**Kidney Function Tests**

**Renal Physiology**

The nephron is the functional unit of the kidney ,Each kidney contains about 1,000,000 to 1,300,000 nephrons. The nephron is composed of glomerulus and renal tubules. The nephron performs its homeostatic function by ultra filtration at glomerulus and secretion and reabsorption at renal tubules.



**Each nephron is a complex apparatus comprised of five basic parts:**

1-Glomerulus

 functions to filter incoming blood. Factors facilitate filtration:

 -high pressure in the glomerular capillaries, which is a result of their position between two arterioles.

-the semipermeable glomerular basement membrane, which has a molecular size cutoff value of approximately 66,000 Da.

*\*The volume of blood filtered per minute is the glomerular filtration rate (GFR), and its determination is essential in evaluating renal function*

2-Proximal convoluted tubule:

-Returns the bulk of each valuable substance back to the blood circulation.

-75% of the water, sodium, and chloride.

-100% of the glucose (up to the renal threshold)

-almost all of the amino acids, vitamins, and proteins

-varying amounts of urea, uric acid, and ions, such as magnesium, calcium and potassium.

*\*With the exception of water and chloride ions, the process is active; that is, the tubular epithelial cells use energy to bind and transport the substances across the plasma membrane to the blood.*

-Secretes products of kidney tubular cell metabolism, such as hydrogen ions, and drugs, such as penicillin.

3-Loop of Henle:

-Facilitates the reabsorption of water, sodium, and chloride.

*\*The osmolality in the medulla in this portion of the nephron increases steadily from the corticomedullary junction inward*

4-Distal convoluted tubule:

-The filtrate entering this section of the nephron is close to its final composition.

-Effects small adjustments to achieve electrolyte and acid-base homeostasis (under the hormonal control of both antidiuretic hormone (ADH) and aldosterone).

\**The distal convoluted tubule is much shorter than the proximal tubule, with two or three coils that connect to a collecting duct*

5-Collecting duct:

-The collecting ducts are the final site for either concentrating or diluting urine.

-The hormones ADH and aldosterone act on this segment of the nephron to control reabsorption of water and sodium.

-Chloride and urea are also reabsorbed here.

**Renal Function**

1-Excretory Functions include : Formation and excretion of urine,Glomerular filtration ,Tubular reabsorption ,Tubular secretion and Excreting toxic substances in synergy with liver

2-Homeostatic function include : Regulation of blood volume ,Regulation of blood pH ,Regulation of serum electrolytes; Na, K, Cl and Ca and Reabsorption of essential nutrients

3-Endocrine function include :Erythropoietin ,Renin Angiotensin system ,Vitamin D activation and Degradation of hormones like insulin and aldosterone

4-Metabolic function :Along with liver site for gluconeogenesis

**Renal function tests; Why needed?**

1-To assess functional capacity of kidneys

2-To diagnose renal impairment

3-To assess the severity and progression of renal impairment

4-To assess the effectiveness of treatment

**Causes of renal disease**

1-Pre-renal

•Any condition that results in reduced blood flow to kidneys

•Severe blood loss

•Hemolysis

2-Renal

•Damage to renal tissue, glomerular basement membrane or tubules

•Glomerulonephritis

•Diabetic or hypertensive nephropathy

•Tubular damage due to toxic substances

3-Post Renal

•Obstruction to urine outflow

•Ureteric or urethral stone

•Prostatic cancer

**Renal function test**

Can be divided into two categories

1-Test for glomerular function include Serum Urea ,Serum Creatinine and Clearance tests

2-Tests for tubular function include Urine concentration test ,Dilution test ,Para amino hippuric acid clearance test and Acidification test

\*Urine examination :-Important for assessing both glomerular and tubular function

\*The following parameters are commonly included in assessing renal function include Serum Urea ,Serum Creatinine ,Serum Uric acid ,Total protein ,Serum albumin and Serum electrolytes

Renal Function Tests include

1-Complete hemogram like Hemoglobin , RBC and ESR

2-Routine urine examination like Physical appearance ,Color and pH

3-Clearance test

•Clearance of substance is defined as the volume of plasma that is cleared of that substance in unit time

•Inulin clearance accurately measures GFR as it is neither secreted or absorbed by the renal tubules

•However it is not routinely done in patients.

•In clinical setting estimated GFR (eGFR) is more commonly used; it is calculated from serum creatinine value

4-Estimated GFR

•The Cockcroft-Gault formula for estimating creatinine clearance (CrCl) is routinely as a simple means to provide a reliable approximation of residual renal function in all patients with CKD. The formulas are as follows:

•CrCl(male) = ([140-age] ×weight in kg)/(serum creatinine ×72)

•However this has been extensively modified and there are online calculators of eGFR from serum creatinine and body weight of patients

•The eGFR is used to determine the stage of chronic kidney disease

**Changes in serum analyses in kidney disease**

1-Serum Urea and creatinine

•They both are increased in renal disease

•Urea increases more in glomerular disease as compared to creatinine

•Urea is a less reliable indicator than creatinine as it is affected by many factors such as;

•Protein intake

•Dehydration

•Muscle breakdown

2-Serum Uric acid

•It may increase in chronic kidney disease but not sufficient to cause gout

•However raised uric acid is a bad prognostic indicator for chronic renal disease

3-Total protein and albumin

•Both serum total protein and albumin is decreased in chronic kidney disease (CKD) due to increased proteinuria

•Even though proteinuria may also be seen in acute kidney disease but it usually does not alter the total protein and albumin

4-Serum electrolytes

•Sodium is decreased (hyponatremia) and potassium is increased (hyperkalemia) in chronic kidney disease (CKD) as kidney reabsorb sodium in exchange of potassium

•Chloride and phosphate is increased in CKD

•Calcium is decreased as vitamin D is deficient

5-RBC count and hemoglobin is decreased in advanced stages of kidney disease due to deficiency of erythropoietin

6-Urine examination reveals

•Proteinuria is seen in both acute and chronic kidney disease as well as kidney infection

•Proteinuria can be of two types

•In the initial stages very less amount of albumin escapes into urine; microalbuminuria (30 to 300 mg/day)

•Frank proteinuria ( when it is greater than 300 mg/day)

•Best evaluated in 24 hour urine sample

•In spot urine albumin/ creatinine ratio is used to evaluate proteinuria

•Presence of RBC may indicate glomerulonephritis , acute nephritis, kidney infection

•Presence of pus cells, esterase positivity, nitrites may indicate bacterial infection

**Tests for tubular function**

1-Urine concentration test

•In CKD kidneys loses the ability to concentrate urine

•Specific gravity is measured in urine

•Low fixed specific gravity is indicative of chronic kidney disease

2- Urine Dilution test

•After overnight water deprivation patient is asked to take 1200ml of water in half hour, urine specific gravity is measured in samples collected over next 4 hours. At least one sample should show spgr of 1.003 or below

3-Para amino hippuric acid clearance test

•PAH is unique in that it is completely excreted in one passage through kidney as it is both filtered and secreted.

•Therefore clearance of PAH is a measure of renal plasma flow

4-Acidification test

•In this the ability to acidify urine is tested after administering 0.1g/kg ammonium chloride gelatin coated samples