Mbala Margaret Ojiji

17/MHS01/239

Renal Physiology

1.

Pathophysiology involved in Renal Failure

Chronic kidney disease (CKD) is initially described as diminished renal reserve or renal insufficiency, which may progress to renal failure (end-stage renal disease). Initially, as renal tissue loses function, there are few noticeable abnormalities because the remaining tissue increases its performance (renal functional adaptation).

Decreased renal function interferes with the kidneys' ability to maintain fluid and electrolyte homeostasis. The ability to concentrate urine declines early and is followed by decreases in ability to excrete excess phosphate, acid, and potassium. When renal failure is advanced (glomerular filtration rate [GFR] $\leq$ 15 mL/min/1.73 m^2), the ability to effectively dilute or concentrate urine is lost; thus, urine osmolality is usually fixed at about 300 to 320 mOsm/kg, close to that of plasma (275 to 295 mOsm/kg), and urinary volume does not respond readily to variations in water intake.

Fluid and electrolyte derangement

- Sodium: In a normal individual, more than 25,000 mmol of sodium ions are filtered daily with < 1% being excreted. CRF can be associated with sodium retention, sodium depletion or normal sodium balance and is influenced by factors such as diuretic use and cardiac function. However, most patients demonstrate a mild degree of sodium and water retention whist the extracellular fluid volume remains isotonic. Ironically, the patient with CRF also has impaired renal concentrating mechanisms and thus extra renal fluid losses such as vomiting, diarrhea or pyrexia may rapidly cause hypovolemia.
- Calcium, phosphate, parathormone and renal osteodystrophy: Total plasma calcium concentration is reduced in CRF. As phosphate concentrations increase, calcium phosphate is deposited in soft tissues such as skin and blood vessels further lowering plasma calcium concentration. Hyperphosphatemia also has a negative effect on 1-α-hydroxylase, the

enzyme responsible for renal calcitriol production. Both hypocalcaemia and hyperphosphatemia are potent stimuli to parathormone secretion, leading to hyperplasia of the parathyroid gland and secondary hyperparathyroidism. This causes increased osteoclast and osteoblastic activity causing osteitis fibrosa cystica.

- Acidosis: Chronic metabolic acidosis is a common feature of ESRD. The inability to secrete protons and buffers (e.g. phosphate) or to regenerate bicarbonate limits the clearance of hydrogen ions. Furthermore, reduction in glutamine utilization reduces ammonia production and secretion into the proximal tubule. Retention of organic anions causes a progressive increase in the anion gap and a further fall in plasma bicarbonate concentration.

- Potassium and magnesium: Adaptive processes increase potassium secretion in the distal nephron (collecting tubules) and also in the gut. Whilst a wide range of plasma potassium concentrations can be encountered dependent on factors such as diuretic use, it tends to be elevated. Acute changes present the greatest threats to life.

Hematological abnormalities

A normochromic normocytic anemia is a common finding in CRF. Decreased renal parenchymal erythropoietin production reduces stem cell transformation into erythrocytes, while uremic toxins reduce red cell life. Chronic upper GI tract losses and those from dialysis further compound the problem. Dietary deficiency in iron and folate also occurs. The introduction in 1989 of synthetic erythropoietin has revolutionized the management of anemia in these patients but a compensated relative anemia is still to be expected. A rapid increase in hemoglobin concentration above 10 g dlitre–1 often worsens hypertension and may precipitate heart failure. Compensatory mechanisms increase 2, 3-diphosphoglycerate production and move the oxyhemoglobin dissociation curve to the right.

- Coagulopathy: Patients with CRF have a tendency to excessive bleeding in the peri-operative period.

Endocrine disturbances

Changes in parathyroid function and lipid clearance have been noted above. Glucose tolerance is impaired but there is a reduced requirement for exogenous insulin in diabetic patients, probably related to the reduced metabolism of insulin by the failing kidney. Patients with CRF have abnormalities of temperature

regulation with reduced basal metabolic rate and a tendency to hypothermia. This may by important when assessing fever.

Cardiovascular and pulmonary abnormalities

Cardiovascular abnormalities are common in CRF and are responsible for 48% of deaths in these patients. Systemic hypertension is the most common with an incidence approaching 80%, although it is often not a feature of sodium-wasting nephropathies such as polycystic kidney disease or papillary necrosis. Plasma volume expansion resulting from sodium and water retention is the most frequent cause of hypertension; it may be improved significantly by dialysis. Some patients may require β-blockers, ACE inhibitors, α-antagonists and vasodilators to control their blood pressure adequately. Alteration in the control of renin and angiotensin secretion may also contribute to hypertension in 30% of patients. Ischemic heart disease (IHD) is a frequent cause of mortality in patients with CRF. The incidence varies with patient subgroup but is present in 85% of diabetics > 45 years of age with CRF. Accelerated atherosclerosis results from a decreased plasma triglyceride clearance, hypertension and fluid overload causing left ventricular hypertrophy and failure. The elevation in plasma triglyceride concentrations is caused by a defect in lipoprotein lipase activity and reduced lipolysis.

Gastrointestinal abnormalities

Gastrointestinal abnormalities are frequent with anorexia, nausea and vomiting contributing to malnutrition. Urea is a mucosal irritant and bleeding may occur from any part of the GI tract. Gastric emptying is delayed, residual volume increased and pH lowered. Peptic ulcer disease is common and most patients will receive proton pump inhibitors. The use of a rapid sequence induction technique needs be balanced against the risks of difficult intubation in chronically ill patients with poor dentition.

Immune function

Sepsis is a leading cause of death in patients with CRF. Inhibition of cell-mediated immunity and humoral defense mechanisms occurs, with little improvement following dialysis. There is an increased production of pro-inflammatory cytokines suggesting that activation of monocytes may play a role in uremic immune

dysfunction. Superficial infections are common in fistula and catheter sites; wound healing is poor.

Neurological abnormalities

Many patients with CRF have abnormalities in central (CNS) and peripheral nervous system function. There is a wide spectrum of CNS changes. For example, from mild personality alterations to asterixis (i.e. lapse of posture, usually manifest by bilateral flapping tremor), myoclonus, encephalopathy and convulsions. Peripheral neuropathy is common in advanced stages of the disease. Initially, it presents as a distal 'glove and stocking 'sensory loss but then progresses to motor changes. Both dialysis and renal transplantation may improve the neuropathy

2.

Types of Dialysis

Dialysis is a treatment that filters and purifies the blood using a machine. This helps keep your fluids and electrolytes in balance when the kidneys can't do their job. It often involves diverting blood to a machine to be cleaned.
There are two main types of dialysis we may use: peritoneal and hemodialysis.

I. Peritoneal Dialysis

Like the kidneys, the peritoneum contains thousands of tiny blood vessels, making it a useful filtering device. To perform peritoneal dialysis, we will:

- Surgically place a soft, hollow tube into the lower abdomen near the navel.
- Instill a special solution called dialysate into the peritoneal cavity. The peritoneal cavity is the space in the abdomen that houses the organs and is lined by two special membrane layers called the peritoneum.
- Leave the dialysate in the abdomen for a certain period of time, which we will determine on an individual basis. The dialysate fluid absorbs the waste products and toxins through the peritoneum.
- Drain the fluid from the abdomen, measure it and then discard it.

Types of Peritoneal Dialysis

There are three different types of peritoneal dialysis:

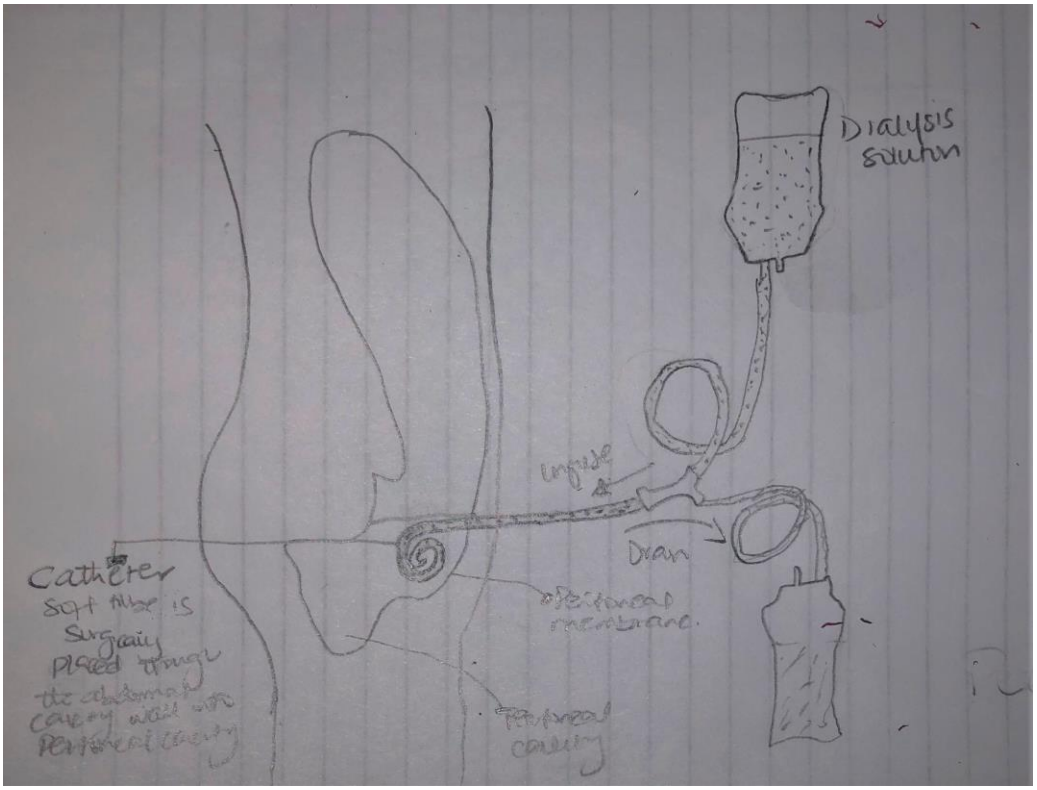
- Continuous ambulatory peritoneal dialysis (CAPD): Does not require a machine. Exchanges, often referred to as "passes," can be done three to five times a day, during waking hours.

- Continuous cyclic peritoneal dialysis (CCPD): Requires the use of a special dialysis machine that can be used in the home. This type of dialysis is done automatically, even while you are asleep.
- Intermittent peritoneal dialysis (IPD): Uses the same type of machine as CCPD, but treatments take longer. IPD can be done at home, but it is usually in the hospital.

Peritoneal Dialysis: Possible Complications

Possible complications of peritoneal dialysis include an infection of the peritoneum, or peritonitis, where the catheter enters the body. Peritonitis causes fever and stomach pain. A dietitian will help plan your diet during peritoneal dialysis, so we can ensure you are choosing appropriate meals. During dialysis:

- You may have different protein, salt and fluid needs.
- You may have different potassium restrictions.
- You may need to reduce your calorie intake, since the sugar in the dialysate may cause weight gain.



II. Hemodialysis

Hemodialysis is can be performed at home or in a dialysis center or hospital by trained healthcare professionals. During the procedure:

1. A special type of access, called an arteriovenous (AV) fistula is surgically placed usually in your arm. An artery and a vein is then joined together. (An external, central intravenous (IV) catheter may also be inserted but is less common for long-term dialysis.)
2. The patient is then connected to a large hemodialysis machine.
3. The machine drains the blood, bathes it in a special dialysate solution to remove waste substances and fluid and then returns it to the patient's bloodstream.

To get the blood to flow to the artificial kidney, your doctor will perform surgery to create an entrance point (vascular access) into your blood vessels. The three types of entrance points are:

- Arteriovenous (AV) fistula. This type connects an artery and a vein. It's the preferred option.
- AV graft. This type is a looped tube.
- Vascular access catheter. This may be inserted into the large vein in your neck.

  Both the AV fistula and AV graft are designed for long-term dialysis treatments. People who receive AV fistulas are healed and ready to begin hemodialysis two to three months after their surgery. People who receive AV grafts are ready in two to three weeks. Catheters are designed for short-term or temporary use.

<u>Tips for Undergoing Hemodialysis</u>

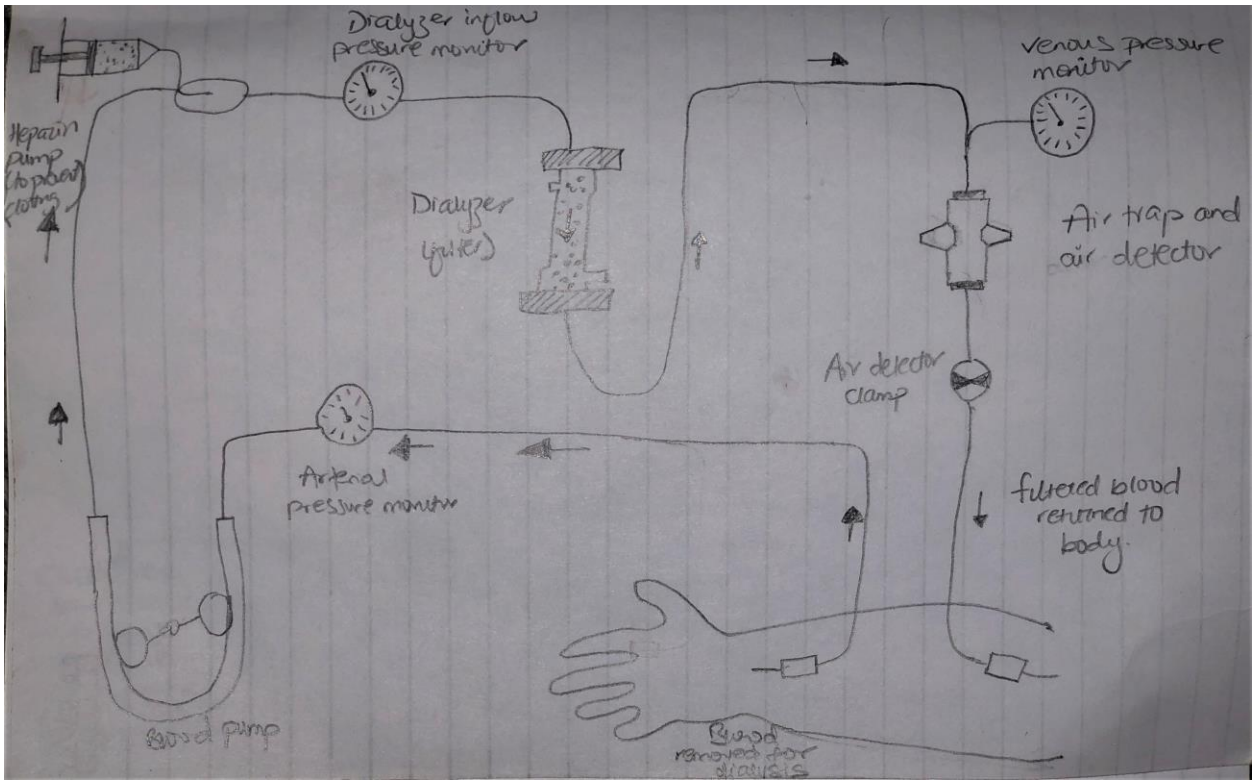
- Hemodialysis is usually performed several times a week and lasts for four to five hours. Because of the length of time hemodialysis takes, it may be helpful to bring reading material, in order to pass the time during this procedure.
- During treatment you can read, write, sleep, talk or watch TV.
- At home, hemodialysis is done with the help of a partner, often a family member or friend. If chosen to be done home, you and your partner will receive special training.

<u>Hemodialysis: Possible Complications</u>

Possible complications of hemodialysis include muscle cramps and hypotension (sudden drop in blood pressure). Hypotension may cause you to feel dizzy, weak or sick to your stomach. You can usually avoid side effects by following the proper diet and taking your medications.

A dietitian will work with you to plan your meals according to your physician's orders. Generally:

- You may eat foods high in protein such as meat and chicken (animal proteins).
- You may have different potassium restrictions.
- You may need to limit the amount you drink.
- You may need to avoid salt.
- You may need to limit foods containing mineral phosphorus (such as milk, cheese, nuts, dried beans, and soft drinks).



Other types include:

<u>Continuous renal replacement therapy (CRRT)</u>

This therapy is used primarily in the intensive care unit for people with acute kidney failure. It's also known as hemofiltration. A machine passes the blood through tubing. A filter then removes waste products and water. The blood is returned to the body, along with replacement fluid. This procedure is performed 12 to 24 hours a day, generally every day.