Chapter 4

RENAL FUNCTION TESTS

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INTRODUCTION

- Renal function may be assessed by measuring blood urea and serum creatinine. Renal function decreases with age, which must be taken into account when interpreting test values.
- These tests primarily evaluate glomerular function by assessing the glomerular filtration rate.
In many renal diseases, urea and creatinine accumulate in the blood because they are not excreted properly.

These tests also aid in determining drug dosage for drugs excreted through the kidneys.
Azotemia describes excessive retention of nitrogenous waste products in the blood. The clinical syndrome resulting from decreased renal function and azotemia is called uremia.

Renal azotemia results from renal disease such as glomerular nephritis and chronic pyelonephritis.
Prerenal azotemia results from such conditions such as severe dehydration, hemorrhagic shock and excessive protein intake.

Post renal azotemia results from such conditions as urethral stones or tumors and prostatic obstructions.
Clearance - a theoretical concept defined as the volume of plasma from which a measured amount of substance can be completely eliminated or cleared, into the urine per unit time - can be used to estimate glomerular function.
BLOOD UREA NITROGEN (BUN)

- Urea, an end product of protein metabolism is produced in the liver. From there, it travels through the blood and is excreted by the kidneys. Urea is filtered at glomerulus, where the tubules reabsorbed approximately 40%. Thus under normal conditions, urea clearance is about 60% of the true GFR.
Normal values for BUN range from 8mg/dl to 18 mg/dl

- Decreased BUN levels occurred with significant liver disease.
- Increased BUN levels may indicate renal disease.
SERUM CREATININE

- Creatinine, the metabolic break down product of muscle creatinine phosphate, has a relatively constant level of daily productions. Blood levels vary little in a given individual.

- Creatinine is excreted by glomerular filtration and tubular secretion. Creatinine clearance parallels the GFR within a range of ±10% and is a more sensitive indicator of renal damage than BUN levels because renal impairment is almost the only cause of an increase in the serum creatinine levels.
Normal values for serum creatinine range from 0.6 to 1.2 mg/dl.

Values vary with the amount of muscle mass—a value of 1.2 mg/dl in a muscular athlete may represent normal renal function, whereas the same value in a small, sedentary person with little muscle mass may indicate significant renal impairment.
Generally, the serum creatinine value doubles with each 50% decrease in GFR. For example, if a patient’s normal serum creatinine is 1mg/dl, 1mg/dl represents 100% renal function, 2mg/dl represents 50% function and 4mg/dl represents 25% function.
CREATININE CLEARANCE

- Creatinine clearance, which represents the rate at which creatinine is removed from the blood by the kidneys, roughly approximates the GFR.

- The value is given in units of millions per minute, representing the volume of blood cleared by the kidney per minute.

- Normal values for men range from 75 to 125 ml/min.
Calculation requires knowledge of urinary creatinine excretion and concurrent serum creatinine levels. Creatinine clearance is calculated as follows:

$$\text{Cl}_{cr} = \frac{C_u V}{C_{cr}}$$

Where $\text{Cl}_{cr}$ is the creatinine clearance in millilitres per minute, $C_u$ is the concentration of creatinine in the urine, $V$ is the volume of urine formed over the collection period and $C_{cr}$ is the serum creatinine concentration.
ELECTROLYTES

- SODIUM
  - Sodium is the major cation of the extracellular fluid. Sodium along with chloride, potassium, and water is important in the regulation of osmotic pressure and water balance between intracellular and extracellular fluids. Normal values are 135-147 mEq/L or mmol/L.
  - An increase in sodium concentration (hypernatremia) may indicate impaired sodium excretion or dehydration.
A decrease in sodium concentration (hyponatremia) may reflect over hydration, abnormal sodium loss, or decreased sodium intake.
POTASSIUM

- Potassium is the most abundant intercellular cation (intercellular fluid potassium averages 141 mEq/l) approximately 3500 mEq of potassium is contained in the body of a 70 kg adult. Only 10% of the body potassium is extracellular. Normal values are 3.5-5.0 mEq/L or mmol/L.
- The role or function of potassium is in the maintenance of proper electrical conduction in cardiac and skeletal muscles (muscle and nerve excitability it exerts an influence on the body water balance and plays role in acid-base equilibrium.
Potassium is regulated by:

- Kidneys
- Aldosterone
- Arterial pH
- Insulin
- Potassium intake
- Sodium delivery to distal tubules
Hypokalemia can occur. The kidneys are responsible for approximately 90% of daily potassium loss. Other losses occur mainly through GI system.

Hyperkalemia most common results from decreased renal elimination, excessive intake or from cellular break down.
CHLORIDE

- Chloride is the major anion of extracellular fluid and is important in the maintenance of acid–base balance. Normal value for chloride is 95-105 mEq/L
- Hypochloremia is a decreased chloride concentration and it is often accompanied by metabolic alkalosis or acidosis caused by organic or other acids. Other causes include chronic renal failure, adrenal insufficiency, fasting, prolonged diarrhea, severe vomiting, and diuretic therapy
Hyperchloremia is an increased chloride concentration that may indicate hyperchloremic metabolic acidosis.
BICARBONATE/CARBON DIOXIDE CONTENT

- The carbon dioxide content represents the sum of the bicarbonate concentration and the concentration of carbon dioxide dissolved in the serum. Normal values are 22-28 mEq/L.
- Hypobicarbonatemia is usually caused by metabolic acidosis, renal failure, hyperventilation, severe diarrhoea, drainage of intestinal fluid, and by drugs such as acetazolamide.
Hyperbicarbonatemia is usually caused by alkalosis, hypoventilation, pulmonary disease, persistent vomiting, excess bicarbonate intake with poor renal function, and diuretics.
MINERALS

- CALCIUM

- Calcium plays an important role in nerve impulse transmission, muscle contraction, pancreatic insulin release, hydrogen ion release from the stomach, as a core factor for some enzyme reactions and blood coagulation, and most important bone and tooth structural integrity. Normal total calcium values 8.8-10.3 mg/dl.
Hypocalcemia usually implies a deficiency in either the production or response to parathyroid hormone (PTH) or vitamin D.

Hypercalcemia is an increased calcium concentration and it is usually associated with malignancy or metastatic diseases.
- **PHOSPHATE**
  - Phosphate is a major intracellular anion and is a source of phosphate for ATP and phospholipid synthesis. Normal phosphate values are 2.5-5.0 mg/dl.
  - Hyperphosphatemia and hypophosphatemia can occur.
  - Hyperphosphatemia is usually caused by renal insufficiency, although increased vitamin D or
Phosphate intake, hypoparathyroidism and hyperthyroidism.

- Hypophosphatemia can occur in malnutrition, especially when anabolism is induced, after administration of aluminium-containing antacids or calcium acetate, in chronic alcoholics, and in septic patients.
MAGNESIUM

Magnesium is the second most abundant intracellular and extracellular cation. It is an activator of numerous enzyme systems that control carbohydrate, fat and electrolyte balance, protein synthesis, nerve conduction, muscular contractility, as well as membrane transport and integrity. Normal values are 1.6-2.4 mEq/L.
Hypomagnesemia and hypermagnesemia can occur.

Hypomagnesemia is found more often than hypermagnesemia. Depletion of magnesium usually results from excessive loss from GI tract or kidneys. Depletion can occur either from poor intestinal absorption or excessive GI fluid loss.
Hypermagnesimia is most commonly caused by increased magnesium intake in the setting of renal insufficiency. Other causes include excess magnesium intake, hepatitis and addison disease.