10.1 Urinary system

The Urinary S. (Chp. 10) & Excretion

10.1 Urinary system

What are the functions of the urinary system?

1. Excretion of metabolic wastes (urea, uric acid & creatinine)
2. Maintenance of water-salt balance
3. Maintenance of acid-base balance
4. Hormone secretion: renin and erythropoietin

10.1 Urinary system

Maintenance of water-salt and acid-base balance

- Both are homeostatic mechanisms
- Water-salt balance helps to maintain blood pressure
- The kidneys by excreting hydrogen ions and reabsorbing the bicarbonate ions this acid-base balance helps maintain a blood pH of ~7.4
Hormone secretion

- Renin – secreted by the kidneys to allow the adrenal glands to secrete aldosterone to help regulate water-salt balance
- Erythropoietin – secreted by the kidneys to stimulate red blood cell production when blood oxygen is low

Anatomy of the kidney
R. cortex, R. medulla & R. pelvis

What are nephrons?
- Microscopic functional unit of the kidney that produces urine
- > 1 million per kidney
Anatomy of a nephron

- Glomerulus – a ‘knot’ of capillaries inside the glomerular capsule where pores allow blood filtrate to come out (Glomerular Filtration)
- Proximal convoluted tubule – epithelial layer with a brush border of microvilli to allow reabsorption of filtrate components
- Loop of nephron – U-shaped structure that has a descending limb to allow water to leave and an ascending limb that pushes out salt
- Distal convoluted tubule – made of epithelial cells rich in mitochondria and thus is important for movement of molecules from the blood to the tubule (tubular secretion)
- Collecting ducts – several nephrons share a collecting duct which serve to carry urine to the renal pelvis

10.2 Kidney structure

How does the nephron form urine?
Name the 3 processes…

10.3 Urine formation

Glomerular filtration

- Water and small molecules move from the glomerulus to the glomerular capsule while large molecules and formed elements remain in the glomerular blood
10.3 Urine formation

**Tubular reabsorption and secretion**

- Many molecules and ions are reabsorbed from the nephron into the blood
- A second way to remove substances such as drugs, H⁺ and creatinine from the blood

<table>
<thead>
<tr>
<th>Reabsorbed Urine Components</th>
<th>Remanufactured Urine Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>First water</td>
<td>Same water</td>
</tr>
<tr>
<td>Filtrate</td>
<td>Rare filtrate water</td>
</tr>
<tr>
<td>Regurgitate with [urea]</td>
<td>Rare solids [urea]</td>
</tr>
</tbody>
</table>

10.4 Regulatory functions of the kidneys

**How is blood volume and pressure maintained by the kidneys?**

- Reabsorption of salt – increases the blood volume
  - Aldosterone: promotes the excretion of K⁺ and the reabsorption of Na⁺ (Cl⁻ follows and so does water into blood=higher volume)
  - (Atrial natriuretic hormone (ANH) – secreted by the heart when blood volume increases and inhibits the secretion of aldosterone which promotes the excretion of Na⁺=not highervolume)
- Establishment of solute gradient – a greater concentration is towards the inner medulla
- Reabsorption of water – due to the solute gradient water leaves the descending limb of the loop of the nephron then antidiuretic hormone (ADH) from the pituitary plays a role in water reabsorption at the collecting duct

**Water reabsorption in nephron**

ADH helps keen water/alcohol effects
How is the acid-base balance maintained?

- Buffers are a chemical or a combination of chemicals that can take up excess H⁺ or excess OH⁻.

  When H⁺ are added to blood:
  \[ \text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{CO}_3 \]

  When OH⁻ are added to blood:
  \[ \text{OH}^- + \text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}_2\text{O} \]

- The respiratory center in the brain can increase breathing rate if the buffers cannot maintain the pH.
- Ultimately, the kidneys are responsible for maintaining blood pH.

Kidney function disorders

- Diabetes, hypertension and inherited conditions are the most common causes of renal disease and failure such as:
  - Urethritis – localized infection of the urethra
  - Cystitis – infection in the bladder
  - Pyelonephritis – infection of the kidneys
  - Kidney stones – hard granules formed in the renal pelvis due to UTI’s, enlarged prostate, pH imbalances or intake of too much calcium
  - Uremia – high levels of urea and other waste substances in the blood that causes a serious condition when water and salts are retained due to extensive nephron damage

How can kidney failure be treated?

- Hemodialysis – uses an artificial kidney machine to subtract and add substances to the blood as needed
- Continuous ambulatory peritoneal dialysis (CAPD) – used the peritoneal membrane to filter the blood and allows a person to go about their normal life without interruption
- Kidney replacement – single kidney transplant with a high success rate (first transplants!)
How do the kidneys maintain homeostasis?

- Excrete wastes
  - Urea, creatinine and uric acid

- Water-salt balance of blood
  - Helps regulate blood volume and pressure

- Acid-base balance of blood
  - Helps regulate pH

- Assistance to other systems
  - Endocrine, cardiovascular, skeletal, muscular, nervous and digestive

Bioethical focus: what do you think?

- Does prolonging life mean prolonging suffering?
- Who should make the decisions: the patient or the doctor?
- Does a doctor have a responsibility to treat a patient to extend his/her life even if it is against the patient’s wishes?
- If a patient is unable to decide their own medical treatment who should make the decisions?