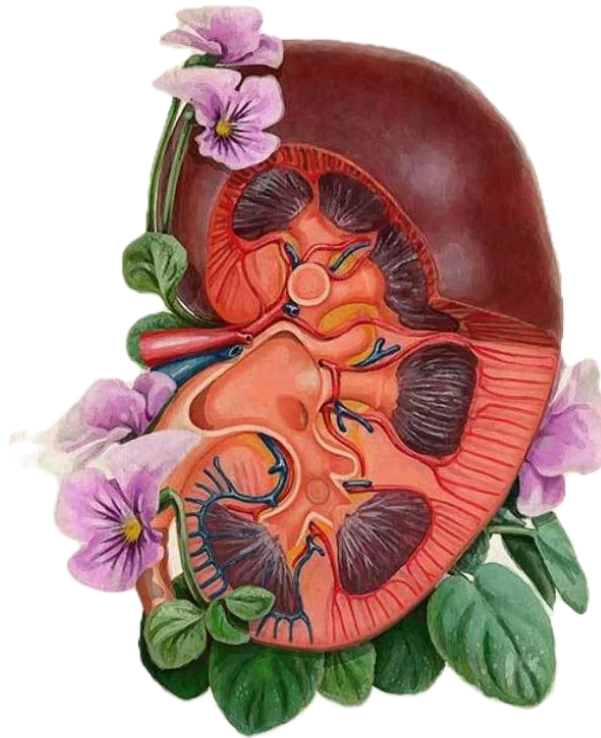




UGS Physiology Sheet 11



Doctor: Yanal A Shafagoj, MD, PhD

Written by: Almothana Khalil

Reviewed by: Mohammad Mahasneh

This lecture is easier than other lectures. We tried not to repeat any ideas that were explained in previous lectures. We hope this one is a quick one. Good Luck!

Proteinuria

Proteinuria is **not always** pathological; it can be normal (usually in small amounts), especially in younger individuals.

Proteinuria is used for **early detection** of renal disease in patients with risk factors, such as hypertension, diabetes, or pregnancy.

There is more than one type of dipstick for urine protein analysis; note that albumin has its own specific dipstick type.

For urine protein content, a concentration **less than 30 mg/dL** is usually labeled “trace” and is considered benign. Higher concentrations are classically graded from **+1** to **+4** depending on the magnitude of the concentration.

Diuretics

Many other details were mentioned in previous lectures.

Loop diuretics can be used in the management of **pulmonary edema**. Another indication is **acute renal failure**, but their efficacy here is questionable.

Aldosterone antagonists (potassium-sparing diuretics) are used in the management of patients with **hypokalemia**. Another indication is in patients with **liver cirrhosis**.

Renal Failure

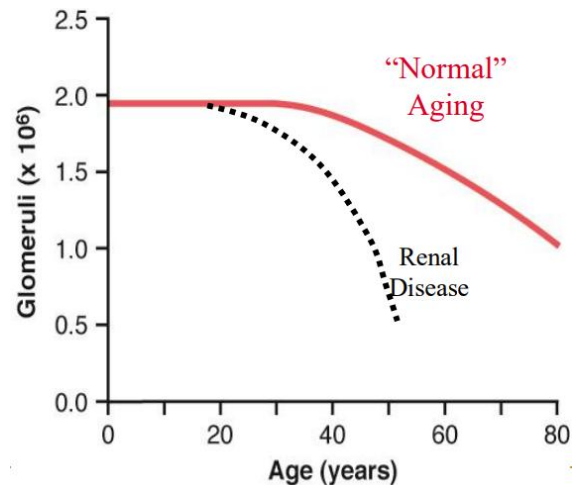
Acute renal failure (ARF), also known as acute kidney injury (AKI), is a clinical entity with abrupt onset (days to few weeks) of declining renal function. It is most probably reversible (85% of cases) but can progress to chronic renal failure (15% of cases).

Acute renal failure can occur in general population settings, in hospitalized patients, and in a high proportion of ICU patients. In ICU settings, it typically happens concomitantly with other organ failures – ARDS, heart failure, liver failure, etc...

Diagnosis of acute renal failure is based on multiple criteria with several stages. The **RIFLE** criteria (**R**isk, **I**njury, **F**ailure, **L**oss, **E**nd-stage) is a commonly used one. No need for details.

Chronic renal failure: progressive decline of renal function over a long period of time (months to years). It is usually irreversible, and patients will most probably require life-long dialysis (or transplant) to substitute for the lost renal function.

The progressive destruction of nephrons induces the destruction of other nephrons due to overload, leading to a vicious cycle that will eventually lead to end-stage kidney disease. Treatment options aim to shift the **dotted** curve toward the **RED** one.



Types of Acute Renal Failure

Prerenal (50-55%)

It is mainly due to **decreased blood flow** to the kidneys, leading to **decreased GFR**.

This leads to **low sodium urine** concentration (most of the filtered sodium is reabsorbed to conserve volume and blood pressure). It also leads to **increased urea-to-creatinine** blood concentration ratio to levels **>20:1** (normally $\approx 10:1$); this happens because **urea reabsorption increases** in the PCT due to slower tubular flow (less GFR \rightarrow slower flow).

Prerenal acute renal failure can be caused by anything that compromises renal perfusion, such as heart failure, massive hemorrhage, severe vomiting or diarrhea, renal artery stenosis, thromboembolic events, hypotensive shock of any cause, etc...

Intrarenal (35-40%)

It is caused by **abnormalities within the kidneys** (think about what we took in pathology), such as capillary or glomerular injuries, renal tubular injuries (drugs, toxins, heavy metals, etc...), renal interstitial injuries, or **ischemia** due to untreated **prerenal** conditions.

Postrenal (10%)

It is caused by abnormalities in the lower urinary tract, such as kidney stones, prostatic hypertrophy, bladder cancer, etc...

Most postrenal causes are **easily preventable or reversible** if treated early. Urinary obstruction (e.g., stones) can lead to chronic renal failure if not relieved promptly.

Changes in Renal Failure Patients

Question:

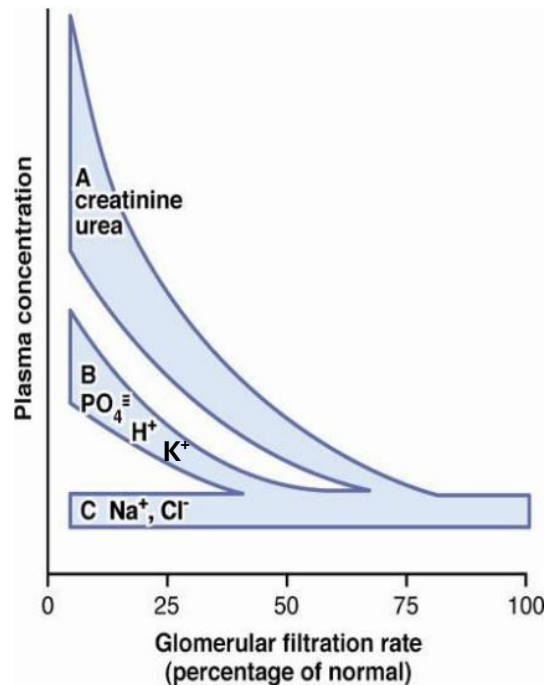
A 26-year-old man develops glomerulonephritis and his GFR decreases by 50% and remains at that level. For which of the following substances do you expect to find the greatest increase in plasma concentration?

Creatinine K⁺ Glucose Na⁺ Phosphate H⁺

Answer:

Creatinine increases the most because it is freely filtered and not significantly reabsorbed or regulated, so at steady state its plasma concentration is inversely proportional to GFR. Other solutes are largely maintained by renal and hormonal homeostatic mechanisms, preventing major changes at a 50% reduction in GFR.

Note the figure on the right. [Na⁺] and [Cl⁻] remain stable with decreasing GFR, while [PO₄³⁻], [H⁺], and [K⁺] increase, causing hyperphosphatemia, metabolic acidosis, and hyperkalemia, respectively.



Several important problems occur in ARF. First, there is a **daily rise in plasma creatinine and urea** due to reduced renal excretion. In complete renal shutdown, **plasma urea may rise by about 5 mmol/L per day**, while **serum creatinine may increase by about 1 mg/dL daily**. These rising levels reflect declining kidney clearance.

Second, **hyperkalemia** is a major danger because impaired potassium excretion can lead to life-threatening cardiac arrhythmias. Third, **metabolic acidosis** develops because the kidneys cannot adequately excrete hydrogen ions or regenerate bicarbonate, leading to an increase in plasma H⁺ concentration and decrease in plasma bicarbonate.

Fourth, **extracellular fluid volume expansion** occurs as sodium and water are retained. This may result in **malignant hypertension** and can also cause **pulmonary edema**, which is fatal if not treated urgently – usually by loop diuretics.

Treatment of ARF focuses first on **correcting the underlying cause**, such as restoring perfusion, relieving obstruction, or stopping nephrotoxic agents. Supportive management includes restricting **sodium, chloride, and water intake** to reduce fluid overload and electrolyte disturbances.

Recovery is usually recognized by a **fall in plasma urea and creatinine levels toward normal**, along with improving urine output and stabilization of electrolytes and acid-base balance. For **complete recovery**, concentration and dilution ability of the kidneys is measured, usually by specific gravity, as mentioned in lecture 7.

In chronic renal failure, reducing **dietary protein intake** lowers urea production because urea is generated from protein metabolism. A lower protein diet may help reduce nitrogenous waste accumulation (mainly urea) and may slow progression of renal dysfunction, thereby delaying end-stage renal failure.

When complications become severe or renal function is markedly impaired, **dialysis** may be required. Note that dialysis can be used for ARF until renal function is back to normal.

DIALYSIS

Dialysis machinery consists of a **dialysate (dialysis fluid)**, a **semi-permeable membrane**, and a system for **vascular access**. The dialysate is formulated to facilitate the removal of waste products and correction of electrolyte imbalances. The semi-permeable membrane allows selective exchange of solutes and water between the patient's blood and the dialysate via diffusion and ultrafiltration. In hemodialysis, vascular access is typically achieved through an arteriovenous (A-V) shunt, graft, or catheter, which connects the patient's circulation to the dialysis circuit.

The composition of the dialysate (dialysis fluid) is carefully controlled so that excess solutes diffuse out of the blood while deficient substances are replenished. **Potassium is included at low concentrations (≈ 1 mEq/L)** to promote its removal from the patient, whereas **bicarbonate is provided at higher concentrations (≈ 36 mmol/L)** to help correct metabolic acidosis. Importantly, **the dialysate contains no urea**, creating a concentration gradient that facilitates the diffusion of urea from the blood into the dialysate. Sodium is kept around normal plasma levels (≈ 140 mEq/L) to prevent rapid osmotic fluid shifts.

في الختام، نستشعر عظمة الخالق سبحانه وتعالى في هذا الإبداع الدقيق،
ونحمده جل وعلا على نعمه علينا أن جعلنا أصحاء، وندعوه أن يديم علينا هذه النعمة وأن يشفي كل مريض.
ولا تنسوننا من صالح دعائكم..