin D

Hormones affecting kidneys

- Bradykinin
- Endothelin
- Renin/angiotensin
- Aldosterone
- Antidiuretic hormone (ADH)
- Atrial natriuretic factor
Renin/Aldosterone system

Water balance and ADH

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>water in beverages 1000 ml</td>
<td>skin &amp; lungs 900 ml*</td>
</tr>
<tr>
<td>water in food 1200 ml</td>
<td>via GI tract 100 ml</td>
</tr>
<tr>
<td>water of oxidation 300 ml</td>
<td>via kidneys 1500 ml</td>
</tr>
<tr>
<td>total 2500 ml</td>
<td>total 2500 ml</td>
</tr>
</tbody>
</table>

*insensible water loss

Water balance and ADH

When output exceeds input, plasma osmotic concentration increases, affecting osmoreceptors of hypothalamus, triggers release of ADH which increases permeability of DCT and collecting duct with increased reabsorption of water in these areas (concentrated urine). When input exceeds output, plasma osmotic concentration decreases resulting in less ADH release. This results in less reabsorption of water from DCT and collecting duct with decreased reabsorption of water in these areas (dilute urine - condition known as diuresis).