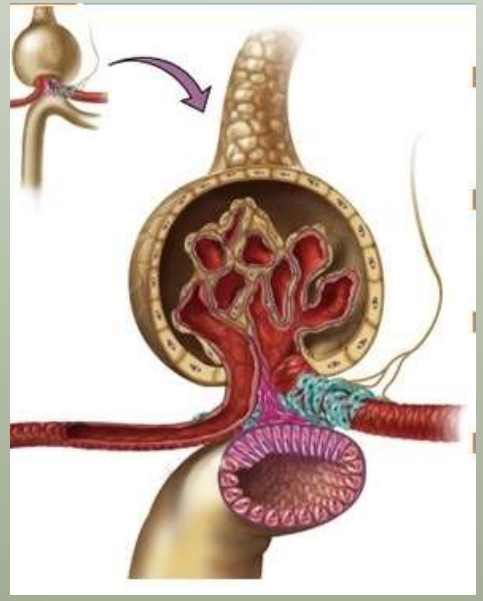
5- RENAL CLEARANCE.



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Plasma clearance

Plasma clearance of a substance (Cx): is the volume of plasma which is cleared (becomes free or cleaned) from this substance per minute.

* Plasma clearance is an important kidney function test because it measures the ability of the kidney to clear plasma from various substances and excrete it in urine.

Its formula is $Cx = Ux \times V / Px$

Where : Ux = concentration of substance in 1 ml urine.

V = volume of urine/min

Px = concentration of substance in 1 ml plasma.

Extraction ratio: is the percentage of this substance (x) that excreted in urine.

Determination of GFR by using clearance concept:

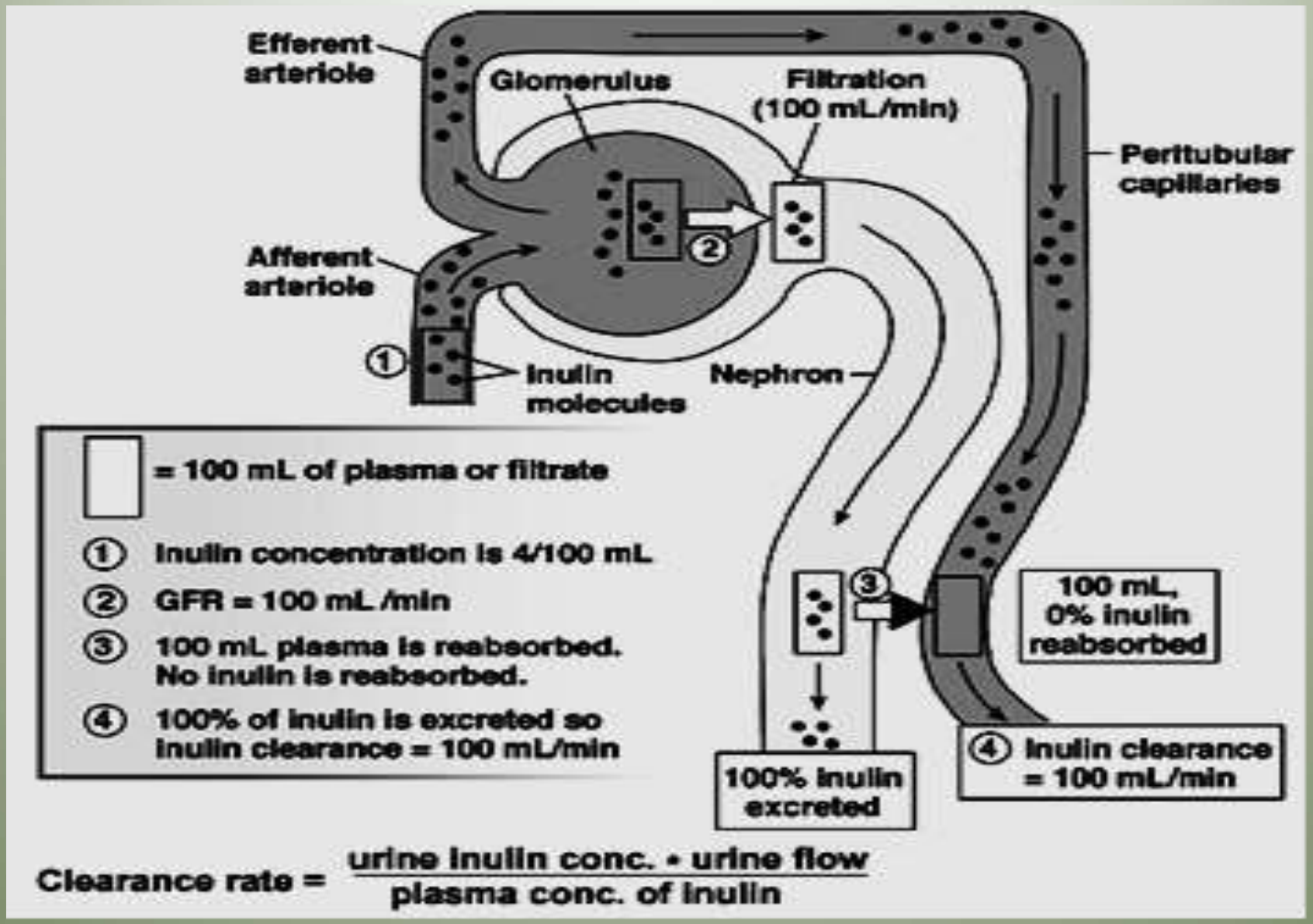
A) By determination of inulin clearance:

- Inulin is a polymer of fructose, non-toxic, not enters RBC's, not metabolised by the tissues and is easily calculated experimentally.
- It also, neither reabsorbed nor secreted by kidney tubules à the filtered amount will excreted in the urine as it is.
- In practice:

* Loading dose of inulin is given IV, followed by IV infusion to keep plasma level constant.

* Urine and plasma samples are obtained to determine Plasma

and urinary inulin concentration.


Efferent arteriole
Glomerulus
Filtration (100 mL/min)
Peritubular capillaries
Afferent arteriole
Inulin molecules
Nephron
= 100 mL of plasma or filtrate
① Inulin concentration is 4/100 mL
② GFR = 100 mL /min
③ 100 mL plasma is reabsorbed. No inulin is reabsorbed.
④ 100% of inulin is excreted so inulin clearance = 100 mL/min
100 mL, 0% inulin reabsorbed
100% inulin excreted
④ Inulin clearance = 100 mL/min
Clearance rate = urine inulin conc. • urine flow / plasma conc. of inulin

* Clearance calculated as follows:-

If UIN = 35mg/ml, V = 0.9 ml/min PIN = 0.25 mg/ml

So CIN = UIN.V/PIN = 35 x 0.9 / 0.25 = 126 ml/min

So GFR = 126 ml/min

B) By determination of creatinine clearance:

- An endogenous method (we do not inject any exogenous substance in patient) because creatinine is produced in the body as an end product of muscle creatine metabolism.
- Rate of creatinine production = rate of creatinine urinary excretion.
- It is also nearly neither reabsorbed nor secreted by kidney tubules (it is secreted by small amount (10%) in proximal tubules, but in the same time, its plasma level is 10% over estimation due to presence of similar substances to creatinine in plasma à two errors cancel each other).

- Ccreatinine is sensitive indicator for determination of GFR only when the GFR is markedly reduced and not sensitive in mild decrease in GFR.

Determination of renal plasma flow by clearance concept:

- It is an important kidney function test.
- PAHA clearance or Diodrast clearance are used because:

a) It has the higher extraction ratio (its extraction ratio = 0.9).

b) Its 90% are cleared by the kidney through single circulation. i.e. 90% secreted and nearly 10% return to blood (which represent amount of blood that supply non-secretory kidney tissues).

c) PAHA clearance represents the effective renal plasma flow that is really 10% less than the actual renal plasma flow.

PAHA clearance calculated as follows:

- If concentration of PAHA in urine = 14 g/ml, Urine flow = 0.9 ml/min, concentration of PAHA in plasma = 0.02 mg/ml and Haematocrit value = 45%.
- So, effective renal plasma flow = UPAH x V/ PPAH

  = 14 x 0.9 / 0.02 = 630 ml/min
- The actual renal plasma flow = = 700 ml/min
- RBF = Actual RPF x 100/100-haematocrit value

= 700 x 100 / 100 – 45 = 7000 / 55 = 1273 ml/min

Free water clearance (C H2O)

- Free water clearance is the difference between the urine volume/min and clearance of osmoles (Cosm)
- CH2O = V – (Uosm .V / Posm)

Where: Uosm and Posm is the urine and plasma osmolality.

- It is used to determine gain or loss of water by the kidneys:

a) CH2O is -ve so the urine is hypertonic maximal antidiuresis.

b) CH2O is +ve so the urine is hypotonic maximal diuresis as in diabetes insipidus.

Remember that:

- Any substance that is neither reabsorbed nor secreted by the renal tubules, as inulin, must have a plasma clearance = glomerular filtration rate = 125 ml/min.
- Any substance that is partially reabsorbed must have a clearance less than CIN e.g., urea.
- Any substance that is partially secreted must have a clearance more than CIN e.g., creatinine.
- Any substance that is completely reabsorbed must have a zero clearance e.g., glucose.
- Any substance that is completely removed from the kidney (totally secreted) by single circulation must have a clearance similar to renal plasma flow.
- Any substance that have a clearance more than renal plasma flow this means that this substance is totally secreted and also is synthesized by kidney e.g., ammonia.

Name	Equation	Units	Comments
Clearance	$C_x = \frac{[U]_x \dot{V}}{[P]_x}$	mL/min	x is any substance
Clearance ratio	$\text{Clearance ratio} = \frac{C_x}{C_{inulin}}$	None	Also means fractional excretion of x
Renal plasma flow	$RPF = \frac{[U]_{PAH} \dot{V}}{[RA]_{PAH} - [RV]_{PAH}}$	mL/min	
Effective renal plasma flow	$\text{Effective RPF} = \frac{[U]_{PAH} \dot{V}}{[P]_{PAH}}$	mL/min	Underestimates RPF by 10%; equals C_{PAH}
Renal blood flow	$RBF = \frac{RPF}{1 - Hct}$	mL/min	1 minus Hct is fraction of blood volume that is plasma
Glomerular filtration rate	$GFR = \frac{[U]_{inulin} \dot{V}}{[P]_{inulin}}$	mL/min	Equals C_{inulin}
Filtration fraction	$FF = \frac{GFR}{RPF}$	None	
Filtered load	$\text{Filtered load} = GFR \times [P]_x$	mg/min	
Excretion rate	$\text{Excretion} = \dot{V} \times [U]_x$	mg/min	
Reabsorption or secretion rate	Reabsorption or secretion = Filtered load – Excretion	mg/min	If *positive*, net reabsorption If *negative*, net secretion
Free-water clearance	$C_{H_2O} = \dot{V} - C_{osm}$	mL/min	If *positive*, free water is excreted If *negative*, free water is reabsorbed

Thank You