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17/MHS01/119

MEDICINE AND SURGERY

RENAL PHYSIOLOGY (PHS 303)

1. DISCUSS THE PATHOPHYSIOLOGICAL PROCESS INVOLVED IN RENAL FAILURE.

Renal failure refers to failure of excretory functions of kidney. It is usually characterized by decrease in glomerular filtration rate (GFR) which is considered as the best index of renal failure. However, decrease in GFR is not affected much during the initial stages of renal failure. If 50% of the nephrons are affected, GFR decreases only by 20% to 30%. It is because of the compensatory mechanism by the unaffected nephrons. Renal failure is always accompanied by other complications such as: deficiency of calcitriol (activated vitamin d) result in hypocalcemia and secondary hyperparathyroidism in some patients, deficiency of erythropoietin resulting in anemia and disturbances in acid-base balance. It may be either acute or chronic. Acute renal failure is the abrupt or sudden stoppage of renal functions. It is often reversible within few days to few weeks though it may result in sudden life-threatening reactions in the body with the need for emergency treatment. It is caused by: acute nephritis (inflammation of kidneys) which usually develops by immune reaction, damage of renal tissues by poisons like lead and mercury, renal ischemia which develops during circulatory shock, acute tubular necrosis (necrosis of tubular cells in kidney) caused by burns, hemorrhage, snake bite, toxins (like insecticides, heavy metals and carbon tetrachloride) or drugs (like diuretics and platinum derivatives), severe transfusion reactions, sudden fall in blood pressure during hemorrhage, diarrhea, severe burns or cholera and blockage of ureter due to the formation of calculi (renal stone) or tumor. It leads to: oliguria (decreased urinary output), proteinuria (appearance of proteins in urine) including albuminuria (excretion of albumin in urine), hematuria (presence of blood in urine), edema due to increased volume of extracellular fluid (ECF) caused by retention of sodium and water, hypertension within few days because of increased ECF volume, acidosis

due to the retention of metabolic end products, anuria (cessation of urine formation) in severe cases and coma due to severe acidosis (if the patient is not treated in time) resulting in death within 10 to 14 days.

Chronic renal failure is the progressive, long standing and irreversible impairment of renal functions. When some of the nephrons loose the function, the unaffected nephrons can compensate it. However, when more and more nephrons start losing the function over the months or years, the compensatory mechanism fails and chronic renal failure develops. It is caused by: chronic nephritis, polycystic kidney disease, renal calculi (kidney stones), urethral constriction, hypertension, atherosclerosis, tuberculosis and slow poisoning by drugs or metals. It can lead to: edema (failure of kidney to excrete sodium and electrolytes causes increase in extracellular fluid volume resulting in development of edema), blood loss (gastrointestinal bleeding accompanied by platelet dysfunction leads to heavy loss of blood), anemia (since, erythropoietin is not secreted in the kidney during renal failure, the production of red blood cells decreases resulting in normocytic normochromic anemia), secondary hyperparathyroidism (developed due to the deficiency of calcitriol in osteomalacia), acidosis uremia(results in acidosis, which leads to coma and death) and uremia (characterized by excess accumulation of end products of protein metabolism such as urea, nitrogen and creatinine in blood. Common features include: anorexia (loss of appetite), lethargy, drowsiness, nausea and vomiting, pigmentation of skin, muscular twitching, tetany, convulsion, mental deterioration and coma).

2. WITH THE AID OF SUITABLE DIAGRAMS, DISCUSS THE TYPES OF DIALYSIS YOU KNOW.

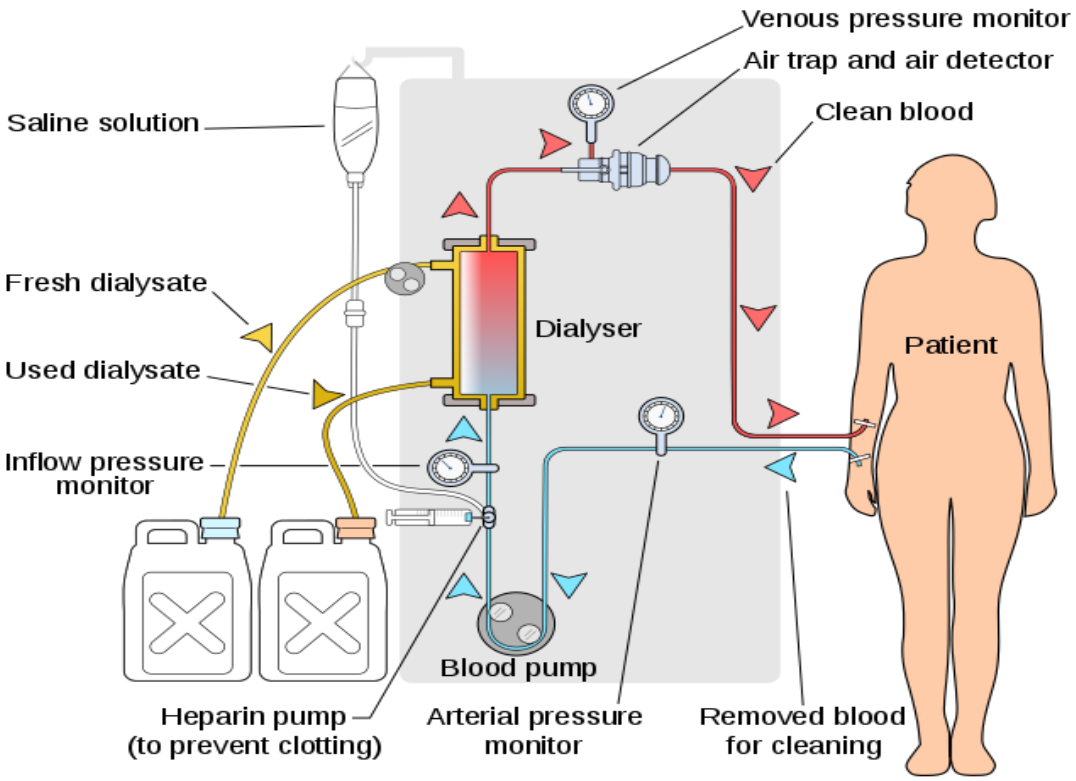
Dialysis is the process of removing excess water, solutes, and toxins from the blood in people whose kidneys can no longer perform these functions naturally. This is referred to as renal replacement therapy .Dialysis is used in patients with rapidly developing loss of kidney function, called acute kidney injury (previously called acute renal failure), or slowly worsening kidney function, called Stage 5 chronic kidney disease (previously called chronic kidney failure, end-stage renal disease, and end-stage kidney disease). Dialysis is used as a temporary measure

in either acute kidney injury or in those awaiting kidney transplant and as a permanent measure in those for whom a transplant is not indicated or not possible. The kidneys have an important role in maintaining health. When the person is healthy, the kidneys maintain the body's internal equilibrium of water and minerals (sodium, potassium, chloride, calcium, phosphorus, magnesium, sulphate). The acidic metabolism end-products that the body cannot get rid of via respiration are also excreted through the kidneys. The kidneys also function as a part of the endocrine system, producing erythropoietin, calcitriol andrenin. Erythropoietin is involved in the production of red blood cells and calcitriol plays a role in bone formation. Dialysis is an imperfect treatment to replace kidney function because it does not correct the compromised endocrine functions of the kidney. Dialysis treatments replace some of these functions through diffusion (waste removal) and ultrafiltration (fluid removal). Dialysis uses highly purified (also known as "ultrapure") water.

Dialysis works on the principles of the diffusion of solutes and ultrafiltration of fluid across a semi-permeable membrane. Diffusions a property of substances in water; substances in water tend to move from an area of high concentration to an area of low concentration. Blood flows by one side of a semi-permeable membrane, and a dialysate, or special dialysis fluid, flows by the opposite side. A semipermeable membrane is a thin layer of material that contains holes of various sizes, or pores. Smaller solutes and fluid pass through the membrane, but the membrane blocks the passage of larger substances (for example, red blood cells and large proteins). This replicates the filtering process that takes place in the kidneys when the blood enters the kidneys and the larger substances are separated from the smaller ones in the glomerulus. There are three primary and two secondary types of dialysis: hemodialysis (primary), peritoneal dialysis (primary), hemofiltration (primary), hemodiafiltration (secondary) and intestinal dialysis (secondary). The two main types of dialysis, hemodialysis and peritoneal dialysis.

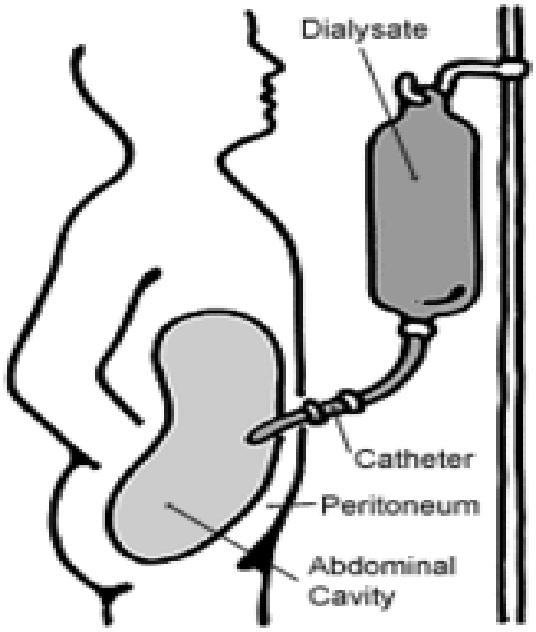
In hemodialysis, the patient's blood is pumped through the blood compartment of a dialyzer, exposing it to a partially permeable membrane. The dialyzer is composed of thousands of tiny hollow synthetic fibers. The fiber wall acts as the semipermeable membrane. Blood flows through the fibers, dialysis solution flows around the outside of the fibers, and water and wastes move between these two solutions. The cleansed blood is then returned via the circuit back

tithe body. Ultrafiltration occurs by increasing the hydrostatic pressure across the dialyzer membrane this usually is done by applying negative pressure to the dialysate compartment of the dialyzer. This pressure gradient causes water and dissolved solutes to move from blood to dialysate and allows the removal of several liters of excess fluid during a typical 4-hour treatment. In the United States, hemodialysis treatments are typically given in a dialysis center three times per week (due in the United States to Medicare reimbursement rules); however, as of 2005 over 2,500 people in the United States are dialyzing at home more frequently for various treatment lengths. Studies have demonstrated the clinical benefits of dialyzing5 to 7 times a week, for 6 to 8 hours. This type of hemodialysis is usually called nocturnal daily hemodialysis, which a study has shown it provides a significant improvement in both small and large molecular weight clearance and decreases the need for phosphate binders. These frequent long treatments are often done at home while sleeping, but home dialysis is a flexible modality and schedules can be changed day to day, week to week. In general, studies show that both increased treatment length and frequency are clinically beneficial.



PROCESS OF HEMODIALYSIS

In peritoneal dialysis, a sterile solution containing glucose (called dialysate) is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a partially permeable membrane. This exchange is repeated 4‑5 times per day; automatic systems can run more frequent exchange cycles overnight. Peritoneal dialysis is less efficient than hemodialysis, but because it is carried out for a longer period of time the net effect in terms of removal of waste products and of salt and water are similar to hemodialysis. Peritoneal dialysis is carried out at home by the patient, often without help. This frees patients from the routine of having to go to a dialysis clinic on a fixed schedule multiple times per week. Peritoneal dialysis can be performed with little to no specialized equipment (other than bags of fresh dialysate).



SCHEMATIC DIAGRAM OF PERITONEAL DIALYSIS

Hemofiltration is a similar treatment to hemodialysis, but it makes use of a different principle. The blood is pumped through a dialyzer or "hem filter" as in dialysis, but no dialysate is used. A pressure gradient is applied; as a result, water moves across the very permeable membrane rapidly, "dragging" along with it many dissolved substances, including ones with large molecular weights, which are not cleared as well by hemodialysis. Salts and water lost from the blood during this process are replaced with a "substitution fluid" that is infused into

the extracorporeal circuit during the treatment. Hemodiafiltration is a combination of hemodialysis and hemofiltration, thus used to purify the blood from toxins when the kidney is not working normally and also used to treat acute kidney injury (AKI).

In intestinal dialysis, the diet is supplemented with soluble fibers such as acacia fiber, which is digested by bacteria in the colon. This bacterial growth increases the amount of nitrogen that is eliminated in fecal waste. An alternative approach utilizes the ingestion of 1 to 1.5 liters of non-absorbable solutions of polyethylene glycol or mannitol every fourth hour.