RENAL FUNCTION TEST

Department of Physiology
Mahatma Gandhi Medical College & Hospitals, Jaipur

Specific learning objectives

- Introduction
- Indications of renal function tests
- Preliminary investigations to RFTs
- Classification of Renal Function Tests
  - Urine Analysis
  - Blood examination
  - Tests for GFR
  - Tests for Renal Plasma flow
  - Tests for Tubular Functions
  - Miscellaneous tests

INTRODUCTION

- Kidneys play a vital role in homeostatic functions of the body. The ability of the mammals to function in widely and rapidly changing environment is due to their ability to maintain a stable internal environment. Kidneys play a principal role in it by regulating ECF volume and composition.
- Thus renal dysfunctions may result in a variety of clinical disorders. Hence the methods that assess the functional capacity of kidneys become important

- What are RFTs:

  Clinical and lab. procedures designed to evaluate various aspects of renal capacity and efficiency to aid in the diagnosis of kidney disorders

INDICATIONS OF RENAL FUNCTION TESTS

- Metabolic diseases e.g-D.M,Amyloidosis
- Infections e.g-Pyelonephritis,T.B
- Obstructive uropathy e.g Renal calculi,BPH,urethral obstruction
- Renal vascular d/s eg-Atherosclerosis
- Immunologic d/s -Glomerulonephritis,SLE
- Congenital disorders e.g-Polycystic kidney d/s, congenital absence of kidney tissue.
- Malignancies e.g-Ca prostate, Ca bladder

PRELIMINARY INVESTIGATIONS TO RFTs

- Patient's history
- Physical examination
- Biochemical parameters:

  Estimation of Serum uric acid,serum creatinine, serum urea.

CLASSIFICATION OF RENAL FUNCTION TEST

- **URINE ANALYSIS-**
- **COLOUR-**
- **Normal-** Pale yellow
  Cloudy-+nce of pus, bacteria, fungi,chyle and amorphous urates and phosphates.
  Milky or opaque-Nephrotic Syndrome
  Greenish yellow-Obstructive Jaundice

URINE ANALYSIS

- **Colour**
- ***Red-Haematuria*-Infections, drugs,injuries and malignancies**
- ***Black*-D/t Parentral Iron therapy**
- ***Greenish blue*-Infection with Psuedo.Aeruginosa.**

Composition

- ***Inorganic-***
- **Na+ 6gm/day**
- **K+ 2gm/day**
- **Ca++ .2gm/day**
- ***Organic-***
- **Urea-20-30gm/day**
- **Uric acid-0.6gm/day**
- **Creatinine-1.2gm/day**

Volume

- ***Normal-1.2-2L/day(avg.1.5L)***
- ***Oliguria-*<400ml/day**
  -(Acute GN, Terminal stages of RF)
- ***Anuria-<100ml/day****(Renal failure)*
- ***Polyuria ->2.5L/day****(Chronic GN)*

Specific gravity

- **N-1.001-1.040**
- **Influenced by-**Na+,Cl-,Albumin and sugar.
- **Increases in:**Diabetes,Albuminuria,Acute nephritis.
- **Decreases in:**Tubular damage,absence of ADH

Reaction

- **Normal pH-6-6.5**
- **After meals-**alkaline

Chemical examination

- For the presence of: **Albumin**
- **Sugar**
- **Ketone bodies**
- **Proteinuria:**
- Abnormal excretion of proteins(>150mgday).
- N-<50mg/day
- Usually glomerular in origin
- Dipstick +ve->300mg/L urine
- Factors causing increased glom.permeability: **Hypoxia,Inflammation,malignancy**

Microscopic examination

- **For urinary sediments**
- Centrifuging the urine at 3000rpm/min
- **Casts:** Coagulation of albuminous material
- **Cylindrical** in shape.
- Assoc. with **Pathological lesions.**
- **Eg. Hyaline casts**-clear &colourless
  (Acute GN)
- **RBC Casts**-GN,**WBC casts**-Pyelonephritis
- **Cells:**
- **RBCs**
- **Pus cells-N-1-2/hpf**
  if>-Urinary infection or contamination with vaginal secretions
- **Epithelial cells-If large no.-Tissue destruc. Of urinary tract.**

BLOOD VALUES

- To measure substances ,normally excreted by kidney
- An ***increase will indicate kidney*** dysfunction

- **S.Urea**
- **S.Creatinine**
- **S.potassium**
- **S.sodium**
- **S.calcium**
- **S.magnesium**
- **S.proteins-Total**
- **Albumin**
- **Globulin**
- **A/G ratio**
- **S.cholesterol**
- **S.uric acid**

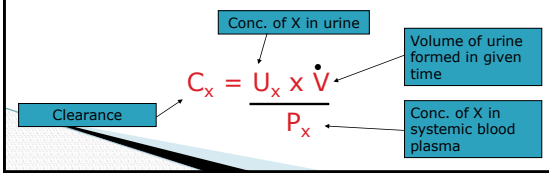
TESTS FOR GFR

- **CLEARANCE MEASUREMENTS:**
- **Clearance- Central concept in renal physiology (as it provides a way of evaluating the elimination of a substance by the kidney,Smith,1951)**
- **It is the volume of plasma (ml) completely freed of a given substance per min by the kidneys**

CLEARANCE (ctd)

- **Expression for clearance:**
- **According to law of conservation of mass:**
  Mass removed from plasma per unit time = Mass excreted per unit time

$$C_x X P_x = U_x X V_x$$

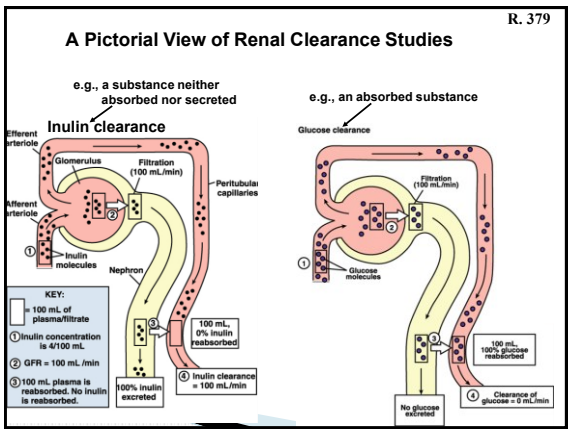


Clearance (ctd)

- **This "clearance" is a theoretical volume(cannot be collected and directly measured)**

Not a single millilitre of plasma has all of its 'X' removed by the kidneys

The concept of clearance is important b/c it can be used to measure GFR and RPF and determine whether the substance is reabsorbed or secreted



MEASUREMENT OF GFR

Salient features of substance

- ***Freely filtered****(not protein bound)*
- ***Neither reabsorbed nor secreted***
- ***Not metabolised***
- ***Not stored in kidney***
- ***Not toxic***
- ***Has no effect on filtration rate***
- ***Easy to measure in plasma and urine.***
- *Someexamples:**Inulin,creatinine,mannitol,sucrose,sodiumferrocyanide,radioactive chromium EDTA etc.***

CLEARANCE TESTS FOR GFR

- **Inulin clearance**
- **Creatinine clearance**
- **Urea clearance** **(obsolete test now)**
- **Radioactive chromium EDTA clearance**

Inulin Clearance

- Research tool of **little value** **in routine clinical practice**.
- Serve as a **reference method** b/c of its **accuracy** and precision.

- **Inulin**-a fructose polymer
- No endogenous production
- Neither reabsorbed nor secreted.

METHOD

- **Large initial dose,**injected i.v.
- Followed by a **constant infusion**
- **Bladder emptied** 1 hr later,urine discarded.
- **Time noted and urine collected 1 and 2 hrs. later.**
- **Volume of urine measured and analysed for Inulin content.**
- **10-15 ml of blood collected** at the midpoint of each collection of urine.
- **Plasma seperated and analysed for Inulin content.**

Calculation and Result

- $C_{In=UxV/P,}$
  Where,U=Conc. Of Inulin in urine
  V=Volume of urine
  P=Conc. of Inulin in plasma

- **Normally: 127ml/min.(avg)/1.73sq.m**
  (100-150 ml/min./1.73sq.m)

- **Test gives:** ***Precise values***
- ***But is :***
  - ***Time consuming.***
  - ***Requires infusion pump.***
  - ***Requires injection of a foreign substance.***
  - ***Requires*** **Tedious & intricate chemical procedure**

Inulin Clearance

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- **Inulin**-a fructose polymer
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Inulin clearance as a reference tool

- If Clearance of a substance is: $C<C_{In}$ the substance is mainly reabsorbed.
- If Clearance of a substance is: $C>C_{In}$ the substance is mainly secreted.
- If Clearance of a substance : $C = C_{In}$ It is neither reabsorbed nor secreted.

Creatinine Clearance

- Endogenous substance
- Organic base formed during muscle protein metabolism
- 1-2% of muscle creatine is converted to creatinine
- Amount relates to body's total muscle mass
- At normal plasma levels:filtered and 10-15% secreted.
- So clearance slightly more than GFR(theoretically)

Method

- An **Accurate 24 hr. urine sample** collected
- A **Blood sample** for serum creatinine
- Serum and urinary conc. estimated
- $C_{cr}=U_{cr}X\ V/P_{cr}$
- Normal:95-105ml/min

Urea Clearance

- Ambard-**first to study**
- At present:**Van Slyke** test used
- $C_{urea}=UxV/P_{urea}$
- When rate of urine flow is-**<2ml/min:(standard urea clearance):Ux $\sqrt{V}/P$**
- When rate of urine flow is-**>2ml/min.:(Maximum urea clearance:UxV/P**
- Normally **one half reabsorbed**
- When **Tubules are damaged- increased reabsorbtion**
- **Normal range is wide and influenced by many variables.**
- Obsolete test now , not used clinically

^{51} Cr EDTA Clearance

- For determination of GFR in adults as well as children.
- Particularly convenient in children where it is not easy to collect 24 hr urine sample can be used in children <1 year old.
- Accuracy is high but less clinical utility

Tests for Renal plasma flow

- PAH Clearance
- Diodrast clearance(an organic iodine compound)
- FF

- *PAH Clearance:*
  - *Fick's equation provides the basis.*

$$RPF=\frac{Q_x}{P_{RAX}-P_{RVX}}$$

Fick's Equation (ctd)

- For a substance,not metabolised/synthesised by kidney:

RPF=UxV

$$\frac{}{P_{RAX}-P_{RVX}}$$

- For a substance,not consumed by other tissues except kidney:

RPF=UxV

$$\frac{}{P_{X}-P_{RVX}}$$

Fick's equation (ctd)

- P_{RVX} .Not easily obtained
- So **Ideal substance** for **RPF: with** $P_{RVX}=0$
  Such a subs. is Paraaminohippuric acid: Filtered at glomerulus **& Almost completely secreted** at PCT ***With EPAH=85-90%***

Fick's equation (ctd)

- Thus,**PAH clearance** gives **ERPF**
- **So, RPF=ERPF**

Extraction ratio of PAH

RPF=ERPF

0.85-0.9

RBF=RPF(100

100-haematocrit)

Filtration fraction for RPF

- **FF=GFR**

RPF **=0.16-0.20 (normally)**

- **Interpretations:**
- When **essential HT** progresses-
  decrease in RPF>decrease in GFR
  Increase in FF
- In **GN**-decrease in GFR>that of RPF
  Decrease in FF

TESTS FOR TUBULAR FUNCTIONS

- **Renal Transport Maximum**
- **Phenolsulphthalein excretion test**
- **Concentration-dilution test**
- **Micropuncture techniques**

Renal Transport Maximum

- **Tm: Maximum amount of solutes that can be transported(reabsorbed or secreted) by renal tubules per minute.**
- **TmPAH or TmG-can be used to assess tubular functions**

Phenolsulphthalein excretion test

- Introduced by **Rowntree & Geraghty** in 1912.
- **Smith** showed-**94% of dye injected** is excreted by **tubules** & only 6% by glomerulus.
- **15 min PSP test-**
- **Amount of dye excreted in first 15 mins is taken as criterion for renal function.**

Concentration & Dilution tests

Fishberg concentration test:
Most commonly used.

- **Procedure:**
- **Pt. Allowed no fluid the previous night.**
- **Evening meal given with high protein diet & fluid<200ml.**
- **NBM next morning.**
- **Urine specimens collected at 8am, 9am &10am.**
- **Specific gravity determined(should be more than 1.025)**

Water Dilution and elimination tests:

- **Principle:**
  - **Ability of kidney to eliminate water is tested-by measuring the urinary output after ingestion of large volumes of water.**

Interpretations:

***Normal*:>80% of water voided in 4 hrs.**
: sp. gr. of at least one of the 4 specimens –1.003 or less

Impaired:
<80% of water excreted.
:sp. gr. Doesn't fall to 1.003, remains fixed at 1.010

Micropuncture Techniques

- **Tiny micropipette is inserted into a nephron segment or adjacent blood vessel.**

- ***Examples:***
- ***Aspiration* of fluid from accessible nephron & composition analysed.**
- **Micropipette sized *pressure Tranducers.***
- **Micropipette sized *glass electrodes.***
- **Microperfusion- *stopped flow microperfusion.***
- ***Microcatheterisation*- from the calyceal area into the papillary collec. duct**

QUANTITATIVE TESTS OF RENAL FUNCTION

Commonly used IMAGING TECHNIQUES include:

- ***Plain X-ray***
- ***Cystoscopy***
- ***Excretion urography***
- ***Ultrasonography***
- ***Computed tomography (CT)***
- ***Magnetic resonance imaging (MRI)***
- ***Antegrade pyelography***
- ***Retrograde pyelography***
- ***Micturating cystourethrography (MCU)***
- ***Aortography or renal arteriography***
- ***Renal scintigraphy – dynamic and static***
- ***Transcutaneous renal biopsy***

EXCRETION UROGRAPHY (IVP)

- **Give iodine-containing contrast medium intravenously & serial x-ray films are taken.**

- **Medium excreted by glomeruli and makes kidneys appear opaque (nephrogram).**

- **Can indicate growths,hydronephrosis, cong.anomalies.**
- **Small size may indicate chronic disease of kidney tissue or vasculature.**

- **Good for tracking obstructions, but more accurate techniques available.**


Thank you