kidney

Normal function of the kidney

1)-Homeostatic Functions

a)-Regulation of water and electrolyte balance.

b)-Regulation of acid base balance.

Regulation of arterial blood pressure.

2)-Excretion of metabolic waste products (urea, creatinine, uric acid & foreign chemicals & excess electrolytes)

3)-Hormonal Function : Secretion of erythropoietin, rennin and 1,25 *dihydroxycholecalciferol*.

Metabolic Function : site for gluconeogenesis.

Homeostatic Functions

Acid-Base Balance (Help stabilize blood pH)

The kidneys control this by **excreting H+ ions and reabsorbing HCO3 (bicarbonate).**

If plasma pH is low (acidic).	**If plasma pH is high (alkaline).**
H+ secretion in the urine and $HCO3^-$ reabsorption back to the plasma **increases**	H+ secretion in the urine and $HCO3^-$ reabsorption back to the plasma **decreases**
thus urine becomes more acidic, and the plasma more alkaline.	**thus urine becomes more alkaline, and the plasma more acidic.**

Erythropoietin is secreted in response to a lowered oxygen content in the blood. It acts on bone marrow, stimulating the production of red blood cells.

Renin the primary stimuli for renin release include reduction of renal perfusion pressure and hyponatremia. Renin release is also influenced by angiotension II and ADH.

- The kidneys are primarily responsible for **producing vitamin D3**

Biochemical Tests of Renal Function

Measurement of GFR

Clearance tests

Plasma creatinine

Urea, uric acid and β2-microglobulin

Renal tubular function tests

Osmolality measurements

Specific proteinurea

Glycouria

Aminoaciduria

Urinalysis

Appearance

Specific gravity and osmolality

pH

osmolality

Glucose

Protein

Urinary sediments

Measurement of GRF

The amount of filtrate that flows out of all the renal corpuscles of both kidneys every minute is called the glomerular filtration rate (GFR). In the normal adult, this rate is about 120 ml/min; about 180 liters/Day

Accurate measurement of GRF by clearance tests requires determination of the concentration in plasma and urine of a substance that is:

- Freely filtered at glomeruli.
- Neither reabsorbed nor secreted by tubules.
- Its concentration in plasma needs to remains constant throughout the period of urine collection.
- Better if the substance is present endogenously.
- Easily measured

Creatinine clearance

The glomerular filtration rate (GFR) provides a useful index of the number of functioning glomeruli.

It gives an estimation of the degree of renal impairment by disease.

Clearance is the volume of plasma cleared from the substance excreted in urine per minute

calculated from the creatinine content of a 24-hour urine collection, and the plasma concentration within this period.

Creatinine clearance in adults is normally about **of 120 ml/min**

C= (UxV) /P

U = Concentration of creatinine in urine μmol /l

V = urine flow rate per min (ml/min)

P = Concentration of the creatinine in serum μmol /l

Serum creatinine

Creatinine is the end product of creatine catabolism

98% of the body creatine is present in the muscles where it functions as store of high energy in the form of creatine phosphate.

About 1-2 % of total muscle creatine or creatine phosphate pool is converted daily to creatinine through the spontaneous, non enzymatic (loss of water or phosphate).

Creatinine is removed from the blood chiefly by the kidneys, primarily by glomerular filtration, but also by proximal tubular secretion. Little or no tubular reabsorption of creatinine occurs.

Plasma creatinine is an endogenous substance not affected by diet.

Plasma creatinine remains fairly constant throughout adult life.

Serum creatinine

It is a better kidney function (glomerular function) test than creatinine clearance because :

Serum creatinine is more accurate.

Serum creatinine level is constant throughout adult life.

It is inversely related to the GFR (GFR =)

Changes in plasma creatinine concentration can occur independently of renal function, owing to changes in muscle mas

Serum Urea

Urea is formed in the liver from ammonia released from transamination & oxidative deamination of amino acids.

As a kidney function test, urea is inferior to serum creatinine because:

High protein diet increases urea formation.

Any condition of increased proteins catabolism (Cushing syndrome, diabetes mellitus, starvation, thyrotoxicosis) will increase urea formation.

More than 90% of urea is excreted through the kidneys.

Passive reabsorption increases at low urine flow rates.

convenient, but insensitive, measures of glomerular function

Causes of an abnormal plasma urea to creatinine ratio	
Increased	**Decreased**
High protein intake Gastrointestinal bleeding (reabsorption of blood proteins) Hypercatabolic state Dehydration Muscle wasting*	Low protein intake Dialysis Severe liver disease

Proteinuria

The glomerular basement membrane does not usually allow passage of albumin and large proteins.

When larger amounts, in excess of 300 mg/24h, →significant damage to the glomerular membrane has occurred.

Quantitative urine protein measurements should always be made on complete 24-hour urine collections.

Albumin excretion in the range 30-300 mg/24h is termed

Microalbuminuria which is the earliest sign of renal damage.

Types of protein in urine

1-albuminuria

2- Globulinuria (Bence jones protein)

as in case of multiple myeloma – leukemia.

It can be detected as follow; globulin p.pt in warming to 50 : 60 C˚ &dissolved at 100 C˚ then re precipitated by cooling

3-nucleoprotein

4-Aminoacids

4- Proteoses & peptones

INVESTIGATION OF TUBULAR FUNCTION

Osmolality measurements in plasma and urine

The water deprivation test

The acid load test

Specific proteinuria(β_{2-} microglobulin and **α_1 - macroglobulin)**

sensitive indicator of renal tubular cell damage

Glycosuria

Aminoaciduria

Aminoaciduria

Normally, amino acids in the glomerular filtrate are reabsorbed in the proximal tubules.

There is some metabolic defects lead to increase in plasma level of one or more of amino acids which exceeds the capacity of normal renal tubules to reabsorb them.

Examples:

Phenylketonuria
Tyrosyluria
Alkaptonuria
Maple syrup urine diseases

There is specific failure of normal tubular reabsorptive mechanisms, such as cystinuria (cystine is relatively insoluble and leads to formation of renal calculus)

Osmolality measurements in plasma and urine

Plasma osmolarity measures the body's electrolyte-water balance.

Osmolality of blood increases with dehydration and decreases with over hydration

In normal people, increased osmolarity in the blood will stimulate secretion of antidiuretic hormone (ADH). This will result in increased water reabsorption, more concentrated urine, and less concentrated blood plasma.

A low serum osmolality will suppress the release of ADH, resulting in decreased water reabsorption and more concentrated plasma.

Calculated serum osmolarity = 2 Na + Glucose + Urea (all in mmol/L).

It reflects the ability of renal tubules and collecting ducts are working efficiently to concentrate the urine

The water deprivation test

fluid or **water deprivation test** is a medical test which can be used to determine whether the patient has diabetes insipidus as opposed to other causes of polydipsia (a condition of excessive thirst that causes an excessive intake of water).

This test measures changes in body weight, urine output, and urine composition when fluids are withheld.

Sometimes measuring blood levels of ADH

If there is no change in the water loss despite fluid deprivation, desmopressin may be administered to distinguish between the two types of diabetes insipidus which are central & nephrogenic diabetes insipidus.

The time of deprivation may vary from 4 to 18 hours

The serum osmolality and urine osmolality are both measured in the test

1)-Physiological polyuria

In winter

During the day more than the night.

In children more than adult in relation to body weight.

Volume increase with high protein diet , as excess urea cause diuresis.

excessive fluid drinking (drinking tea, coffee & ingestion of diuretic drugs)

2)- Pathological polyuria

Diabetes mellitus

Diabetes insipidus

Chronic nephritis

Contracted kidney

The acid loading test (pH)

measures the ability of the kidneys to send acid to your urine when there is too much acid in your blood

ammonium chloride capsules are taken by mouth for 3 days. Then, a urine and blood sample are taken.

The laboratory measures the level of acid (pH)found in both samples.

excretion rates of titratable acid and NH_4^+ and serum HCO_3 concentration, are all measured.

should not be performed on patients who are already acidotic or who have liver disease.

Ammonium chloride is used as a systemic acidifying agent in treatment of severe metabolic alkalosis

in oral acid loading test to diagnose distal renal tubular acidosis

to maintain the urine at an acid pH in the treatment of some urinary-tract disorders

Renal tubular acidosis (RTA)

Renal tubular acidosis (**RTA**) is a medical condition that involves an accumulation of acid in the body due to a failure of the kidneys to reabsorption of bicarbonate (HCO3-), the excretion of hydrogen ion (H+), or both.

Type I. There is a defective H+ secretion in the distal tubule which may be inherited or acquired.

Type II. The capacity to reabsorb bicarbonate in the proximal tubule is reduced.

Type IV. Bicarbonate reabsorption by the renal tubule is impaired as a consequence of aldosterone deficiency, aldosterone receptor defects, or drugs which block aldosterone action.

Fanconi syndrome

Fanconi syndrome

is a disease of the proximal renal tubules of the kidney in which glucose, amino acids, uric acid, phosphate and bicarbonate are passed into the urine, instead of being reabsorbed.

Fanconi syndrome affects the proximal tubule, which is the first part of the tubule to process fluid after it is filtered through the glomerulus. It may be inherited, or caused by drugs or heavy metals

Hypophosphatemic rickets

disorders of proximal renal tubule function causing phosphate loss, hypophosphatemia, and skeletal deformities, including rickets and osteomalacia.

it is treated with phosphate supplements and vit. D

RENAL STONES

Types of stone

Calcium phosphate: may be a consequence of primary hyperparathyroidism (increased intestinal calcium absorption) or renal tubular acidosis.

Magnesium ammonium phosphate: these are often associated with urinary tract infections.

Oxalate: may be a consequence of hyperoxaluria.

Hyperoxaluria is an excessive urinary excretion of oxalate. Individuals with hyperoxaluria often have calcium oxalate kidney stones

Uric acid: may be a consequence of hyperuricemia.

Cystine: these are rare and a feature of the inherited metabolic disorder cystinuria.

Management of renal stones

Treatment of urinary infection

A high Fluid intake

Hyperuricaemia is treated with allopurinpol

Alkalinization of urine ↑the solubility of both cystine and uric acid

Thiazide diuretics decrease urinary Ca excretion

Citrate forms soluble complexes with Ca and is an endogenous inhibitor of Ca stone formation

Uremia

Renal failure can progress from mild to severe

Uremia is the most severe, also known as End Stage Renal Disease (ESRD)

The body is unable to maintain homeostasis or maintain electrolyte balance

No wastes are excreted by the kidneys

Renal function is < 5%

Many body systems are affected and the patient is symptomatic

Renal failure (also **kidney failure** or **renal insufficiency**) is a medical condition in which the kidneys fail to adequately filter waste products from the blood.

The two main forms are acute kidney injury, which is often reversible with adequate treatment, and chronic kidney disease, which is often not reversible.

Renal failure is mainly determined by

decrease in glomerular filtration rate.

Decrease or absence of urine production

Increase of (creatinine or urea) in the blood.

Depending on the cause, hematuria (blood loss in the urine) and proteinuria (protein loss in the urine) may be noted.

In renal failure, there may be problems with increased fluid in the body (leading to swelling), increased acid levels, raised levels of potassium, decreased levels of calcium, increased levels of phosphate, and in later stages anemia. Bone health may also be affected. Long-term kidney problems are associated with an increased risk of cardiovascular disease