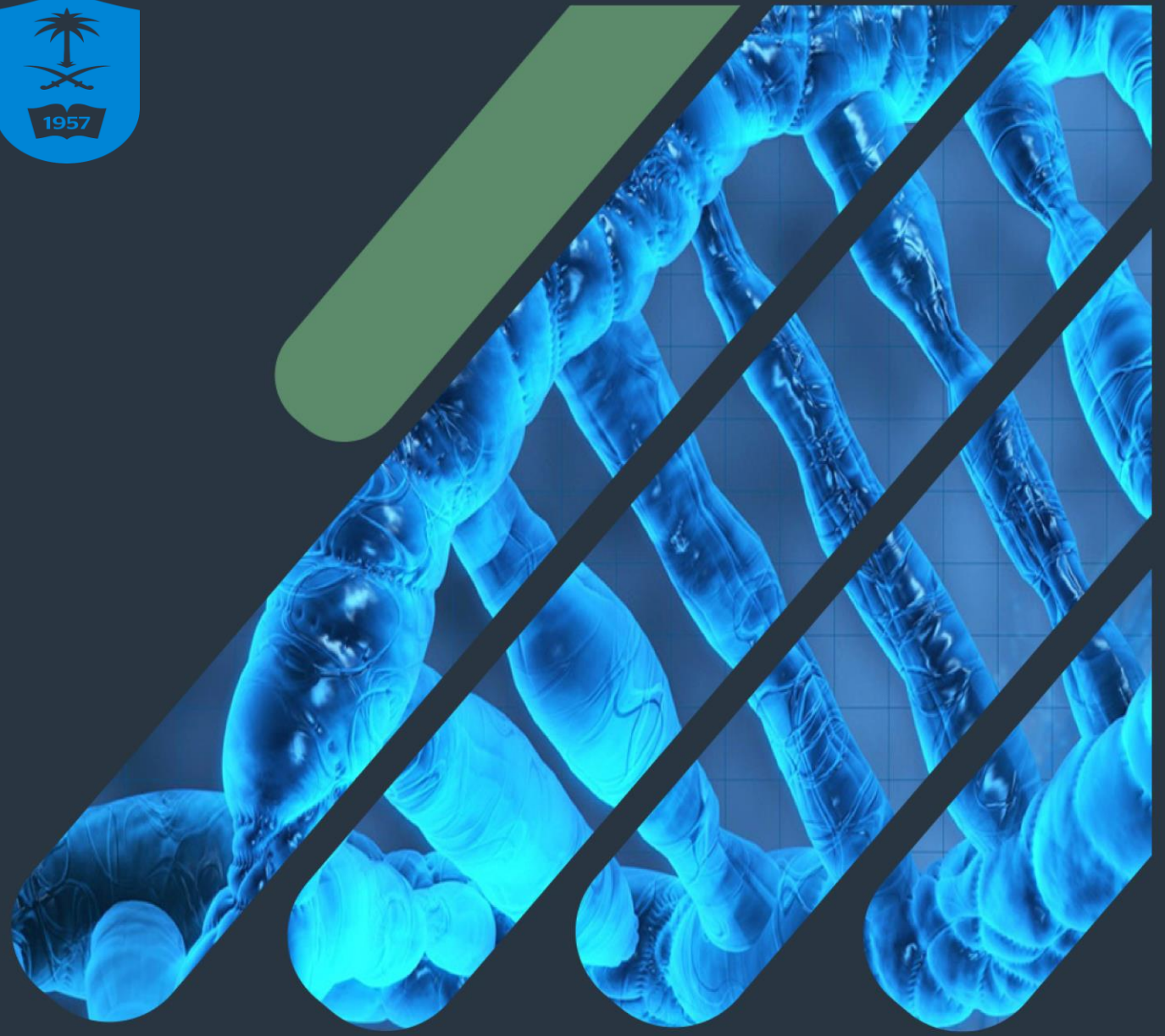
Biochemistry

Kidney Function Test



Worrying doesn't take away tomorrow's troubles .. It takes away today's peace .

Revised by
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- Important.
- Extra Explanation.
- Doctors slides.
- Doctors notes.

Biochemistry team 436

OBJECTIVES:

By the end of this lecture you will be able to:

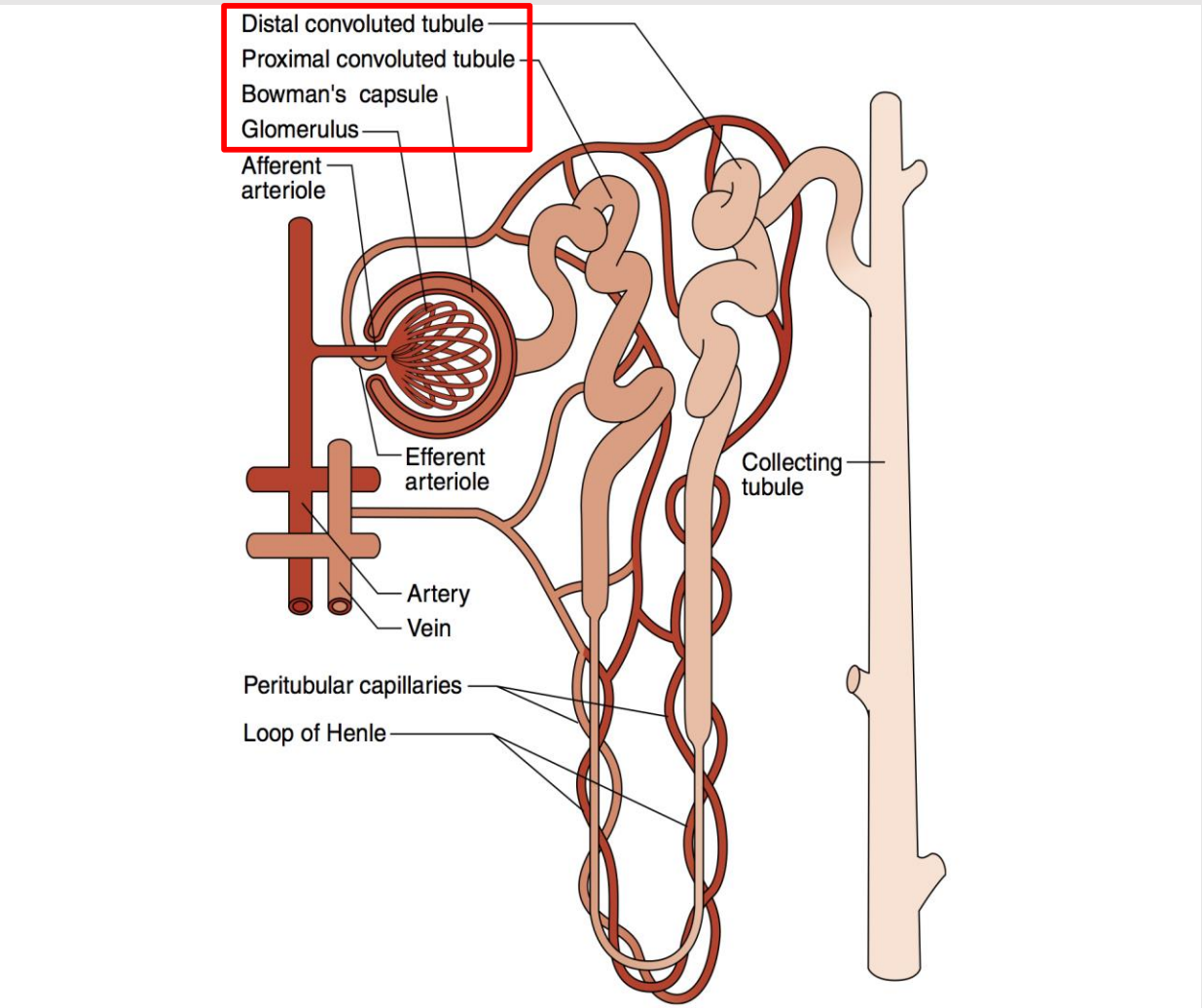
- ✓ know the physiological functions of the kidney.
- ✓ describe the structure and function of the nephron.
- ✓ identify the biochemical kidney function tests with special emphasis on when to ask for the test, the indications and limitations of each kidney function tests.
- ✓ interpret the kidney function tests properly.

What are Nephrons

- ✓ 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.

Laboratory and radiology tests complete each other in diagnosis especially kidney diseases .

The nephron and its blood supply



Kidney functions

IMPORTANT

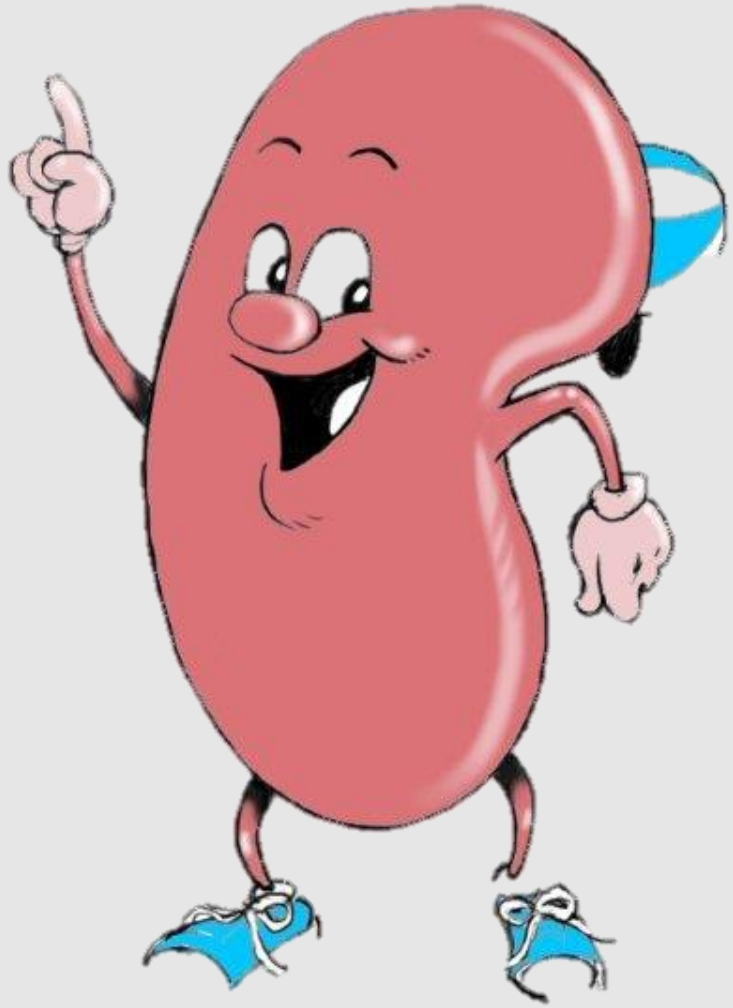
1. Regulation of the following :
- water and electrolyte balance.
- acid base balance.
- arterial blood pressure.
2. Excretion of metabolic waste products and foreign chemicals.

These metabolic wastes will be converted to intoxic (inactive) metabolites in the liver (catabolism reaction), then excreted in the urine by the kidney .

3. Hormonal Function : Secretion of erythropoietin & activation of vitamin D and activation of angiotensinogen by renin .

4. Metabolic Function : site for gluconeogenesis .

Formation of glucose from non carbohydrate precursors.



Why to test renal functions ?

1. Many diseases affect renal functions . (In some, several functions are affected . In others, there is selective impairment of glomerular function or one or more of tubular functions .)

2. Most types of renal diseases cause destruction of complete nephron. This happens when it becomes a chronic disease and lead to renal failure .

We use it as a general management and indication to the body functions ..

Kidney function test

Routine KFTs include the measurement of :

- Serum creatinine (Cr).
- Creatinine clearance.
- Serum urea.

KFT divided into routine and special tests ..

They are arranged from the most to the less important

Both serum Cr and creatinine clearance are used as kidney function tests to :

Important

To check for the response of the treatment before and after dialysis

Serum Creatinine

ضروري نقيسه لانه يقيس لك مقدار الفيلتريشن

Normally (**55-120** µmol/L in adult):

Creatinine is the end product of creatine catabolism.

Serum Creatinine

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.

Doctor told that you must know how to convert mg/dl to µmol/L and vise versa
So to convert mg/dl to µmol/L Multiply the value by 88.4 .

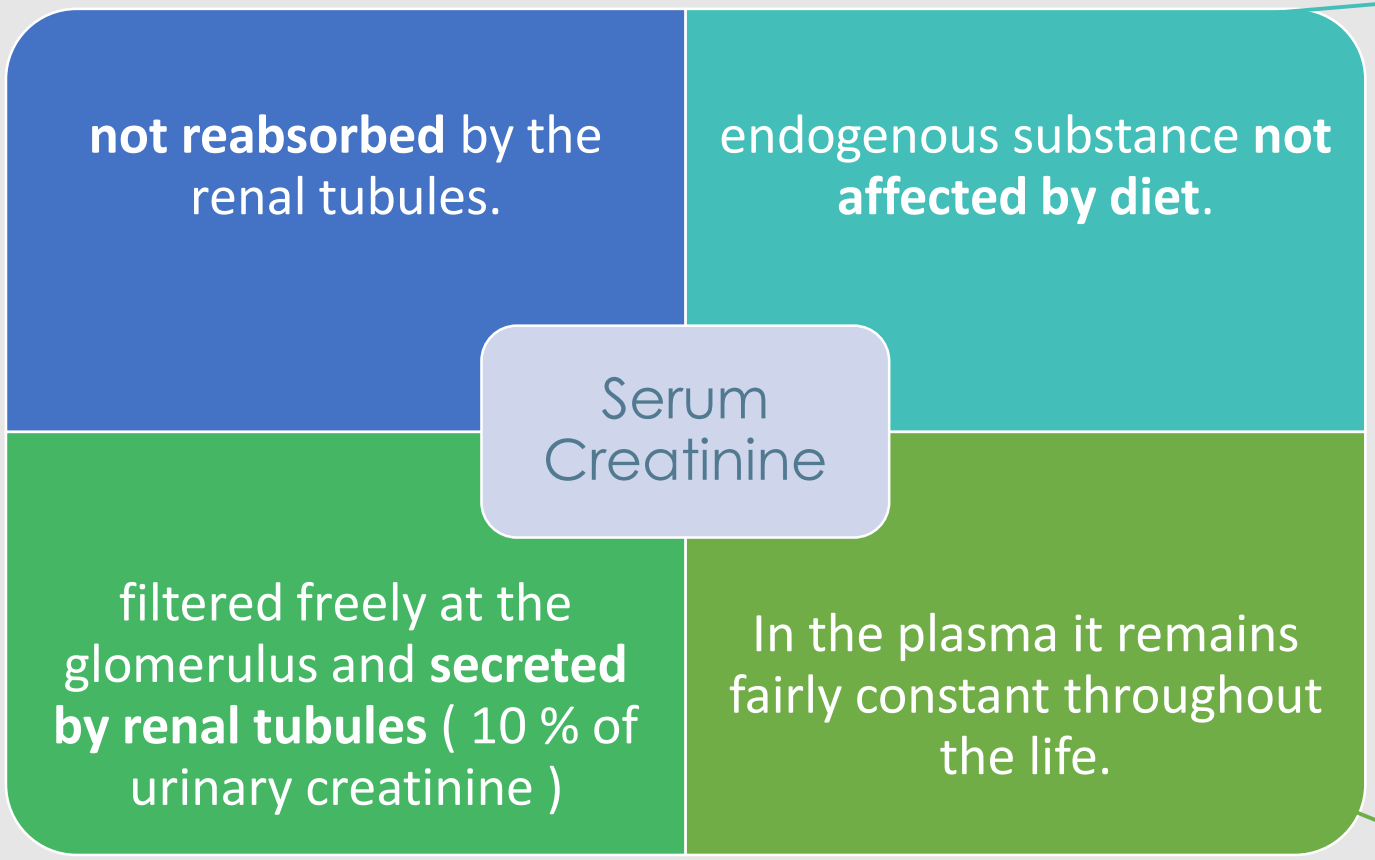
Males & people with sedentary life style & vegetarians have lower creatinine levels, Usually each person (Male or Female) or (Athlete or non athlete) have their own different Creatinine levels.

بما أن عملية التحويل من كرياتين إلى كرياتينين تحدث بدون إنزيمات بكذا نقدر نتأكد أن المشكلة مو من العضلة فهي من الكلية نفسها .

milligram\deciliter ⟶ (X 88.4) µmol/L
µmol/L ⟵ (Divide over 88.4) milligram\deciliter

In some cases there may be renal impairment with out increase in creatinine levels (usually in early stages)

Serum Creatinine



That means if we eat meat It won't rise creatinine in our plasma, because it will be degraded and may be excreted in feces.

That means the serum creatinine test is better than creatinine clearance.

إذا افترضنا أن الشخص شرب الكثير من الماء، راح يزيد معدل التبول عنده وبالتالي يقل تركيز الكرياتينين في البول ، لكن إذا قلت نسبة شرب الماء راح تقل نسبة التبول لأن السوائل قلت ، وبالتالي راح يزيد تركيز الكرياتينين في البول، ومن هذا نستنتج أن هذا الاختبارغير ثابت مقارنة بالسيرم الذي يكون ثابت طول حياة الفرد

Afferent arteriole is more dilated → it has higher pressure →the filtration takes place (not passive nor active transport)

* for example: if we have 100 µmol/L creatinine in blood, it will be 110 µmol/L in urine due to the secretion of 10%. So we have more creatinine in urine than blood.

Serum Creatinine

- ✓ The amount of creatinine in the blood depends on the amount of muscle tissue .
- ✓ Men tend to have higher creatinine level than women .
- ✓ Spontaneous and non enzymatic to accurately indicate renal function .
- ✓ Creatine is converted to creatinine by the loss of water .
- ✓ Creatine phosphate is converted to creatinine by the loss of phosphate group .
- ✓ High serum creatinine > the kidney is not working as it should .

A- Scr less than 55 : muscle wasting disease.

B- Between 55-120 :
1) normal healthy individual
2) there is kidney problem but it's not obvious yet.

*if it is 50 it is considered to be normal but the person is not taking enough protein.

C- More than 120 :renal impairment

Creatinine clearance

نشوف كمية السيرم او البلازما الي صار له فيلتريشن ونظف من الويست الي موجودة فيه

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

The test is done on both a blood sample and on a sample of urine collected over 24 hours

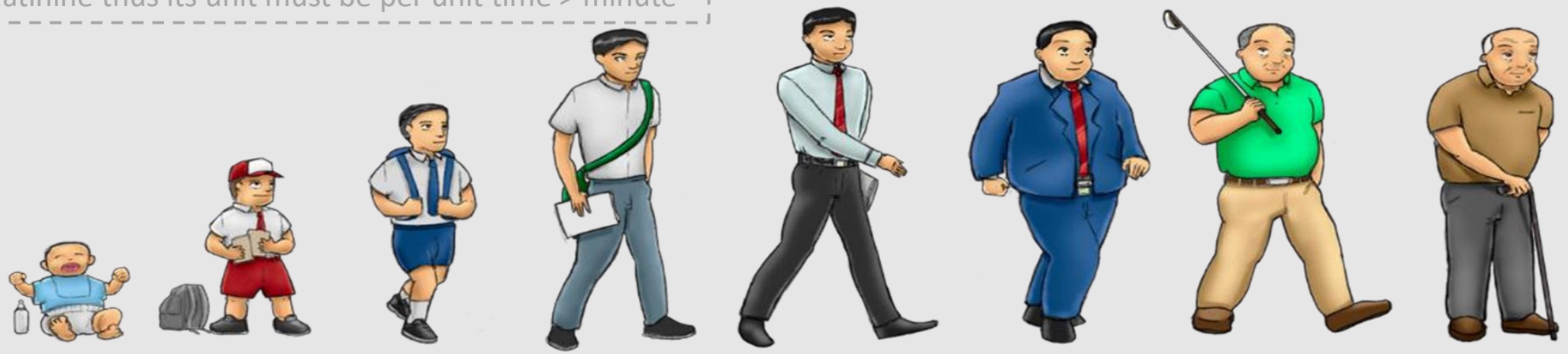
- Freely filtered at glomeruli.
- Neither reabsorbed nor secreted by tubules.
- Its concentration in plasma needs to remain constant throughout the period of urine collection.
- Better if the substance is present endogenously.
- Easily measured.

This is not the case for creatinine but not necessary to have all these features so Creatinine meets most of the criteria.

مو كل المواد ينفع نستخدمها لقياس ال GFR لأن بعضها يعاد امتصاصه أو تفرز زيادة أو تتأثر بعوامل كثيرة ما تخليها مقياس دقيق للاستخدام وبكذا كل ما تطابقت مواصفات المادة مع النقاط هذي بتصير أدق ..

Creatinine clearance

Creatinine clearance represents a rate unlike serum creatinine thus its unit must be per unit time > minute



In children:

the GFR should be related to surface area, when this is done, results are similar to those found in young adults.

Kidney function is proportional to kidney size, which is proportional to body surface area. In young adults, there's a normal mean value of the body surface which is 1.73 m2, while it is variable in children "that's why we should relate the GFR to surface are in children".

in the 20-40 year old adults:

Creatinine clearance is usually about 110 ml/min

in individuals over 80 years of age:

It falls slowly but progressively to about 70 ml/min

Creatinine clearance

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

- It could be calculated from the following equation:

$$\text{Clearance (ml/min)} = \frac{U \times V}{P}$$

U = Concentration of creatinine in urine µmol/l

V = Volume of urine per min

P = Concentration of creatinine in serum µmol/l

In the exam don't forget to make sure that it has the correct units ..

ليست دقيقة بسبب أن المريض ممكن ما يطلع معه الناتج الصحيح لأنه بيقعد يجمع يورين لوقت طويل .. بسببها أوجدوا معادلة Cockcroft-Gault Formula

Cockcroft-Gault Formula for Estimating GFR

- ✓ As indicated above, the creatinine clearance is measured by using a 24-hour urine collection, but this does introduce the potential for errors in terms of completion of the collection.

(for example when some patients hang out without their container and they go to bathroom, so they didn't urinate in the container so there will be error in the final urine volume. Also some patients may add water to the container which damages the sample).

فمن هالمنطلق اخترعوا معادلة بسيطة تغنيهم إلى حد ما عن تجميع اليورين .

An alternative and convenient method is to employ various formulae devised to calculate creatinine clearance using parameters such as

serum creatinine level, gender, age, and weight of the subject.

This formula is good because we **excluded urine** and replaced it by easier parameters

(because we need to measure the urine volume, and once we give the patient the urine container we take a blood sample from him at the same time to measure the creatinine in the blood),

Cockcroft-Gault Formula for Estimating GFR

➢ Cockcroft-Gault Formula: VERY IMPORTANT

$$GFR = \frac{K \times (140 - age) \times Body\ weight}{Serum\ creatinine\ (\mu mol/L)}$$

Constant values are given in the exam

- where K is a constant that varies with gender:
  - ✓ 1.23 for male
  - ✓ 1.04 for females.

(because of lower muscle mass).

- The constant K is used as females have a relatively lower muscle mass.

So Serum creatinine is inversely proportional to GFR

It should not be used if :

- Serum creatinine is changing rapidly
- the diet is unusual, e.g., strict vegetarian
  - (lack of proteins which will decrease muscle mass) ..
- Low muscle mass, e.g., muscle wasting
- Obesity

Obesity will give a normal GFR even if creatinine serum is high.

Creatinine

Serum Cr is a **better** KFT than creatinine clearance because:

1. Serum creatinine is more accurate.
2. Serum creatinine level is **constant** throughout adult life.

(accurate because it measures one variable only which will decrease the chances of errors) ..

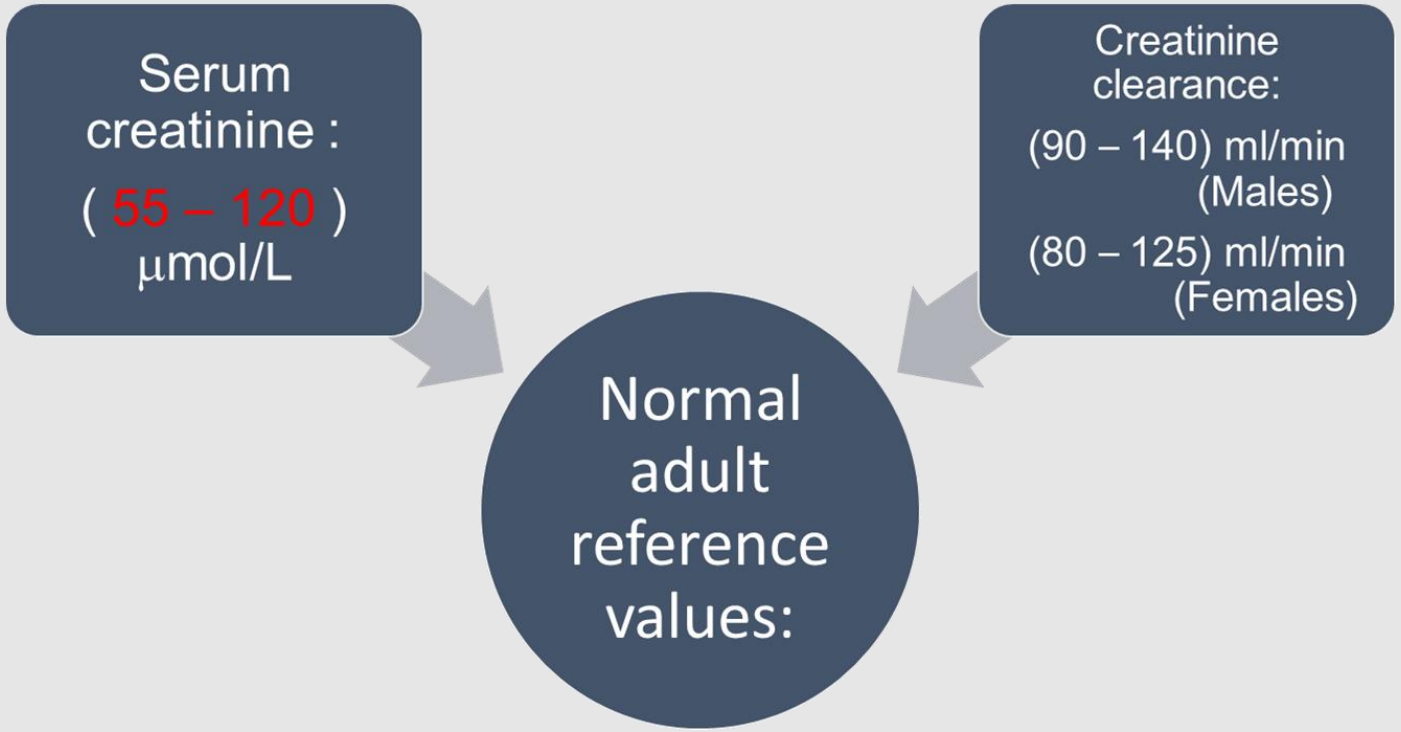
Creatinine clearance is only recommended in the following conditions:

1. Patients with early (minor) renal disease.
2. Assessment of possible kidney donors.
3. Detection of renal toxicity of some nephrotoxic drugs.

we use creatinine clearance for early renal disease due to its tight range. as for creatinine serum its range is wide and therefore it won't indicate impaired renal function unless its highly raised.

Creatinine Normal values

- Urinary excretion of creatinine is 0.5 - 2.0 g per 24 hours in a normal adult, varying according to muscular weight.



- ✓ A **raised serum creatinine** is a good indicator of impaired renal function
- ✓ But normal serum creatinine **does not necessarily indicate normal renal function** as serum creatinine may not be elevated until GFR has fallen by as much as 50%

Serum Urea

Recall : urea is formed from ammonia as an detoxification reaction.

✓ (2.5-6.6 mmol/L) in adult

➢ Urea is formed in the liver from ammonia released from deamination of amino acids.

High protein diet increases urea formation.

Any condition of ↑ proteins catabolism *(Cushing syndrome, diabetes mellitus, starvation, thyrotoxicosis)* →↑ urea formation.

50 % or more of urea filtered at the glomerulus is passively reabsorbed by the renal tubules.

يعني الترتيب من حيث الأهمية :

1. serum creatinine.
2. creatinine clearance.
3. serum urea.

Urea is not endogenous it is affected by diet

Urea is a waste product made when protein is broken down in your body.
Urea is made in the liver and passed out of your body in the urine.
لهذا السبب أي شي يزيد هدم البروتين بيزيد تكوين اليوريا

Normal values of Internal Chemical Environment controlled by the Kidneys:

SODIUM	**135 to 145 mEq/L**
POTASSIUM	3.5 to 5.5 mEq/L
CHLORIDES	100 to 110 mEq/L
BICARBONATE	24 to 26 mEq/L
CALCIUM	8.6 to 10 mg/dl
MAGNESIUM	1.6 to 2.4 mg/dl
PHOSPHORUS	3.0 to 5.0 mg/dl
URIC ACID	2.5 to 6.0 mg/dl
pH	7.4
CREATININE	0.8 to 1.4 mg/dl
BUN (Blood Urea Nitrogen)	15 to 20 mg/dl

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Biochemistry team 436

THANK YOU

PLEASE CONTACT US IF YOU HAVE ANY ISSUE

- Review the notes (with help of 435 team)

- Lippincott's Illustrated Reviews: Biochemistry, 6th E

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