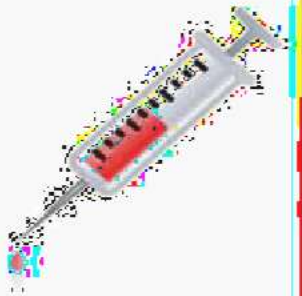
RENAL FUNCTION TESTS

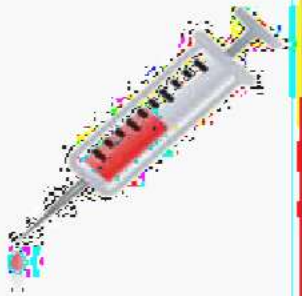


Why test renal function?

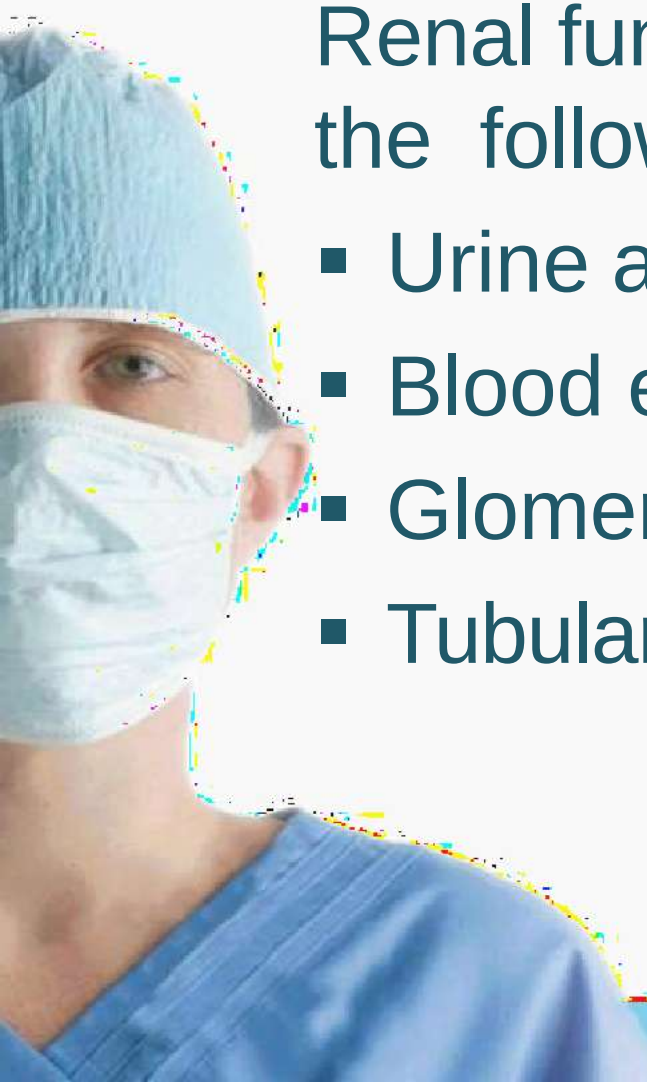
- To asses the functional capacity of kidney
- Early detection of possible renal impairment.
- Severity and progression of the impairment.
- Monitor response to treatment
- Monitor the safe and effective use of drugs which are excreted in the urine

When should we assess renal function?

- Older age
- Family history of Chronic Kidney disease (CKD)
- Decreased renal mass
- Low birth weight
- Diabetes Mellitus (DM)
- Hypertension (HTN)
- Autoimmune disease
- Systemic infections
- Urinary tract infections (UTI)
- Nephrolithiasis
- Obstruction to the lower urinary tract
- Drug toxicity

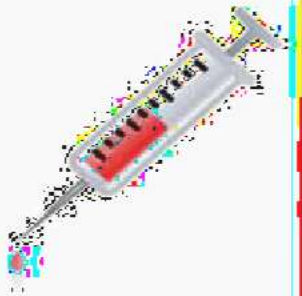


What to examine???



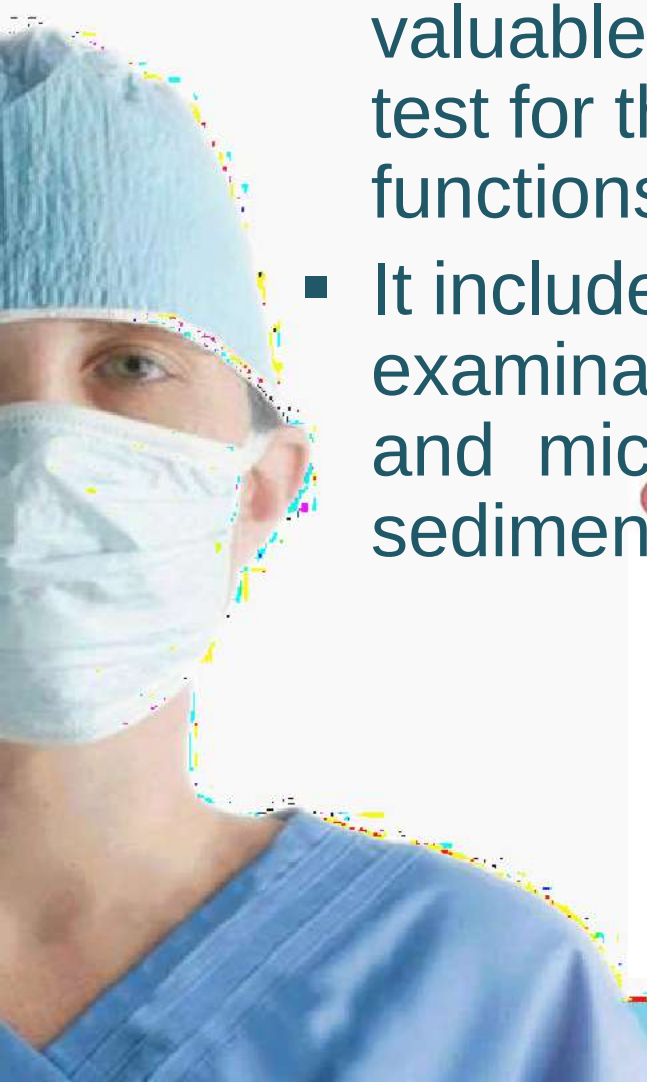
Renal function tests are divided into the following:

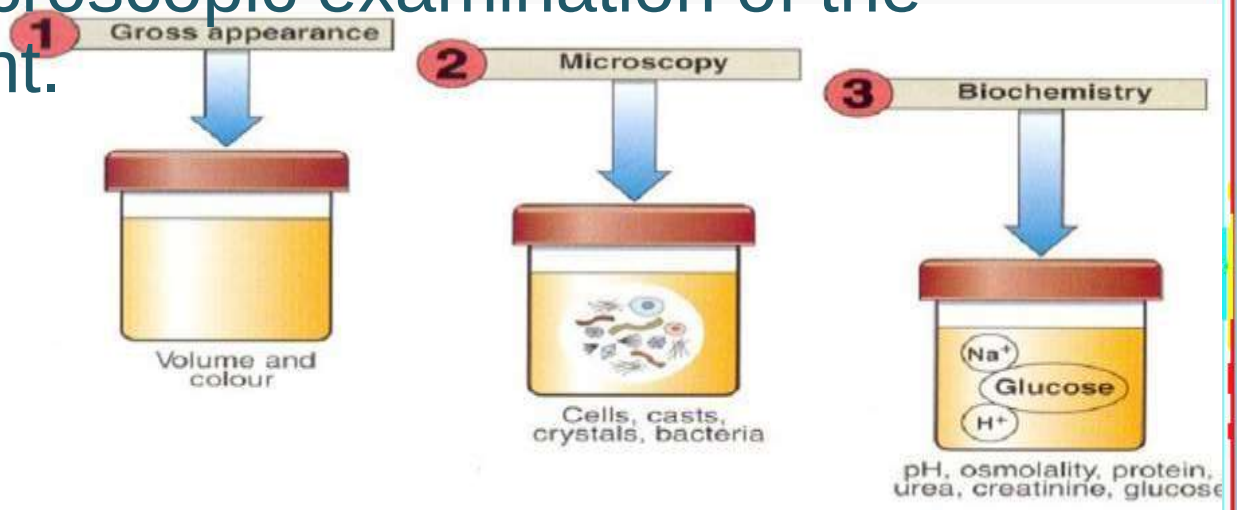
- Urine analysis
- Blood examination
- Glomerular Function Test
- Tubular Function Test



Urine Analysis

- Urine examination is an extremely valuable and most easily performed test for the evaluation of renal functions.
- It includes physical or macroscopic examination, chemical examination and microscopic examination of the sediment.



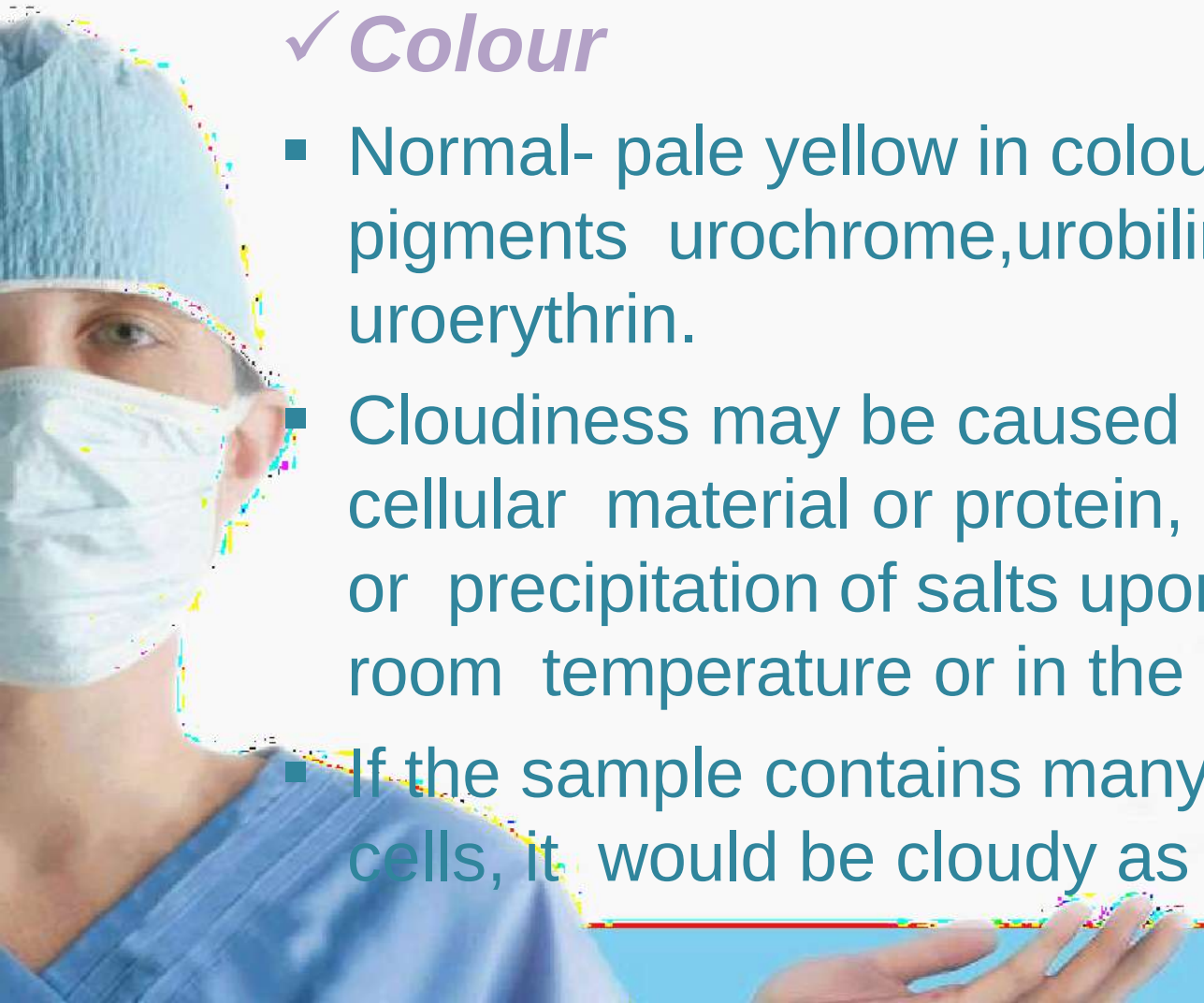


Urine analysis continued.....

Macroscopic examination

✓*Colour*

- Normal- pale yellow in colour due to pigments urochrome,urobilin and uroerythrin.
- Cloudiness may be caused by excessive cellular material or protein, crystallization or precipitation of salts upon standing at room temperature or in the refrigerator.
- If the sample contains many red blood cells, it would be cloudy as well as red.

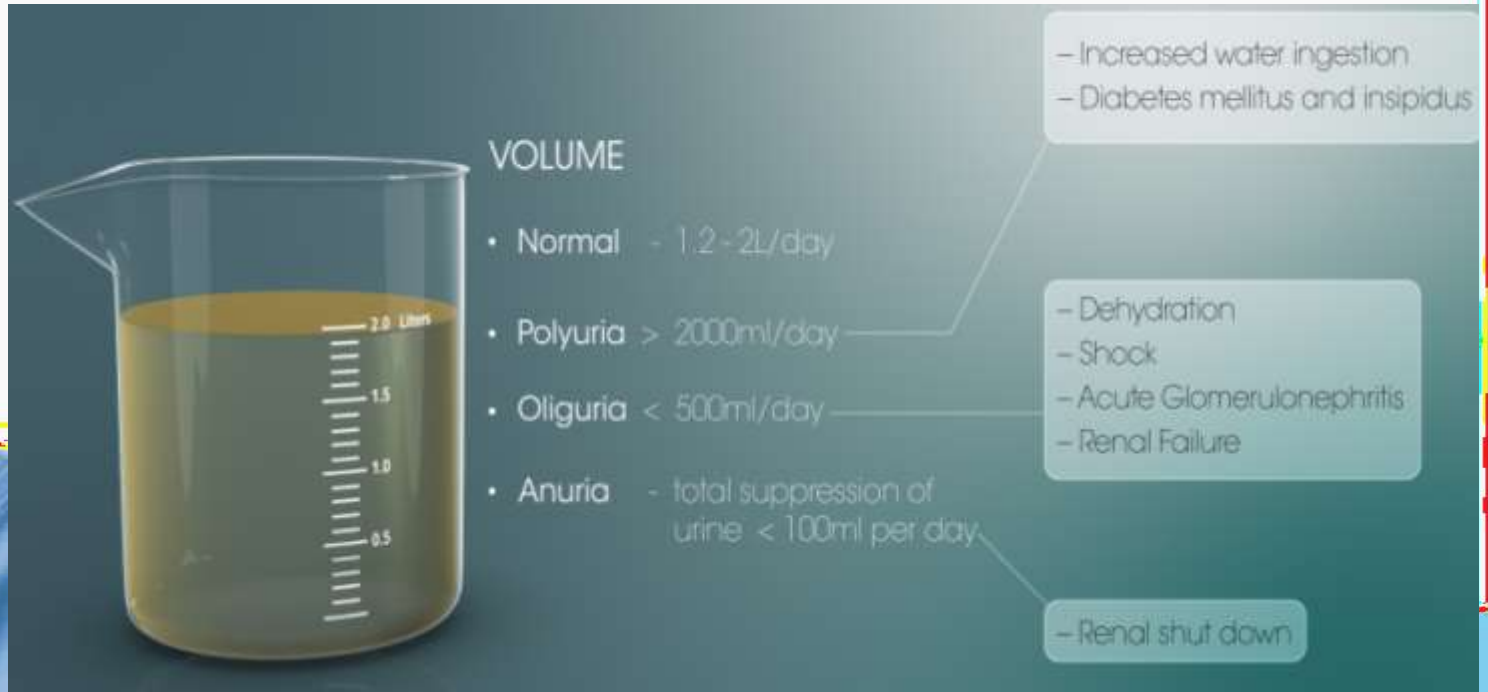


Blue Green	Pink-Orange- Red	Red-brown-black
Methylene Blue	Haemoglobin	Haemoglobin
Pseudomonas	Myoglobin	Myoglobin
Riboflavin	Phenolpthalein	Red blood cells
	Porphyrins	Homogentisic Acid
	Rifampicin	L -DOPA
		Melanin
		Methyldopa

- Colour of urine depending upon it's constituents.

✓ *Volume*

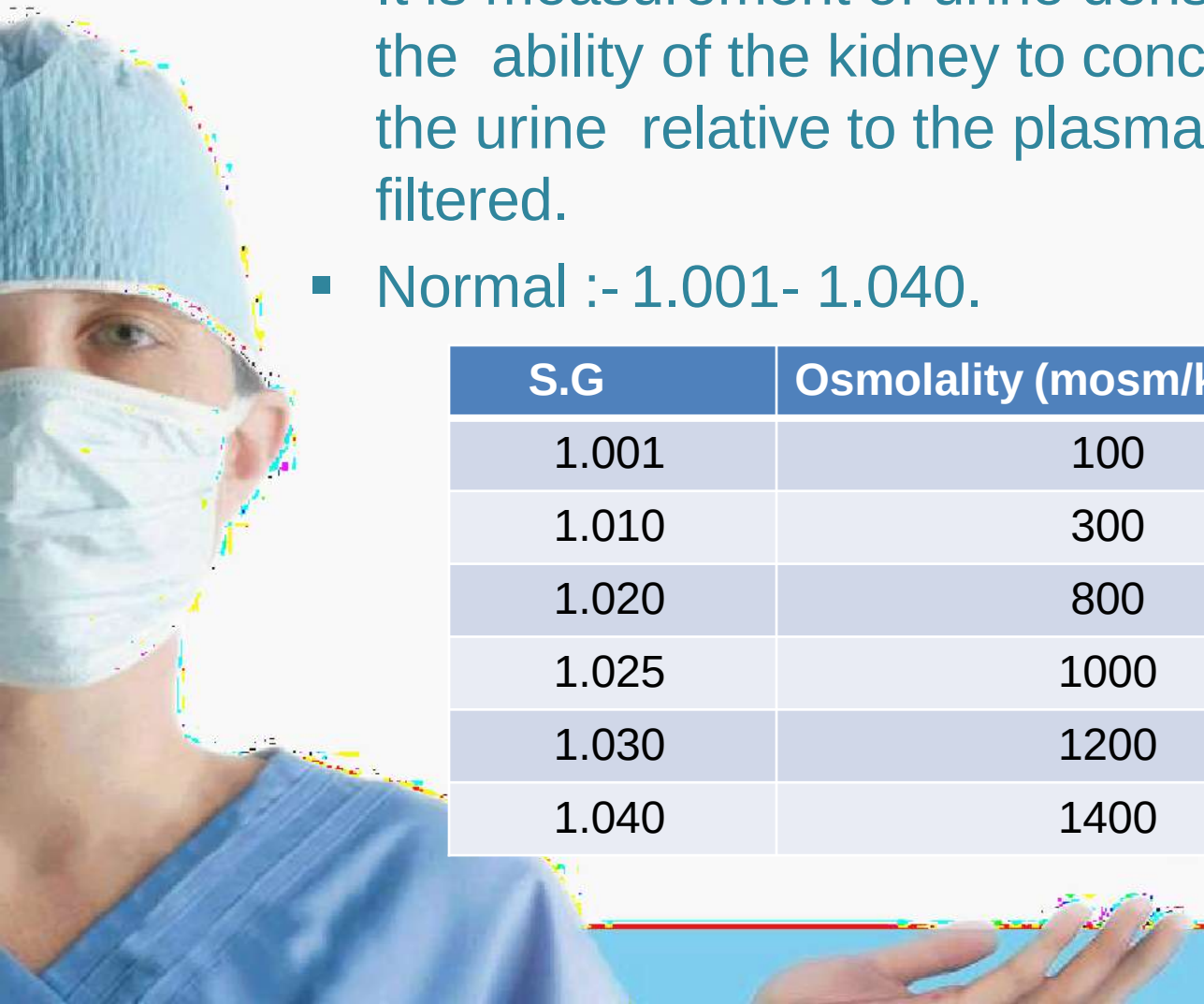
- Normal- 1-2.5 L/day
- Oliguria- Urine Output < 400ml/day Seen in
  - Acute glomerulonephritis
  - Renal Failure
- Polyuria- Urine Output > 2.5 L/day Seen in
  - Increased water ingestion
  - Diabetes mellitus and insipidus.
- Anuria- Urine output < 100ml/day Seen in renal shut down

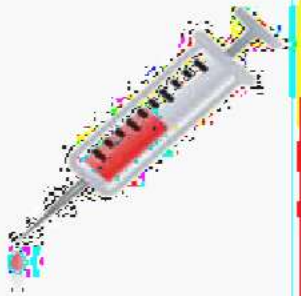


✓ *Specific Gravity*

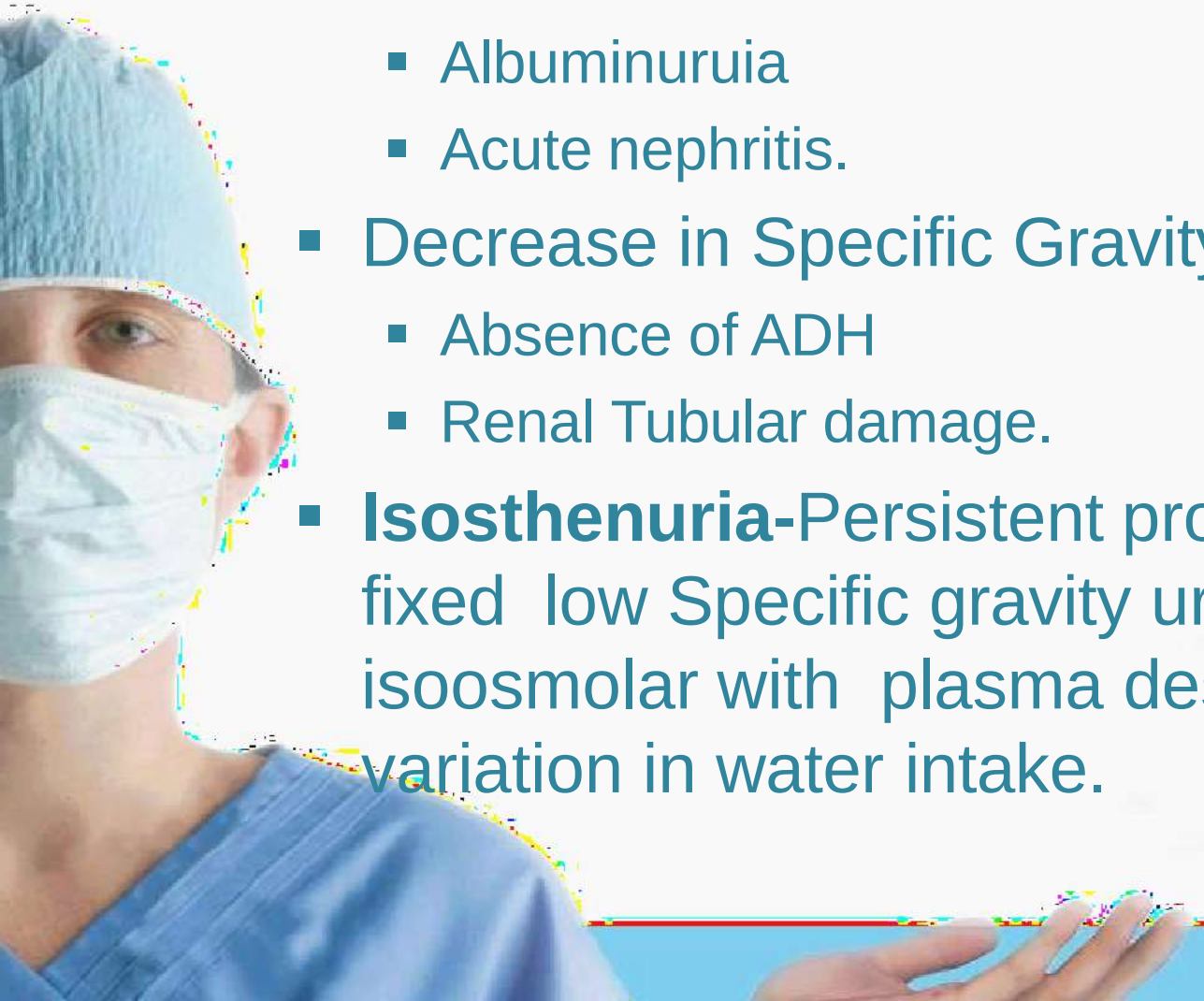
- Measured by urinometer or refractometer.
- It is measurement of urine density which reflects the ability of the kidney to concentrate or dilute the urine relative to the plasma from which it is filtered.
- Normal :- 1.001- 1.040.

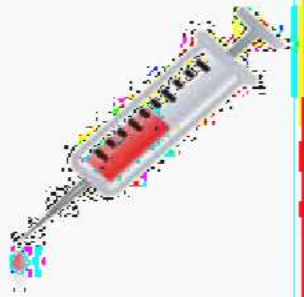
S.G	Osmolality (mosm/kg)
1.001	100
1.010	300
1.020	800
1.025	1000
1.030	1200
1.040	1400





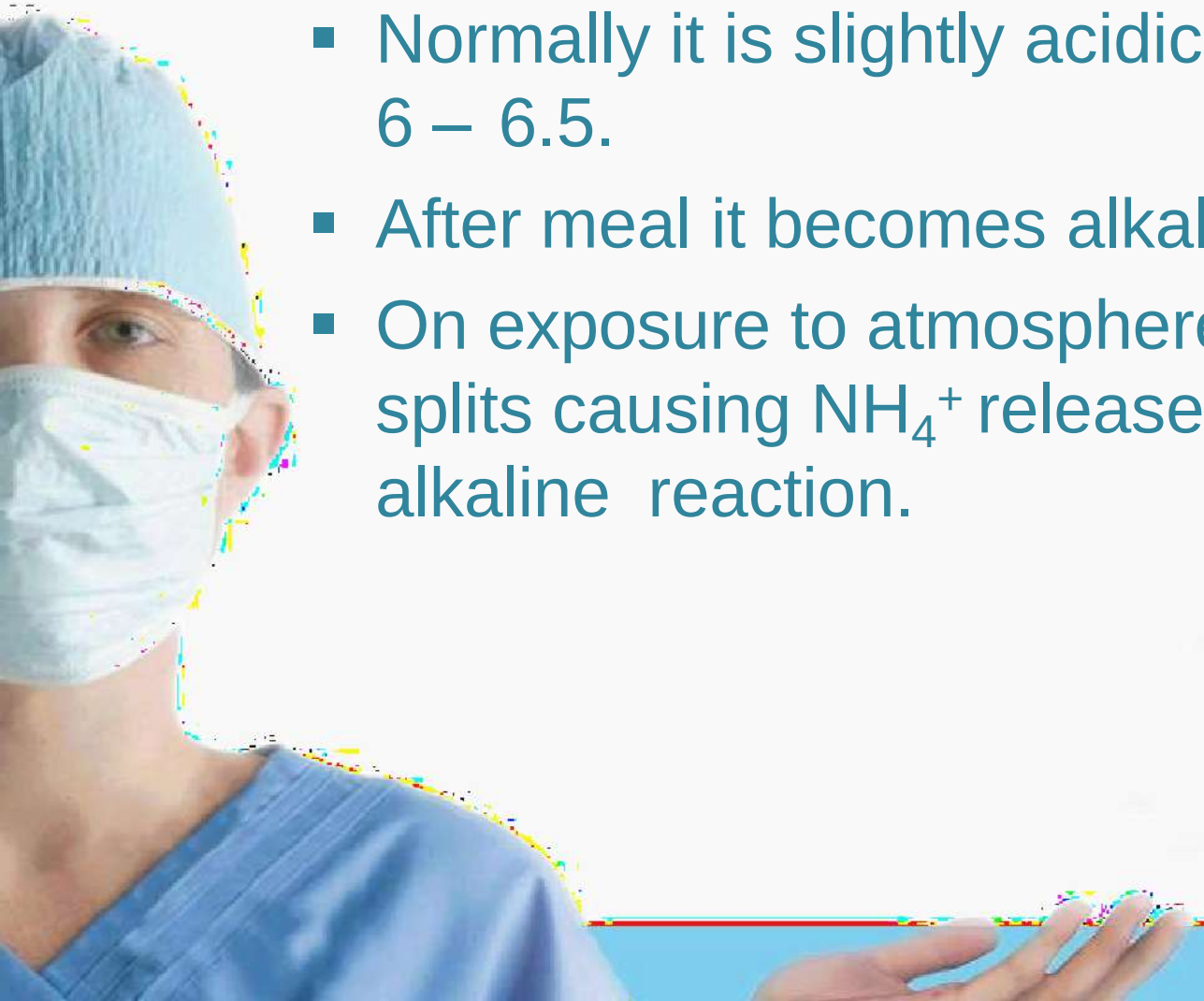
- Increase in Specific Gravity seen in
  - Low water intake
  - Diabetes mellitus
  - Albuminuruia
  - Acute nephritis.
- Decrease in Specific Gravity is seen in
  - Absence of ADH
  - Renal Tubular damage.
- **Isosthenuria-**Persistent production of fixed low Specific gravity urine isoosmolar with plasma despite variation in water intake.

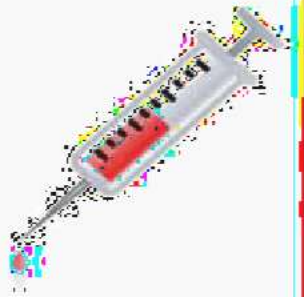




✓ *pH*

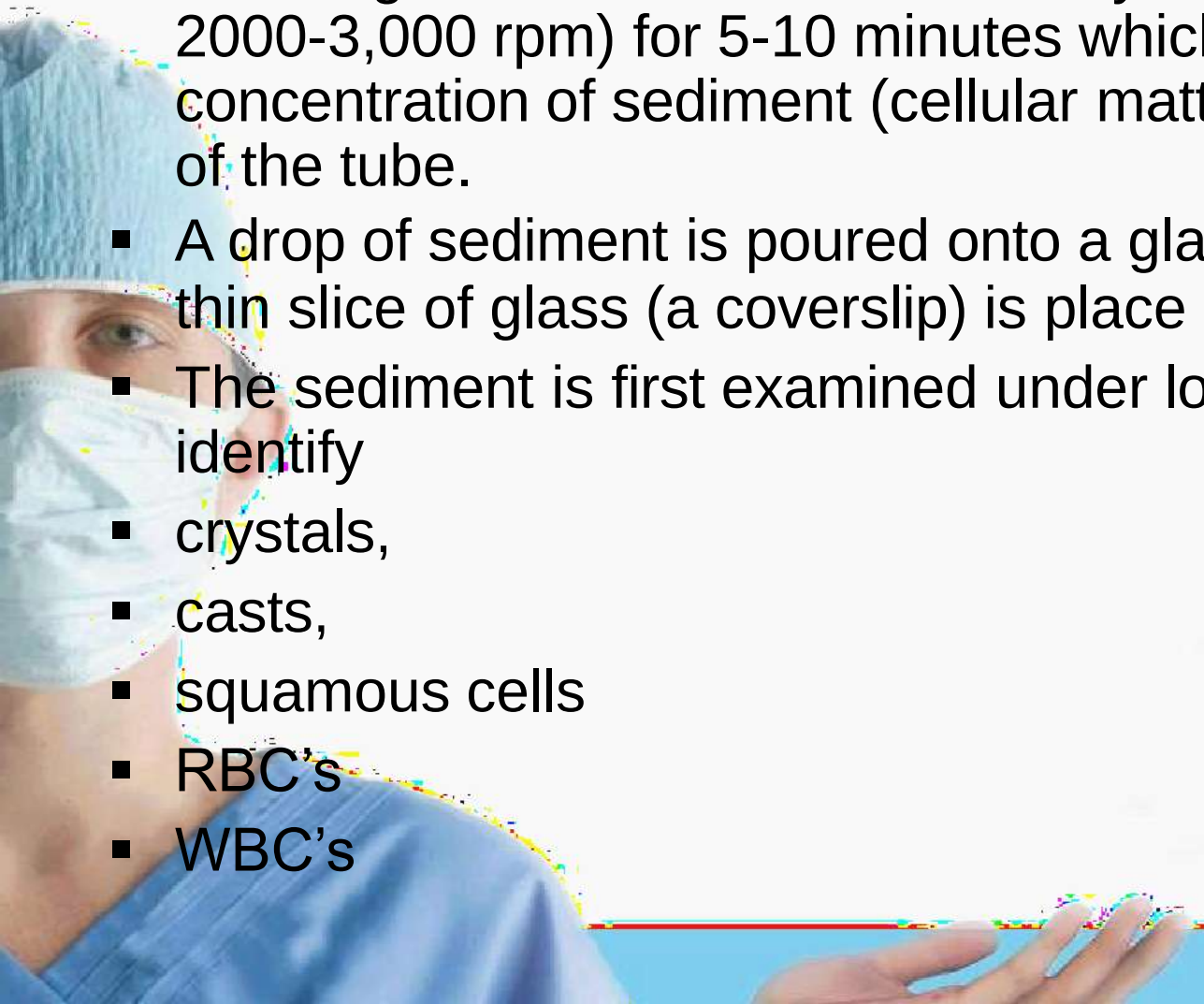
- Urine pH ranges from 4.5 to 8
- Normally it is slightly acidic lying between 6 – 6.5.
- After meal it becomes alkaline.
- On exposure to atmosphere,urea in urine splits causing NH_4^+ release resulting in alkaline reaction.

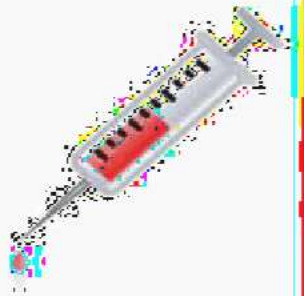


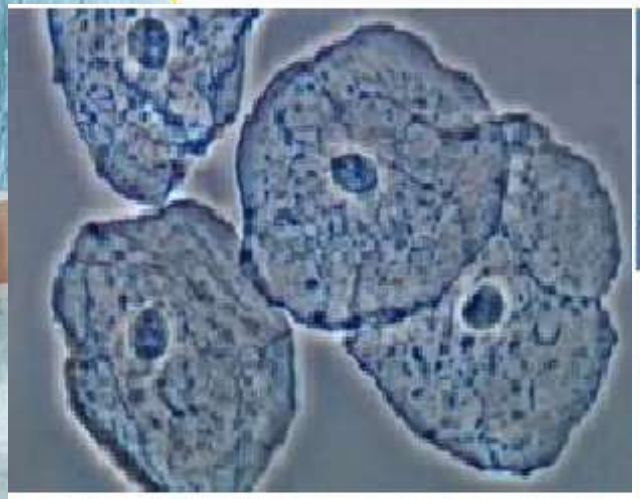


Microscopic examination

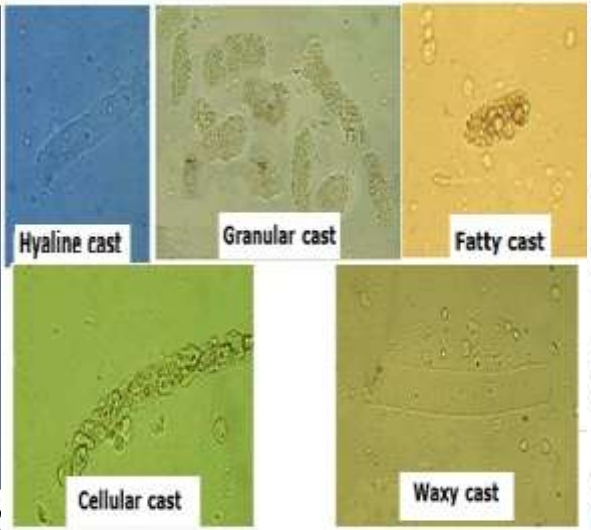
- A sample of well-mixed urine (usually 10-15 ml) is centrifuged in a test tube at relatively low speed (about 2000-3,000 rpm) for 5-10 minutes which produces a concentration of sediment (cellular matter) at the bottom of the tube.
- A drop of sediment is poured onto a glass slide and a thin slice of glass (a coverslip) is place over it.
- The sediment is first examined under low power to identify
- crystals,
- casts,
- squamous cells
- RBC's
- WBC's



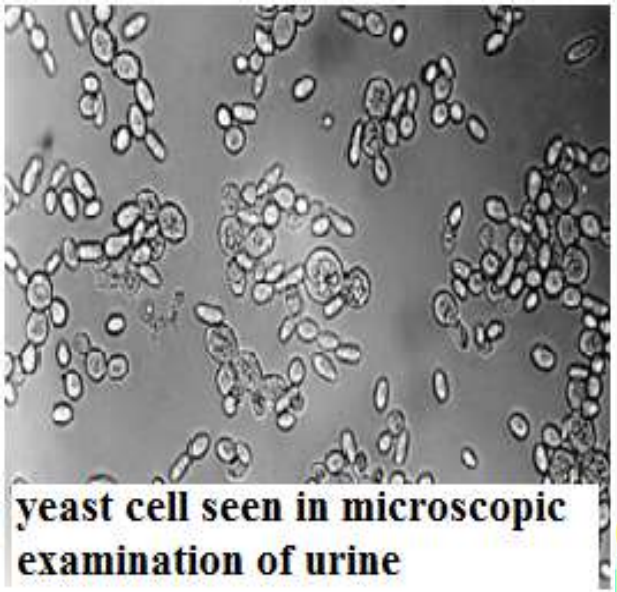




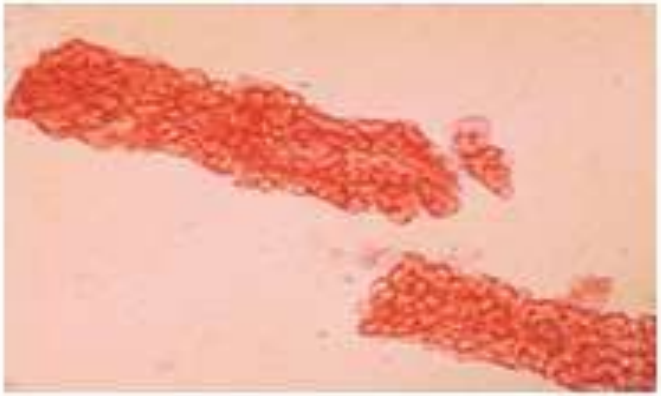
Epithelial Cells in microscopic examination of urine



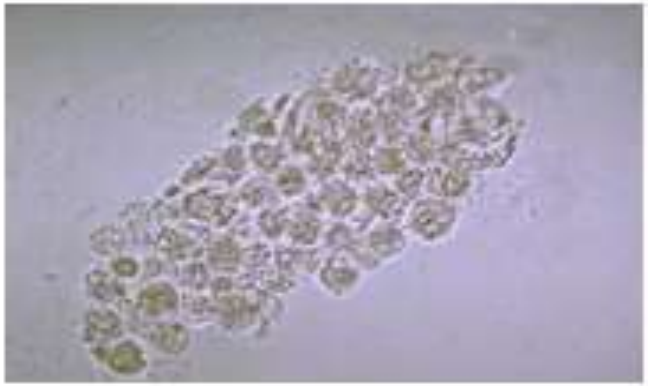
Cast seen in microscopical examination of urine



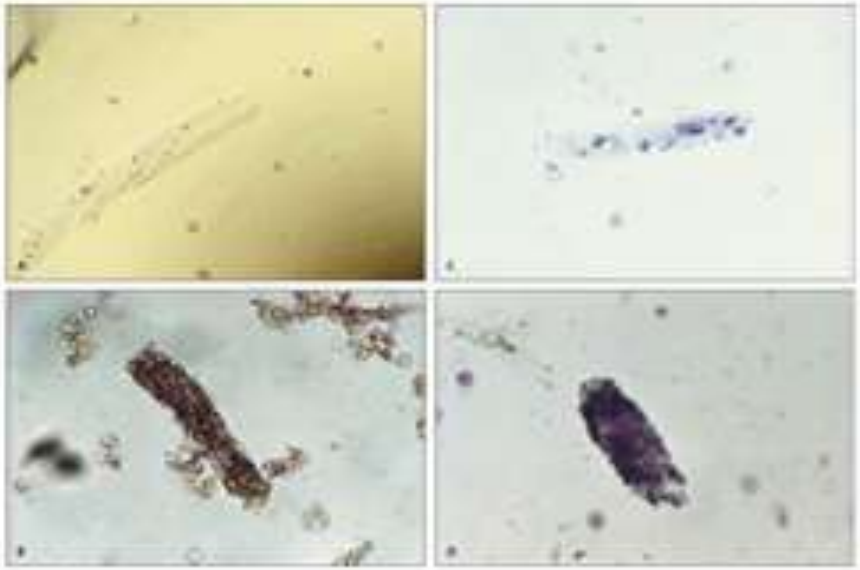
yeast cell seen in microscopic examination of urine



Red blood cell cast in urine



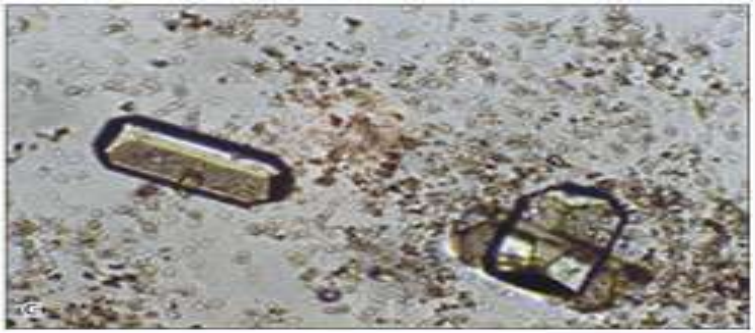
White blood cell cast in urine

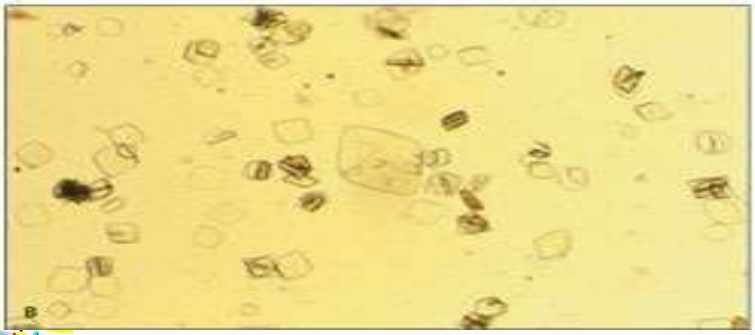


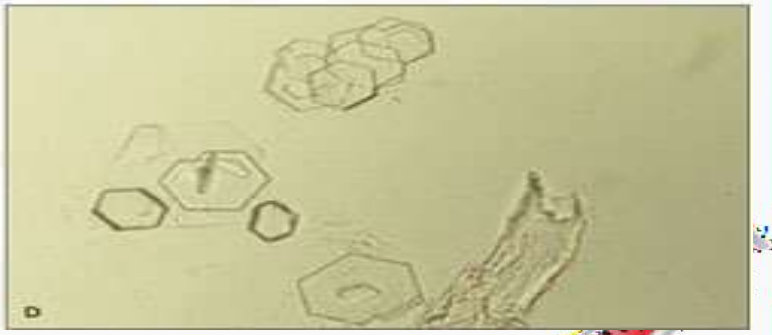
Urinary casts. (A) Hyaline cast (200 X); (B) erythrocyte cast (100 X); (C) leukocyte cast (100 X); (D) granular cast (100 X)

Crystals

- Tyrosine crystals with congenital tyrosinosis
- Leucine crystals in patients with severe liver disease or with maple syrup urine disease.







Urinary crystals. (A) Calcium oxalate crystals; (B) uric acid crystals (C) triple phosphate crystals with amorphous phosphates ; (D) cystine crystals.

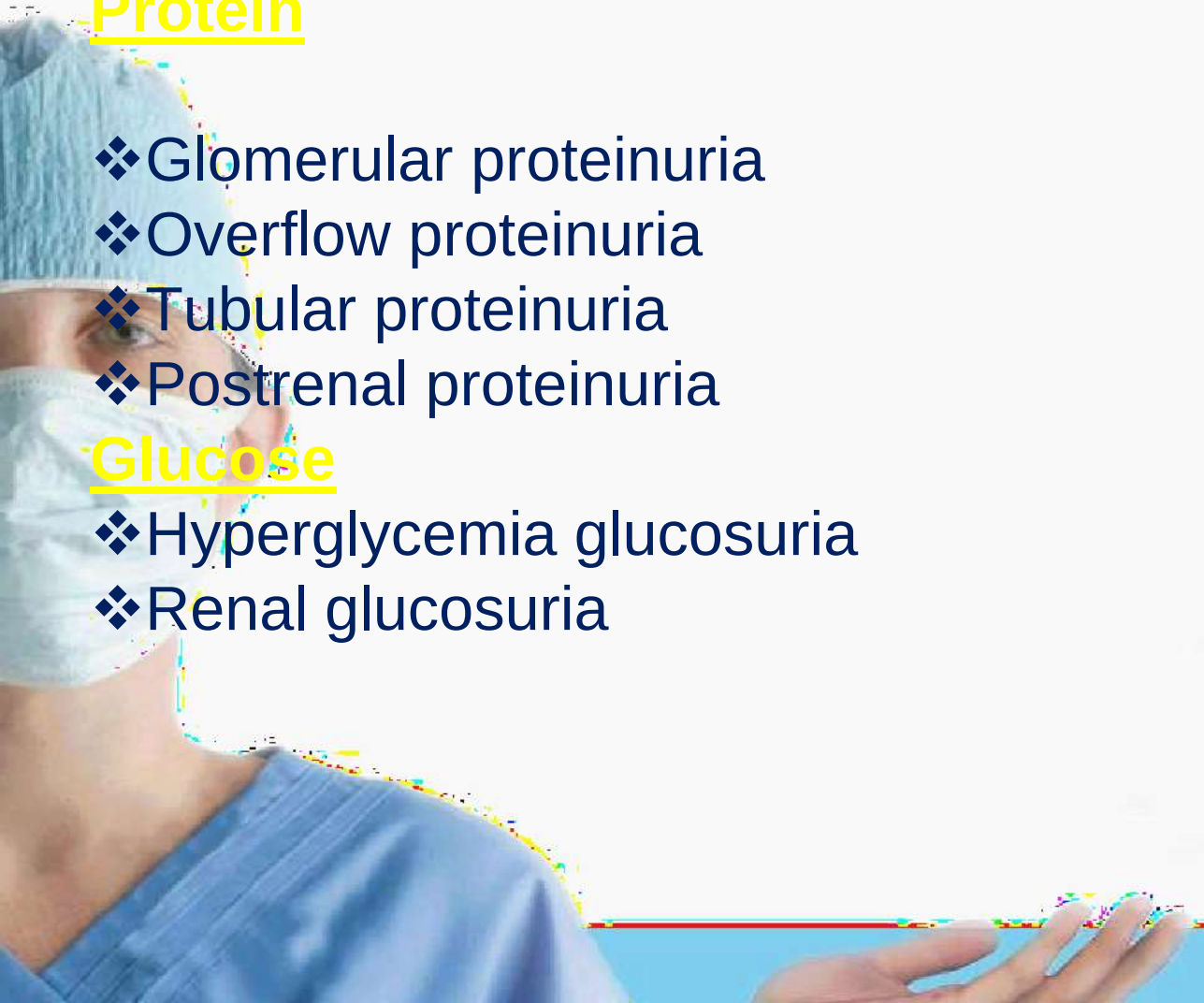
Clinical significance of abnomal constituents of urine

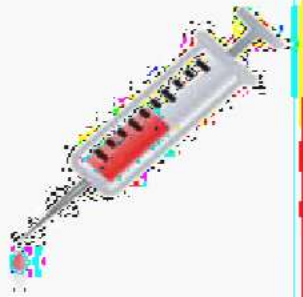
Protein

- Glomerular proteinuria
- Overflow proteinuria
- Tubular proteinuria
- Postrenal proteinuria

Glucose

- Hyperglycemia glucosuria
- Renal glucosuria





Ketone bodies

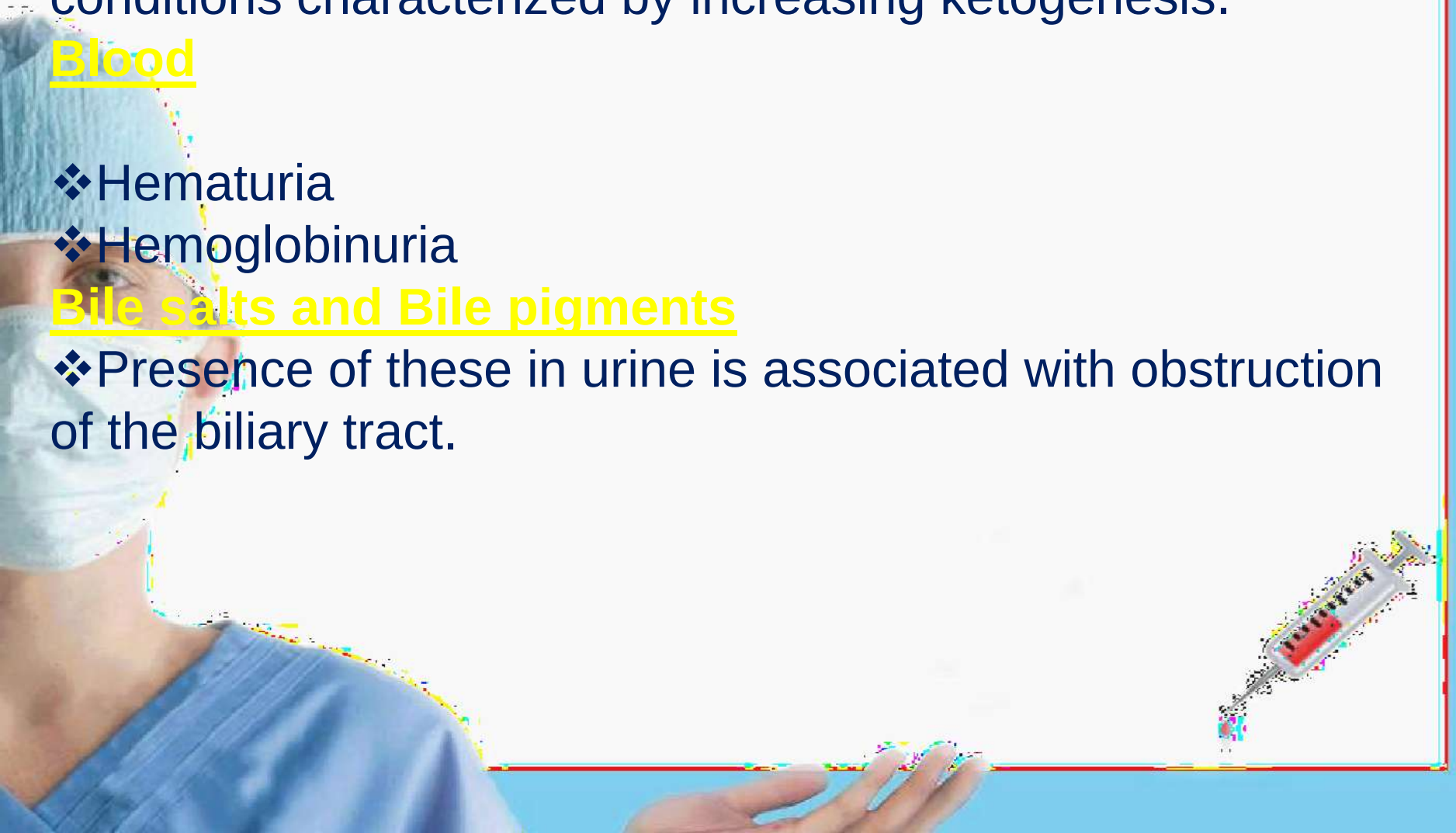
❖Detectable levels in urine (ketonuria) are seen in conditions characterized by increasing ketogenesis.

Blood

❖Hematuria
❖Hemoglobinuria

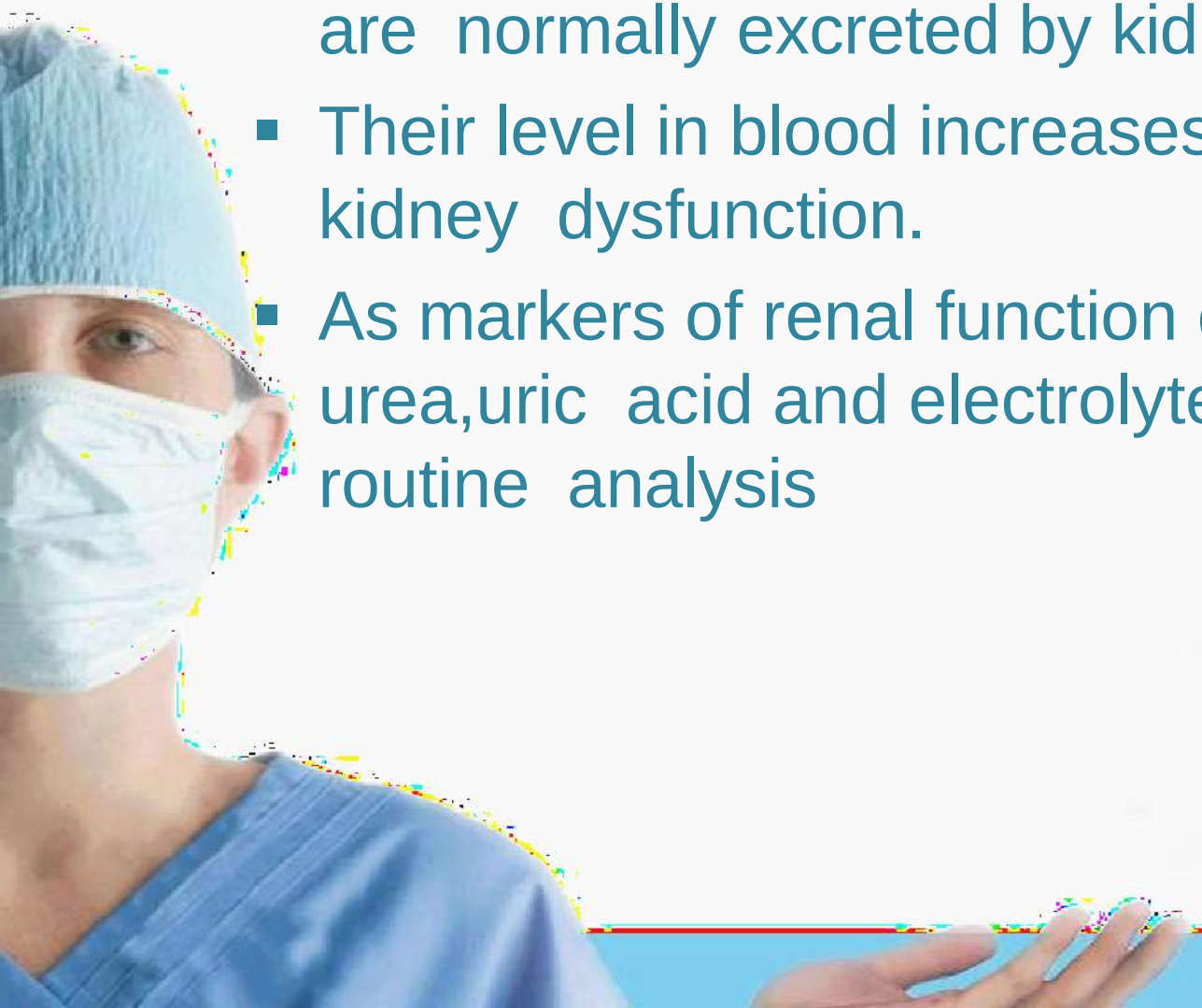
Bile salts and Bile pigments

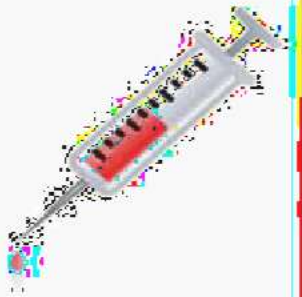
❖Presence of these in urine is associated with obstruction of the biliary tract.



Blood examination

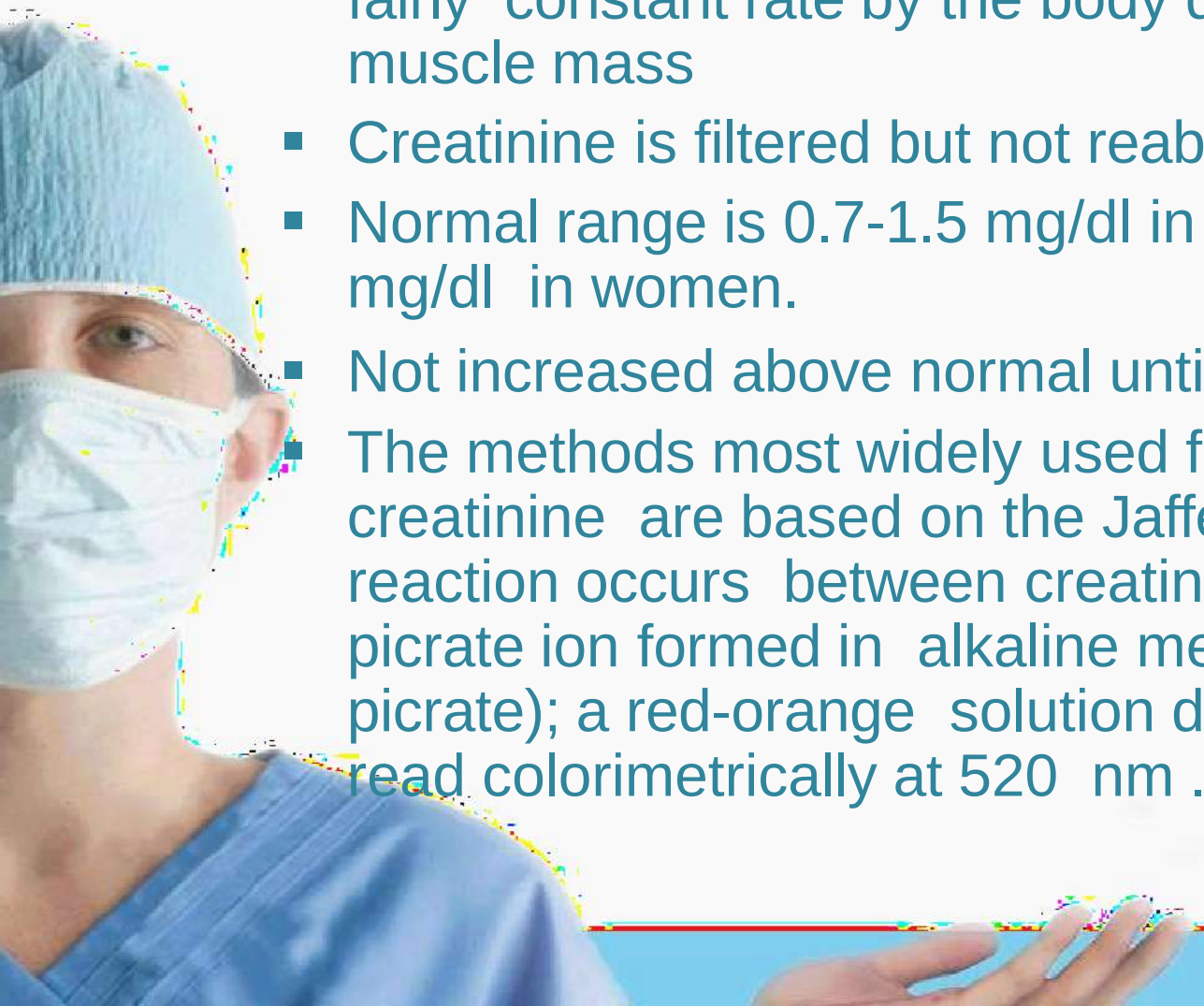
- Done to measure substance in blood that are normally excreted by kidney.
- Their level in blood increases in kidney dysfunction.
- As markers of renal function creatinine, urea,uric acid and electrolytes are done for routine analysis

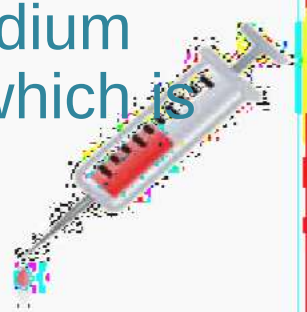




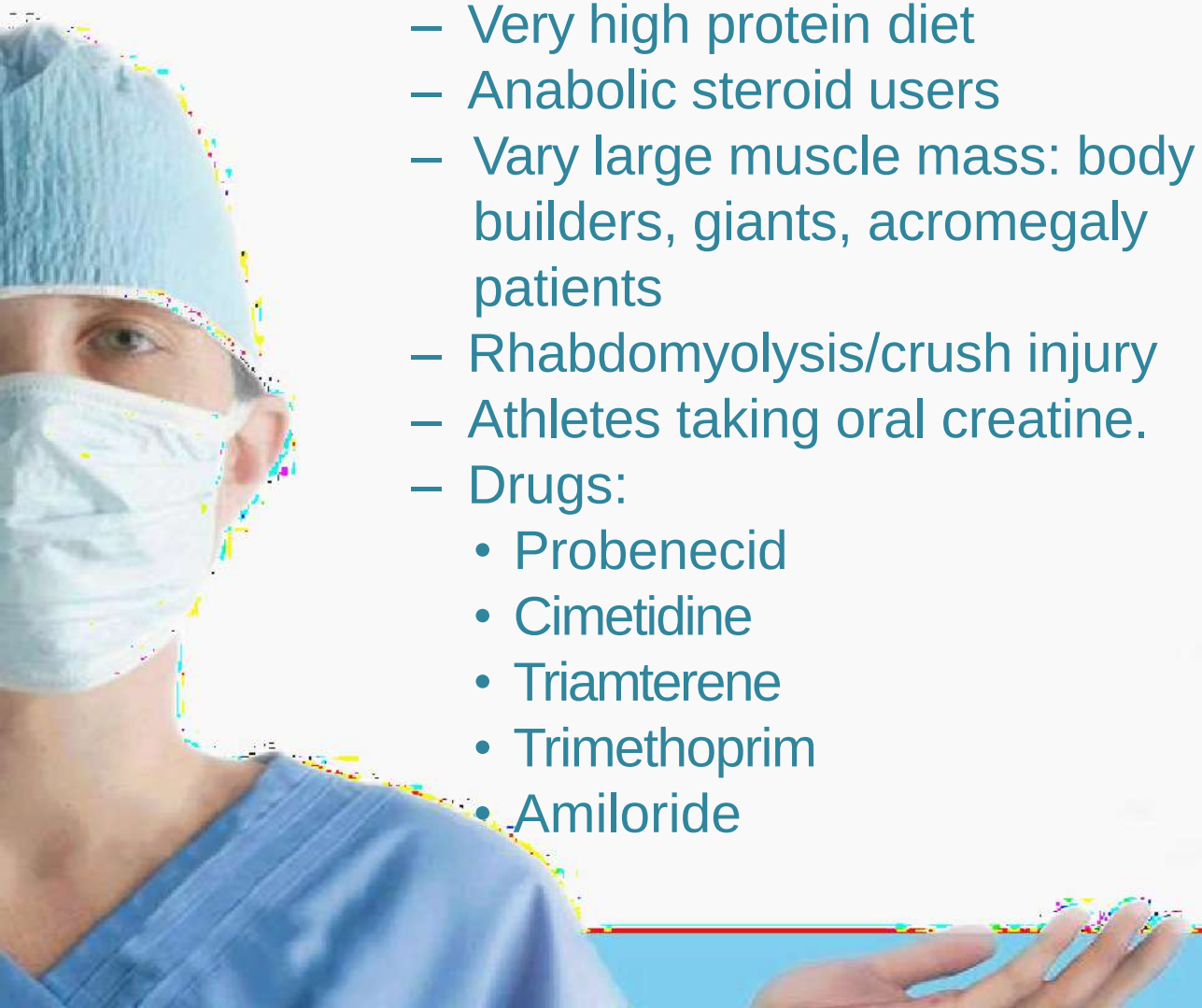
➢ *Serum creatinine*

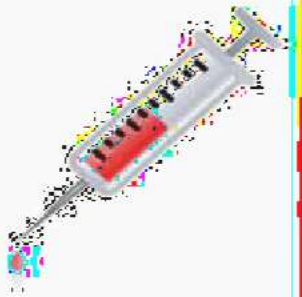
- Creatinine is a breakdown product of creatine phosphate in muscle, and is usually produced at a fairly constant rate by the body depending on muscle mass
- Creatinine is filtered but not reabsorbed in kidney.
- Normal range is 0.7-1.5 mg/dl in men and 0.6-1.4 mg/dl in women.
- Not increased above normal until GFR<50 ml/min .
- The methods most widely used for serum creatinine are based on the Jaffe reaction. This reaction occurs between creatinine and the picrate ion formed in alkaline medium (sodium picrate); a red-orange solution develops which is read colorimetrically at 520 nm .





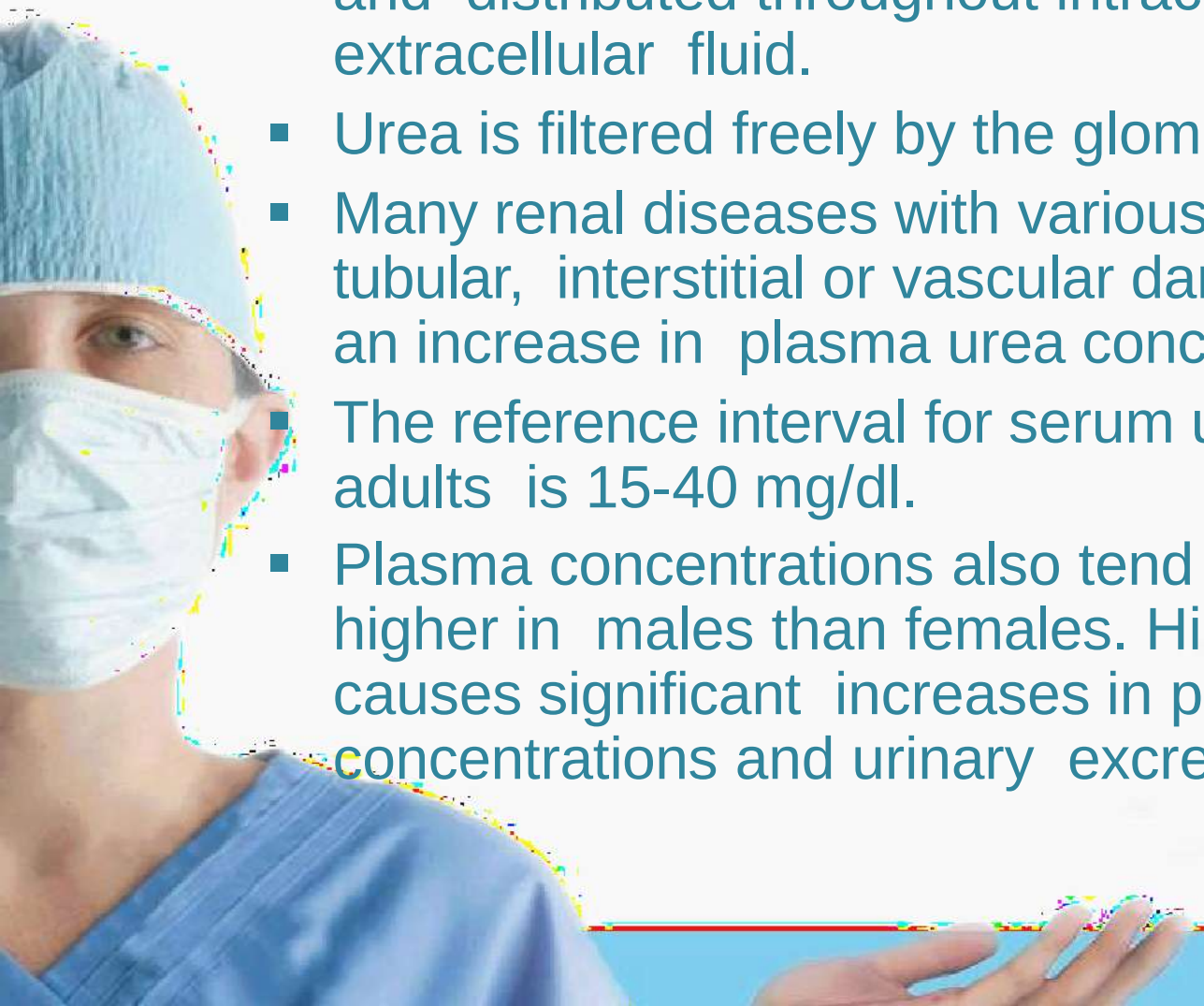
- Increased serum creatinine:
  - Impaired renal function
  - Very high protein diet
  - Anabolic steroid users
  - Vary large muscle mass: body builders, giants, acromegaly patients
  - Rhabdomyolysis/crush injury
  - Athletes taking oral creatine.
  - Drugs:
    - Probenecid
    - Cimetidine
    - Triamterene
    - Trimethoprim
    - Amiloride



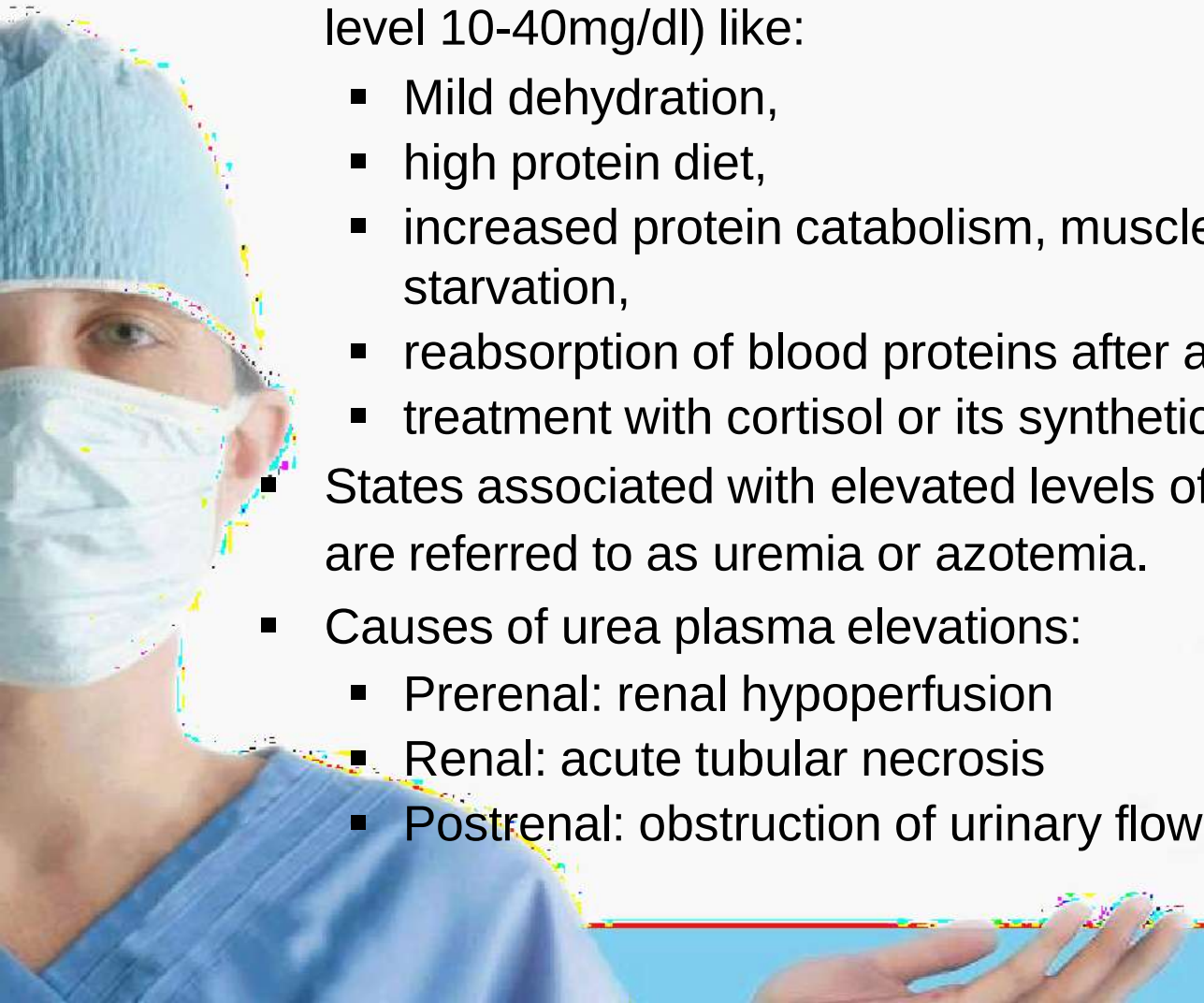


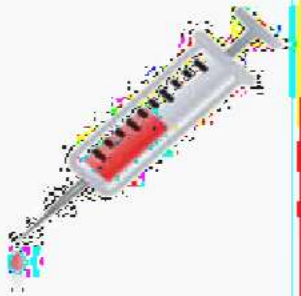
➢ *Blood urea*

- Urea is major nitrogenous end product of protein and amino acid catabolism, produced by liver and distributed throughout intracellular and extracellular fluid.
- Urea is filtered freely by the glomeruli .
- Many renal diseases with various glomerular, tubular, interstitial or vascular damage can cause an increase in plasma urea concentration.
- The reference interval for serum urea of healthy adults is 15-40 mg/dl.
- Plasma concentrations also tend to be slightly higher in males than females. High protein diet causes significant increases in plasma urea concentrations and urinary excretion.



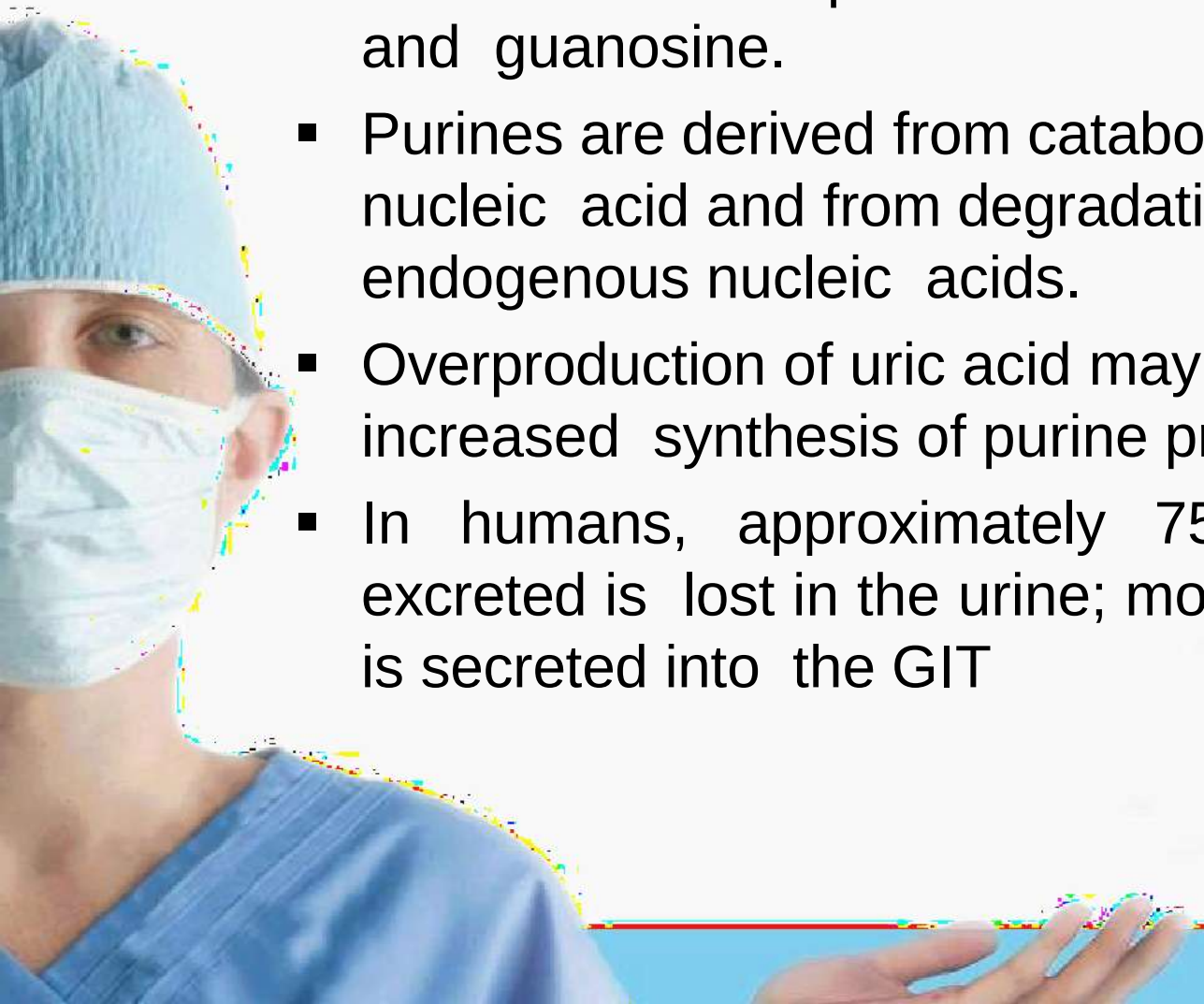
- Measurement of plasma creatinine provides a more accurate assessment than urea because there are many non renal factors that affect urea level.
- Nonrenal factors can affect the urea level (normal adults is level 10-40mg/dl) like:
  - Mild dehydration,
  - high protein diet,
  - increased protein catabolism, muscle wasting as in starvation,
  - reabsorption of blood proteins after a GIT haemorrhage,
  - treatment with cortisol or its synthetic analogous
- States associated with elevated levels of urea in blood are referred to as uremia or azotemia.
- Causes of urea plasma elevations:
  - Prerenal: renal hypoperfusion
  - Renal: acute tubular necrosis
  - Postrenal: obstruction of urinary flow

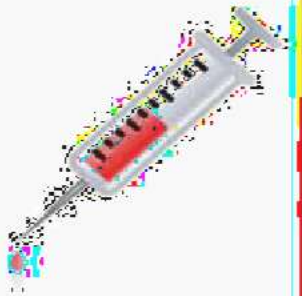




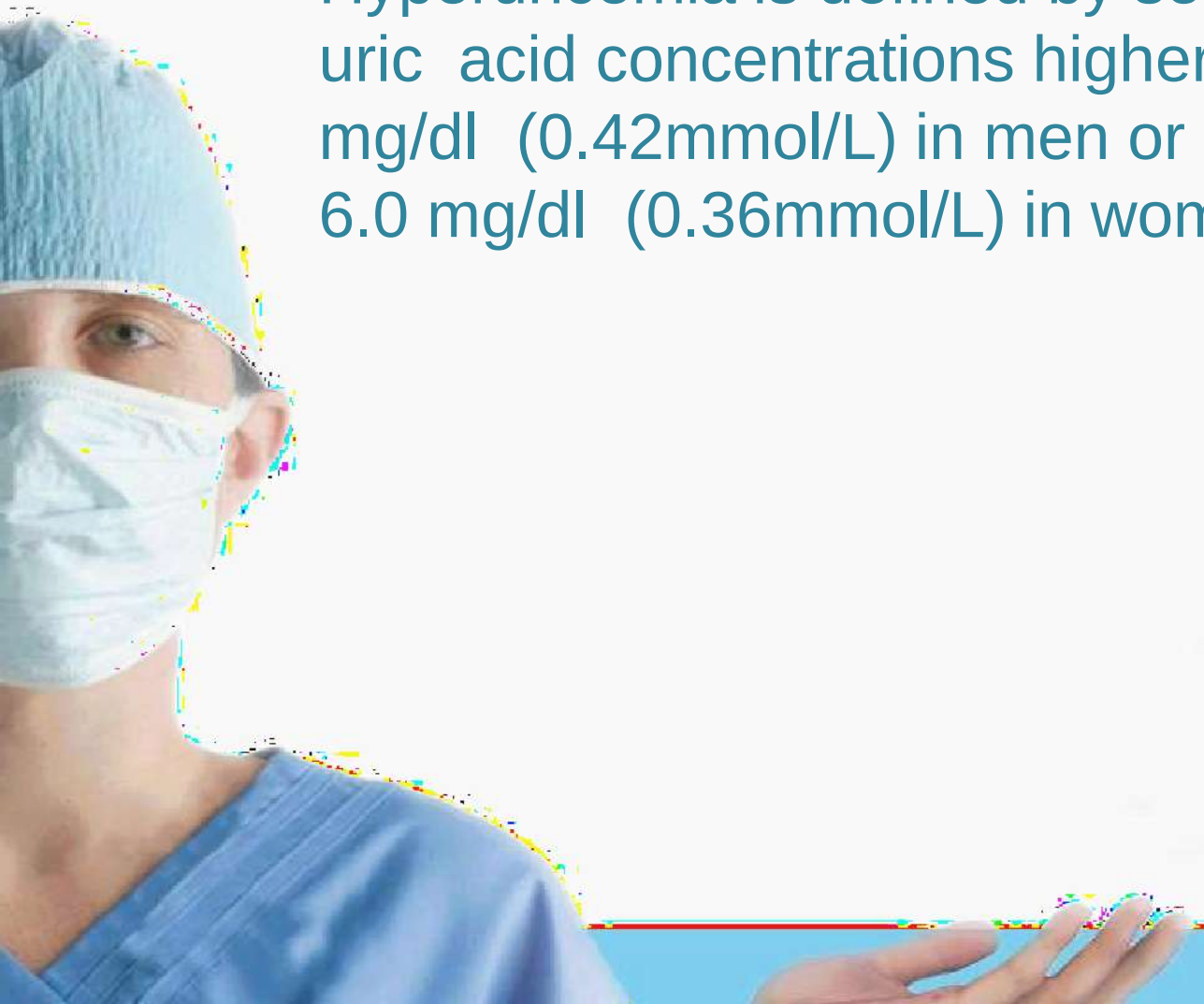
➢ *Serum Uric Acid*

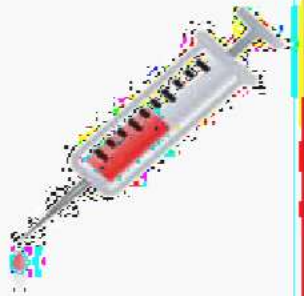
- In human, uric acid is the major product of the catabolism of the purine nucleosides, adenosine and guanosine.
- Purines are derived from catabolism of dietary nucleic acid and from degradation of endogenous nucleic acids.
- Overproduction of uric acid may result from increased synthesis of purine precursors.
- In humans, approximately 75% of uric acid excreted is lost in the urine; most of the reminder is secreted into the GIT





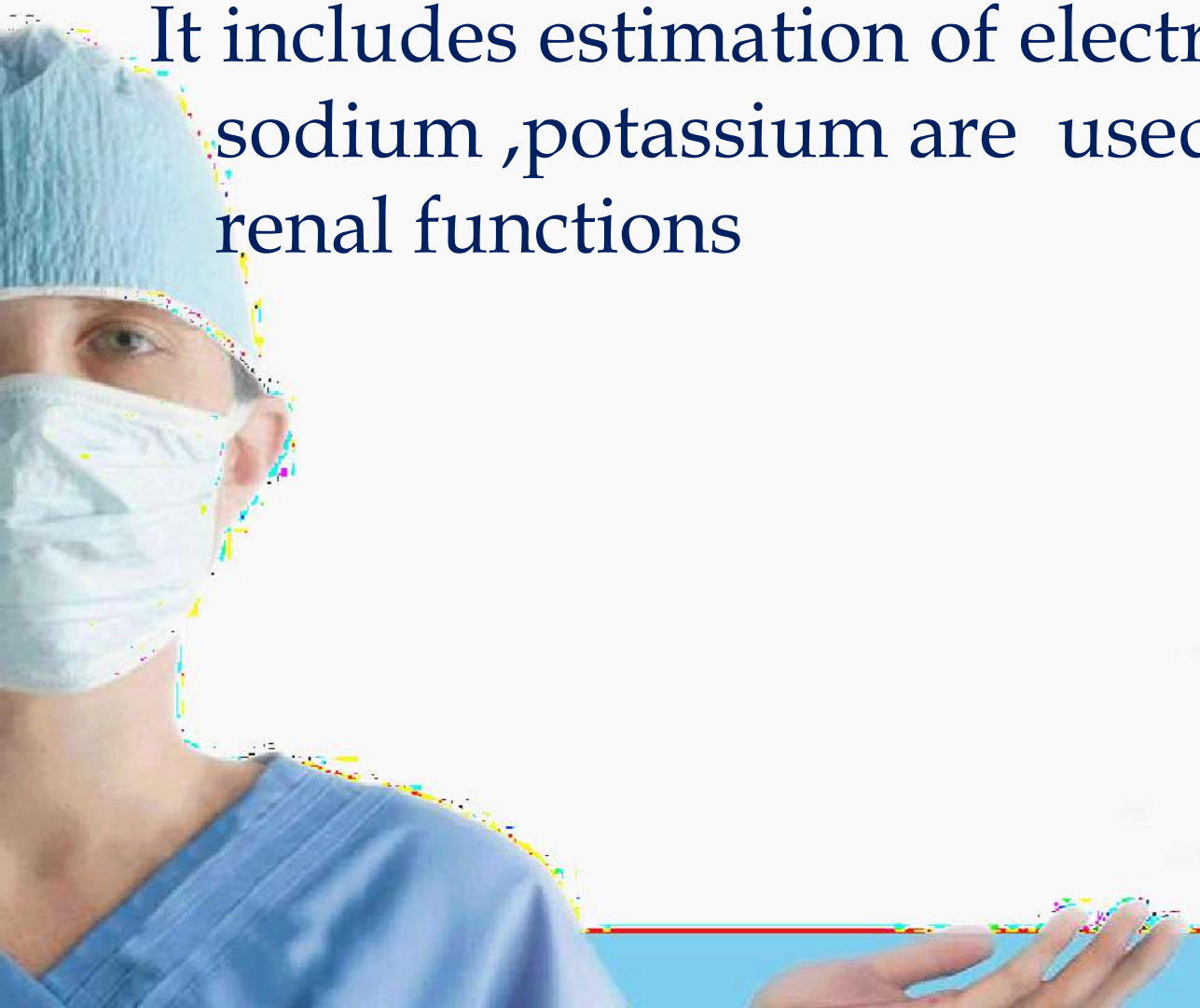
- Normal value of serum uric acid = 3.5-7.0 mg/dl.
- Hyperuricemia is defined by serum or plasma uric acid concentrations higher than 7.0 mg/dl (0.42mmol/L) in men or greater than 6.0 mg/dl (0.36mmol/L) in women

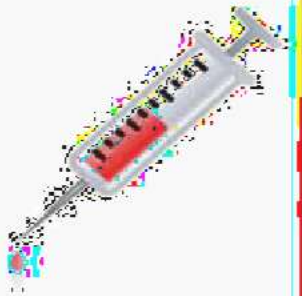




4.Analysis of blood/serum electrolytes

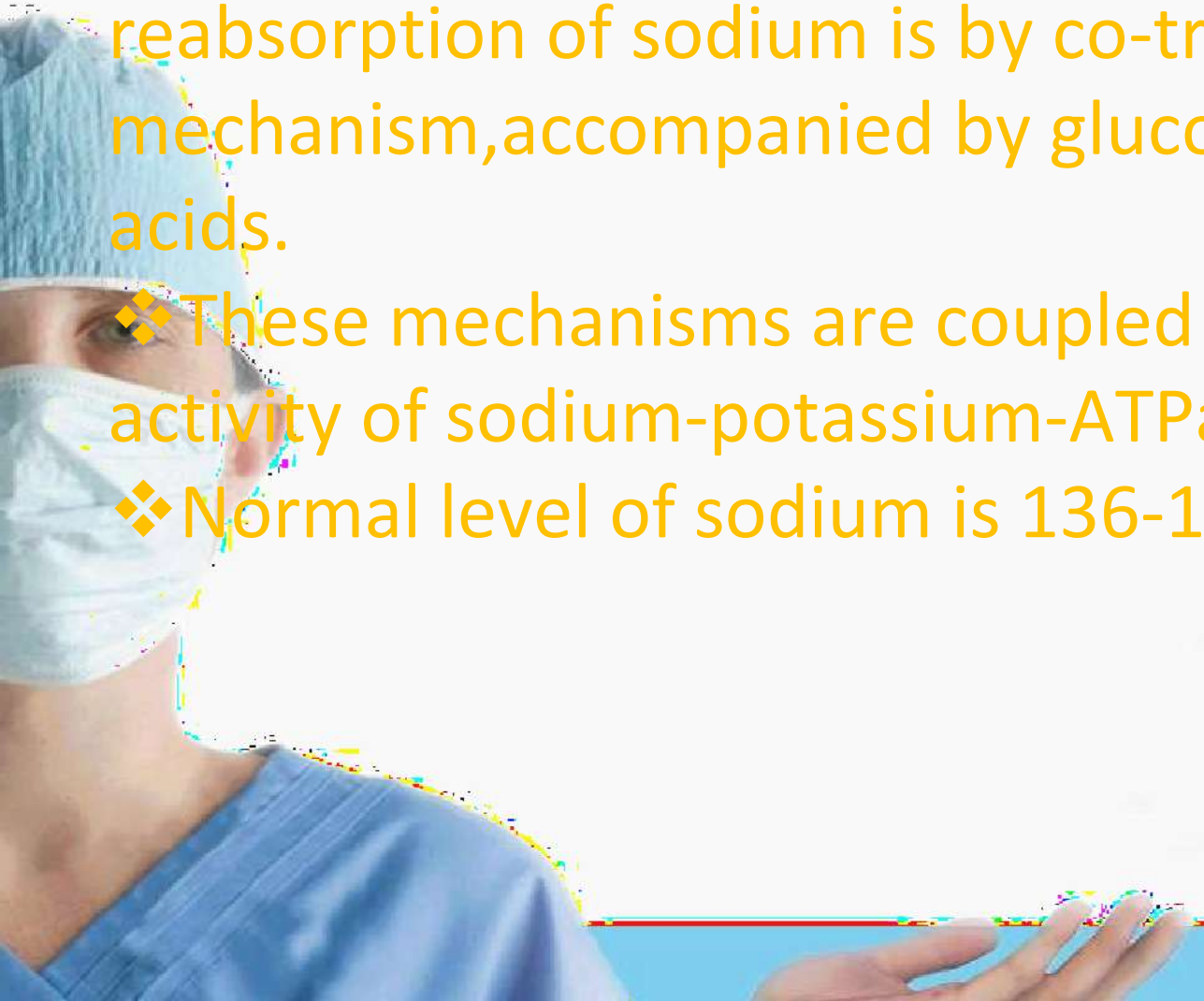
It includes estimation of electrolytes like sodium ,potassium are used to assess renal functions

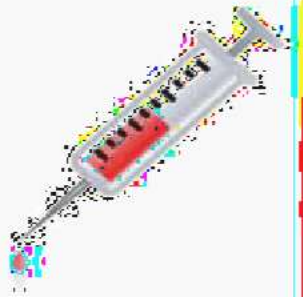




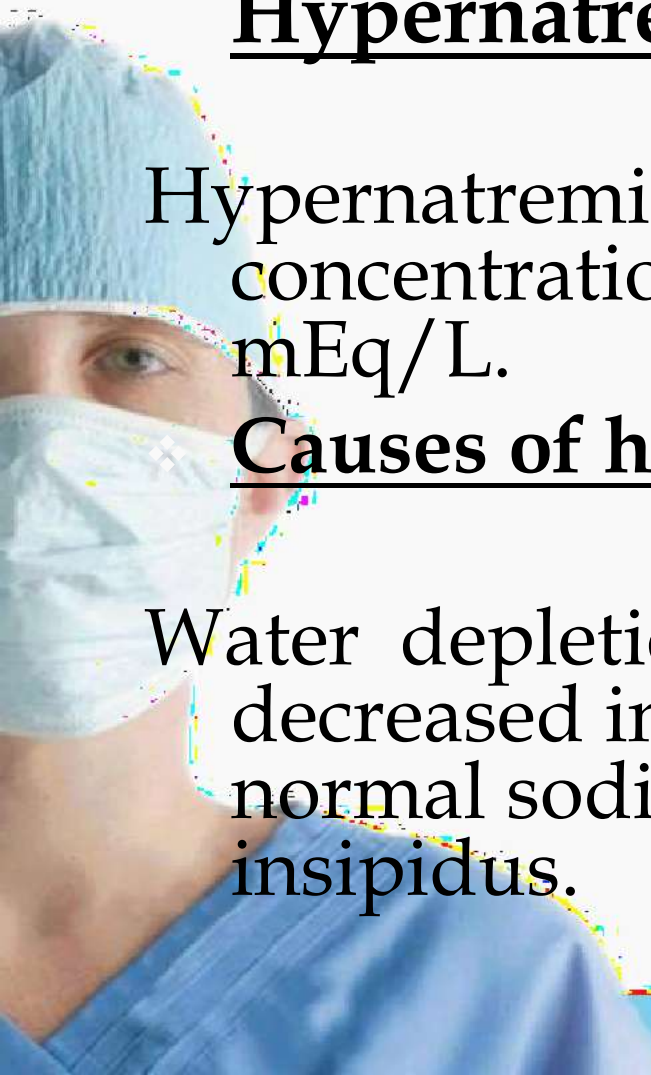
SODIUM-

- In Proximal convoluted tubules,the reabsorption of sodium is by co-transport mechanism,accompanied by glucose,amino acids.
- These mechanisms are coupled with the activity of sodium-potassium-ATPase.
- Normal level of sodium is 136-145mEq/L.





Clinical significance of sodium

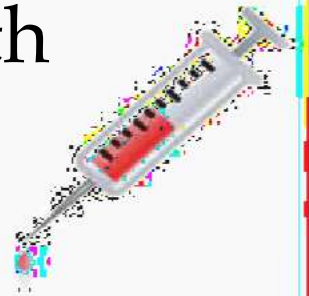


Hypernatremia

Hypernatremia is an increase in serum sodium concentration above normal range of 145 mEq/L.

Causes of hypernatremia

Water depletion – I t may arise from a decreased intake or excessive loss with normal sodium content, eg- diabetes insipidus.



Hyponatremia

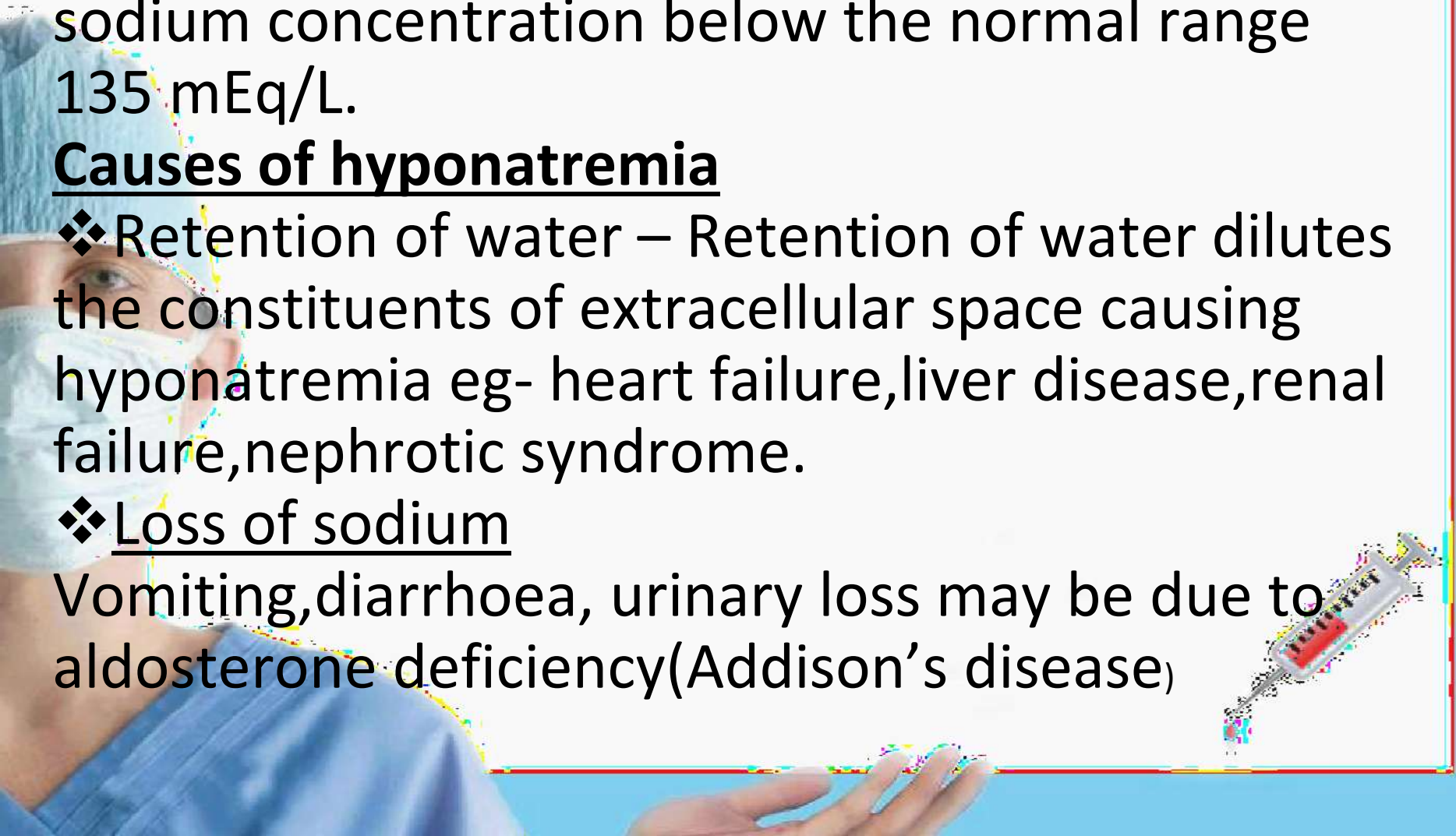
❖Hyponatremia is a significant fall in serum sodium concentration below the normal range 135 mEq/L.

Causes of hyponatremia

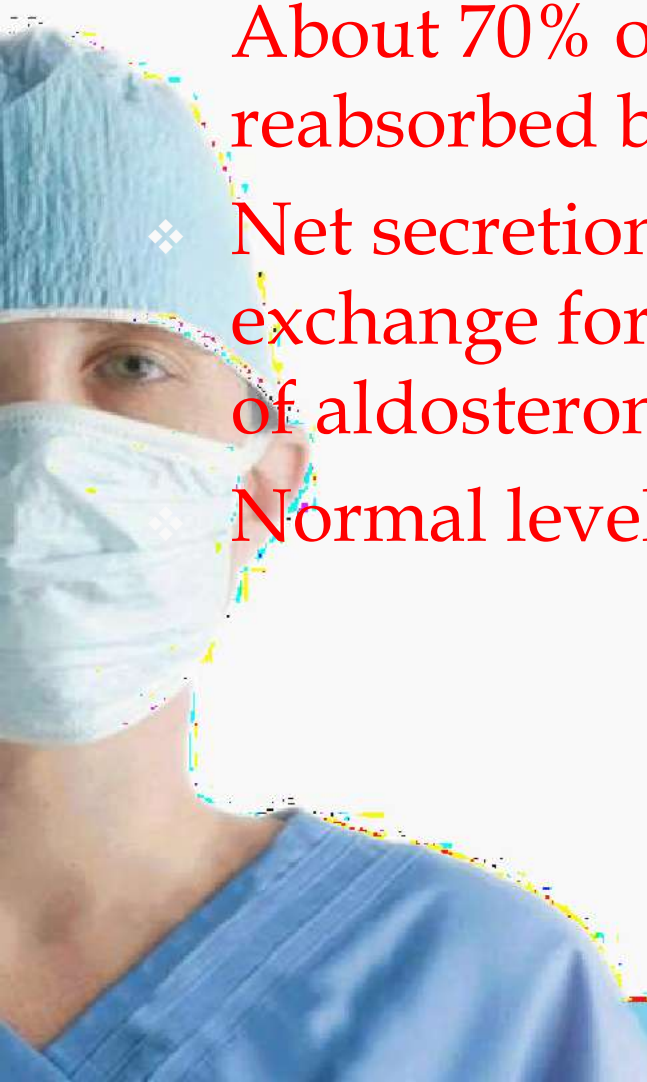
❖Retention of water – Retention of water dilutes the constituents of extracellular space causing hyponatremia eg- heart failure,liver disease,renal failure,nephrotic syndrome.

❖Loss of sodium

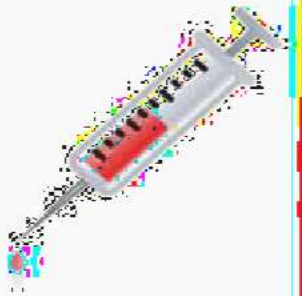
Vomiting,diarrhoea, urinary loss may be due to aldosterone deficiency(Addison's disease)



POTASSIUM



- About 70% of potassium in glomerular filter is reabsorbed by PCT.
- Net secretion of K ion occur at distal tubules, in exchange for Na+ reabsorption,under the effect of aldosterone.
- Normal level of potassium is 3.5 -5. mEq/L.



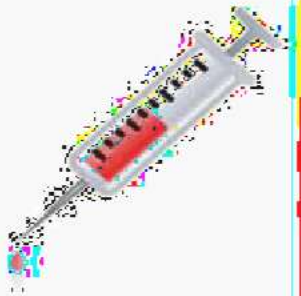
Clinical significance of potassium

Hyperkalemia

- It is a clinical condition associated with elevated plasma potassium above normal range (3.5mEq/L-5mEq/L).

Causes of hyperkalemia

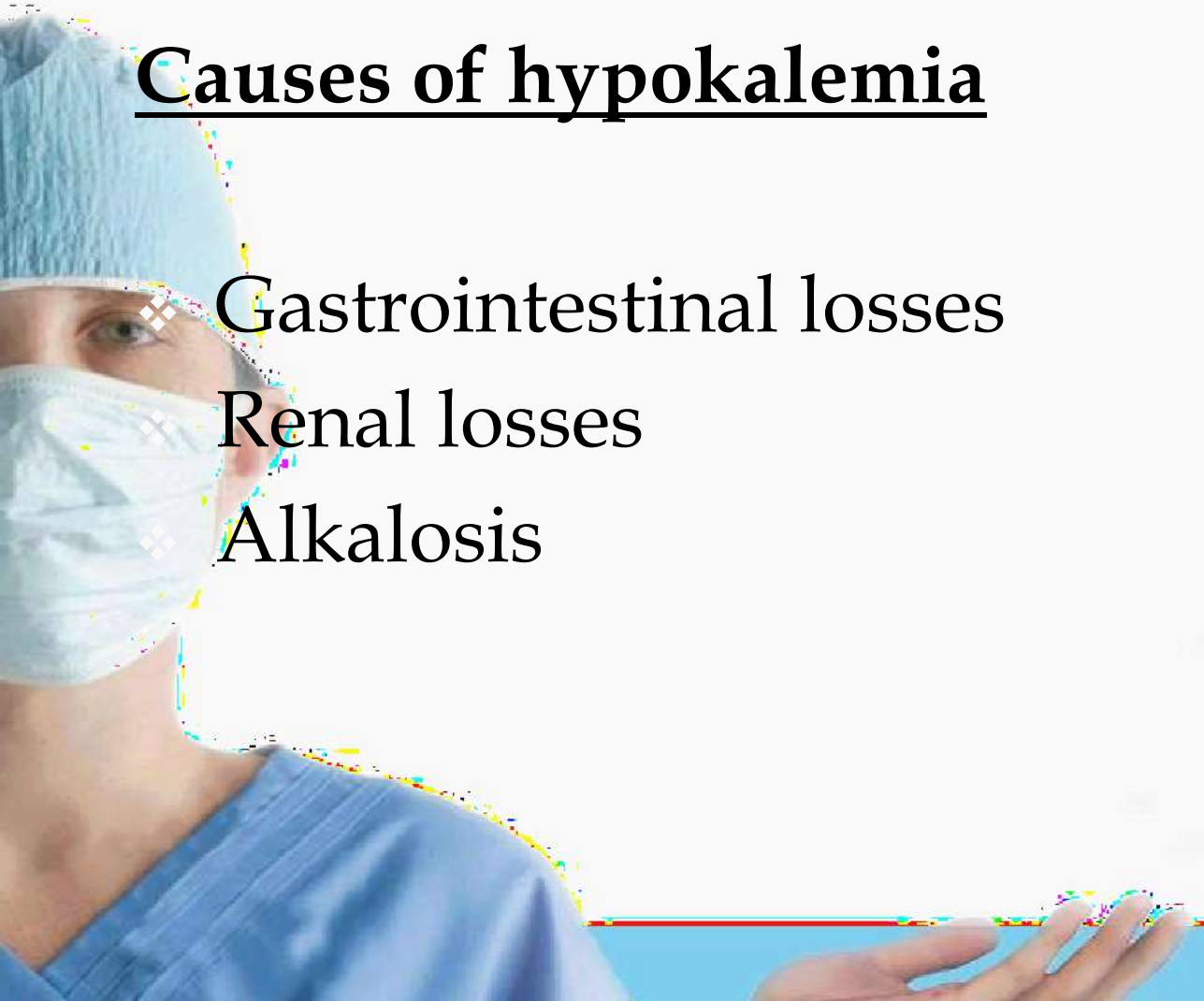
- Renal failure
- Mineralocorticoid deficiency
- Acidosis
- Cell damage



Hypokalemia (Low plasma concentration)

Causes of hypokalemia

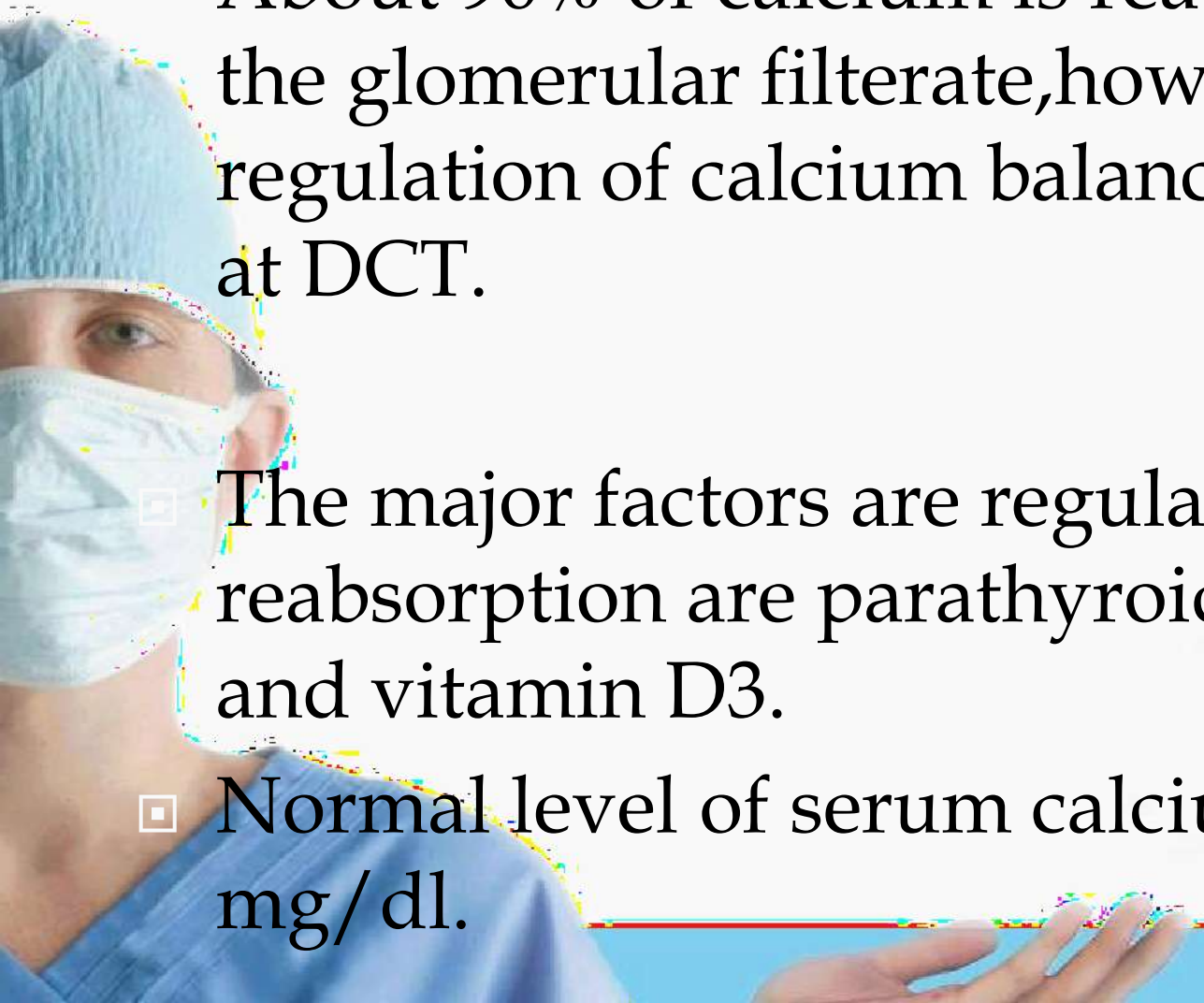
- Gastrointestinal losses
- Renal losses
- Alkalosis

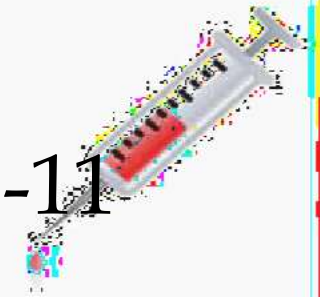


CALCIUM

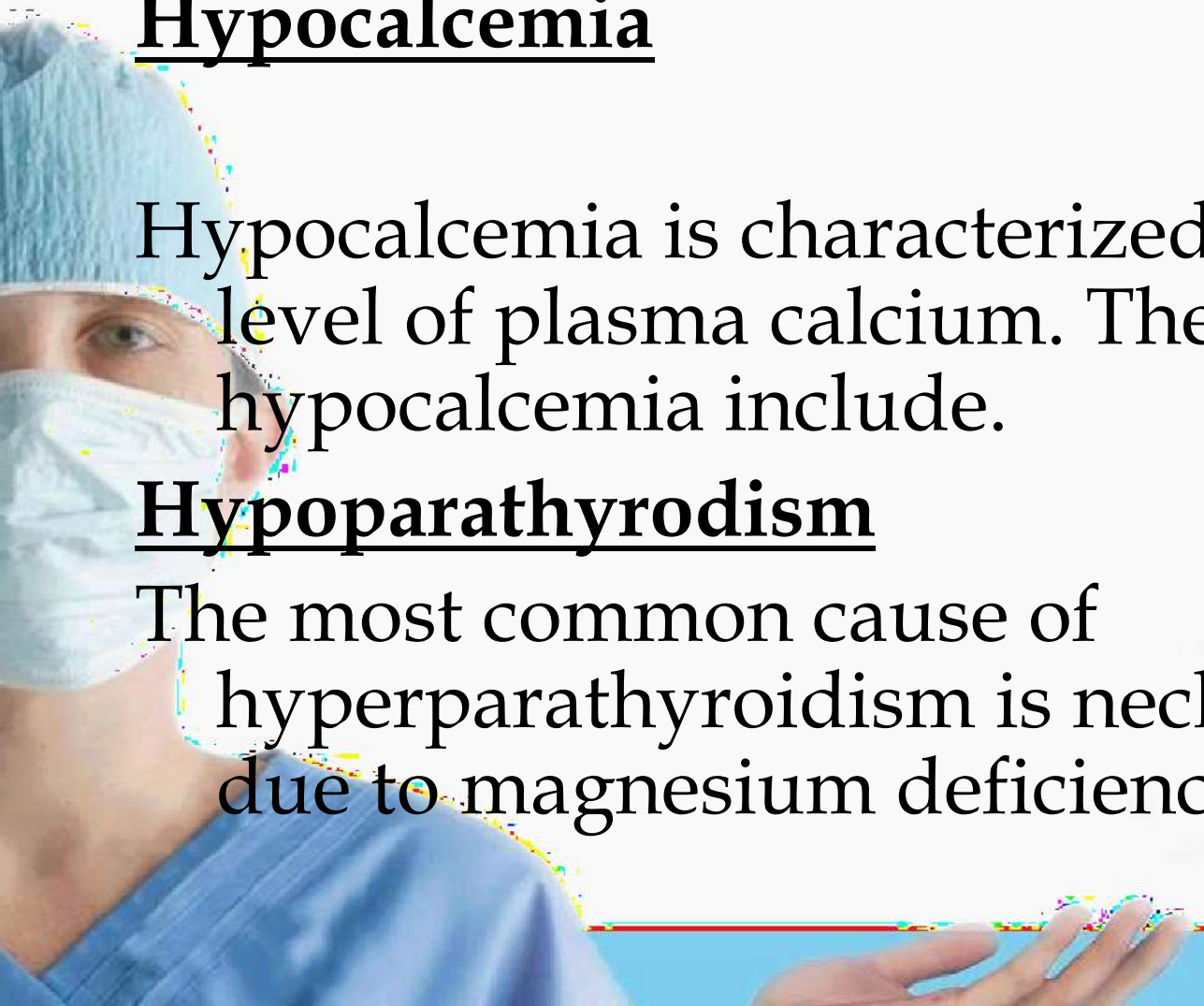
About 90% of calcium is reabsorbed from the glomerular filterate,however the regulation of calcium balance is achieved at DCT.

- The major factors are regulating calcium reabsorption are parathyroid hormones and vitamin D3.
- Normal level of serum calcium is 8-11 mg/dl.





Clinical significance of calcium



Hypocalcemia

Hypocalcemia is characterized by lowered level of plasma calcium. The causes of hypocalcemia include.

Hypoparathyrodism

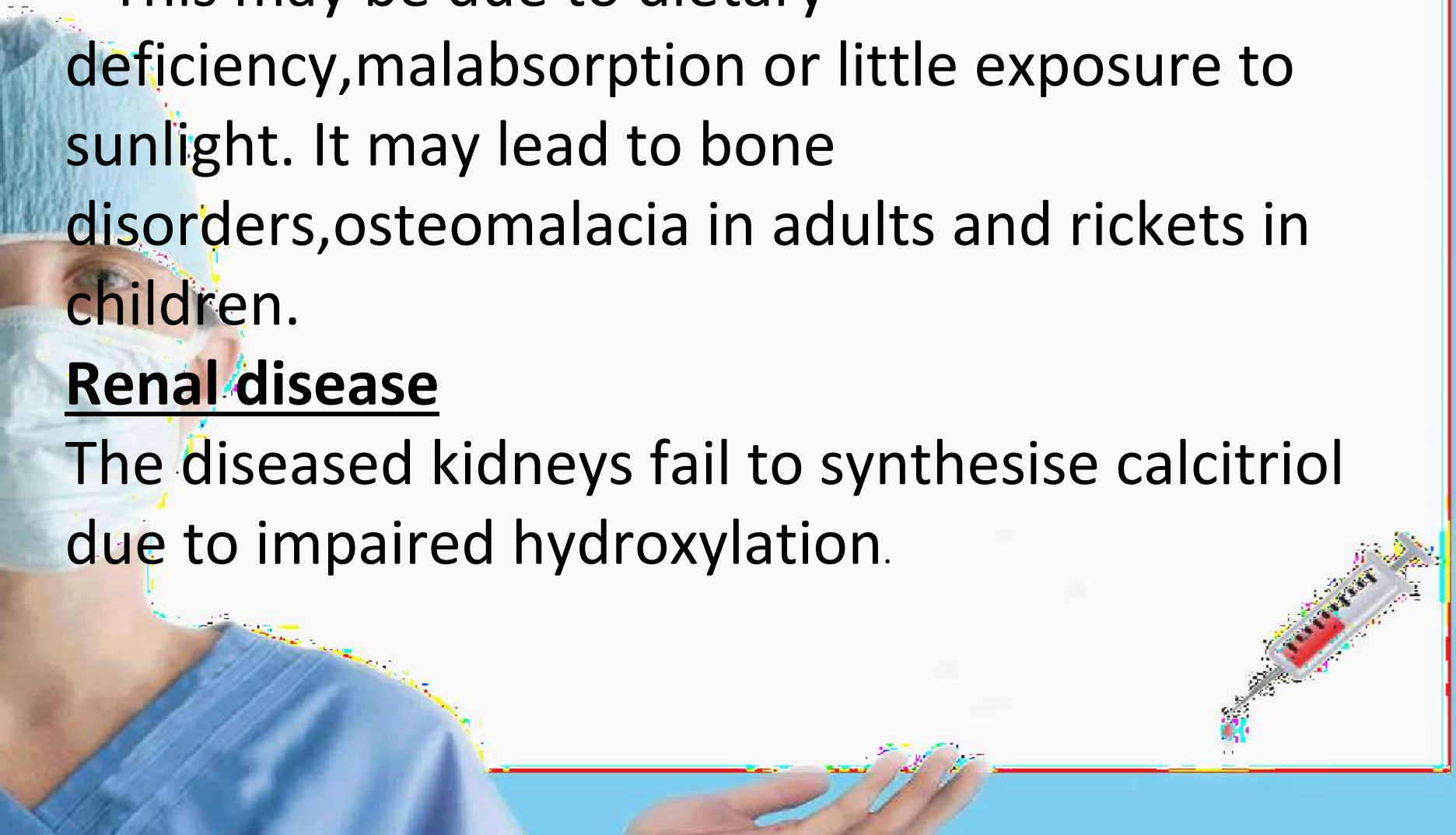
The most common cause of hyperparathyroidism is neck surgery,or due to magnesium deficiency.

Vitamin D deficiency

This may be due to dietary deficiency,malabsorption or little exposure to sunlight. It may lead to bone disorders,osteomalacia in adults and rickets in children.

Renal disease

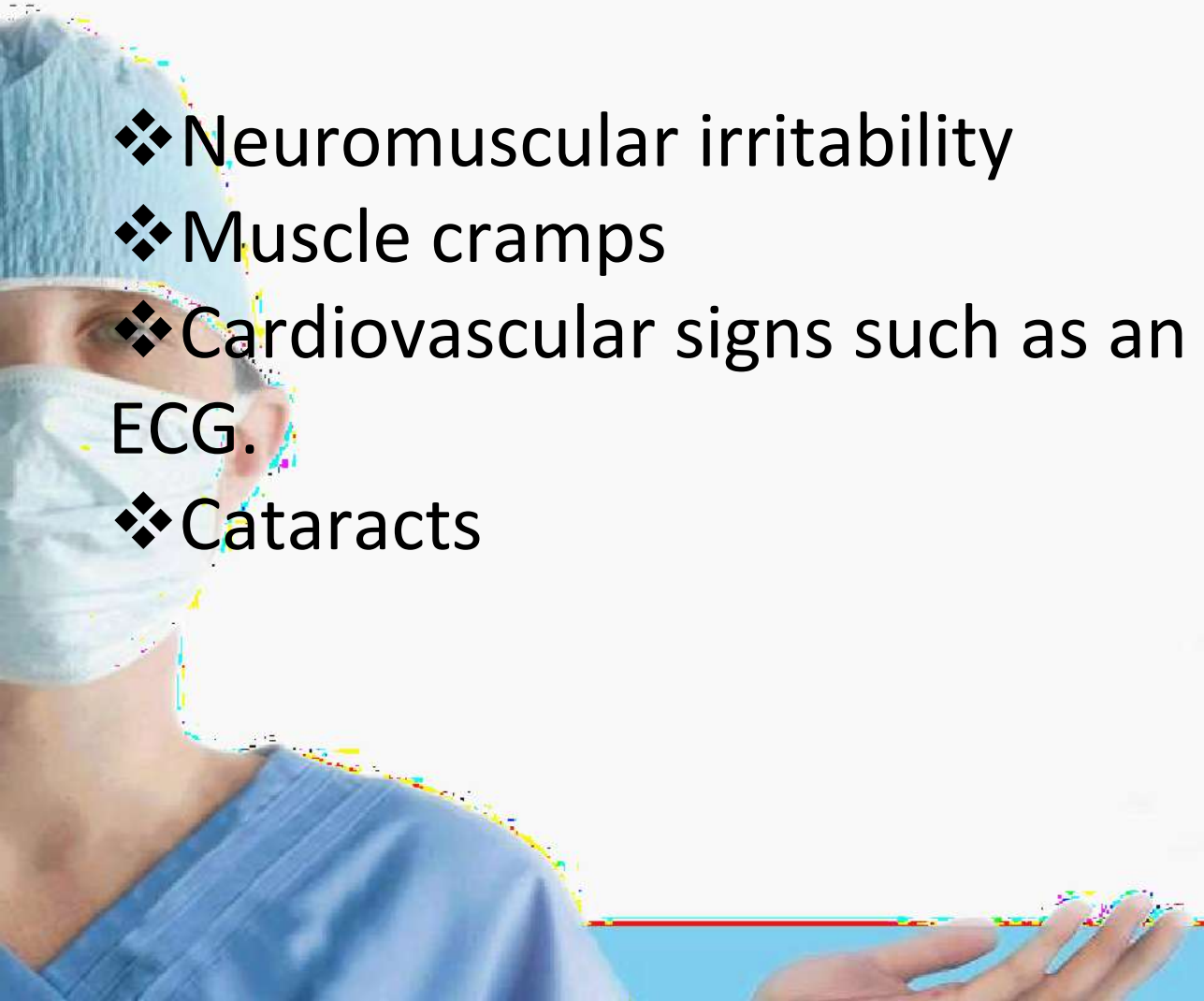
The diseased kidneys fail to synthesise calcitriol due to impaired hydroxylation.

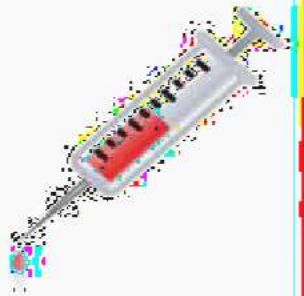


clinical Features of Hypocalcemia

The clinical features of hypocalcemia include :

- Neuromuscular irritability
- Muscle cramps
- Cardiovascular signs such as an abnormal ECG.
- Cataracts





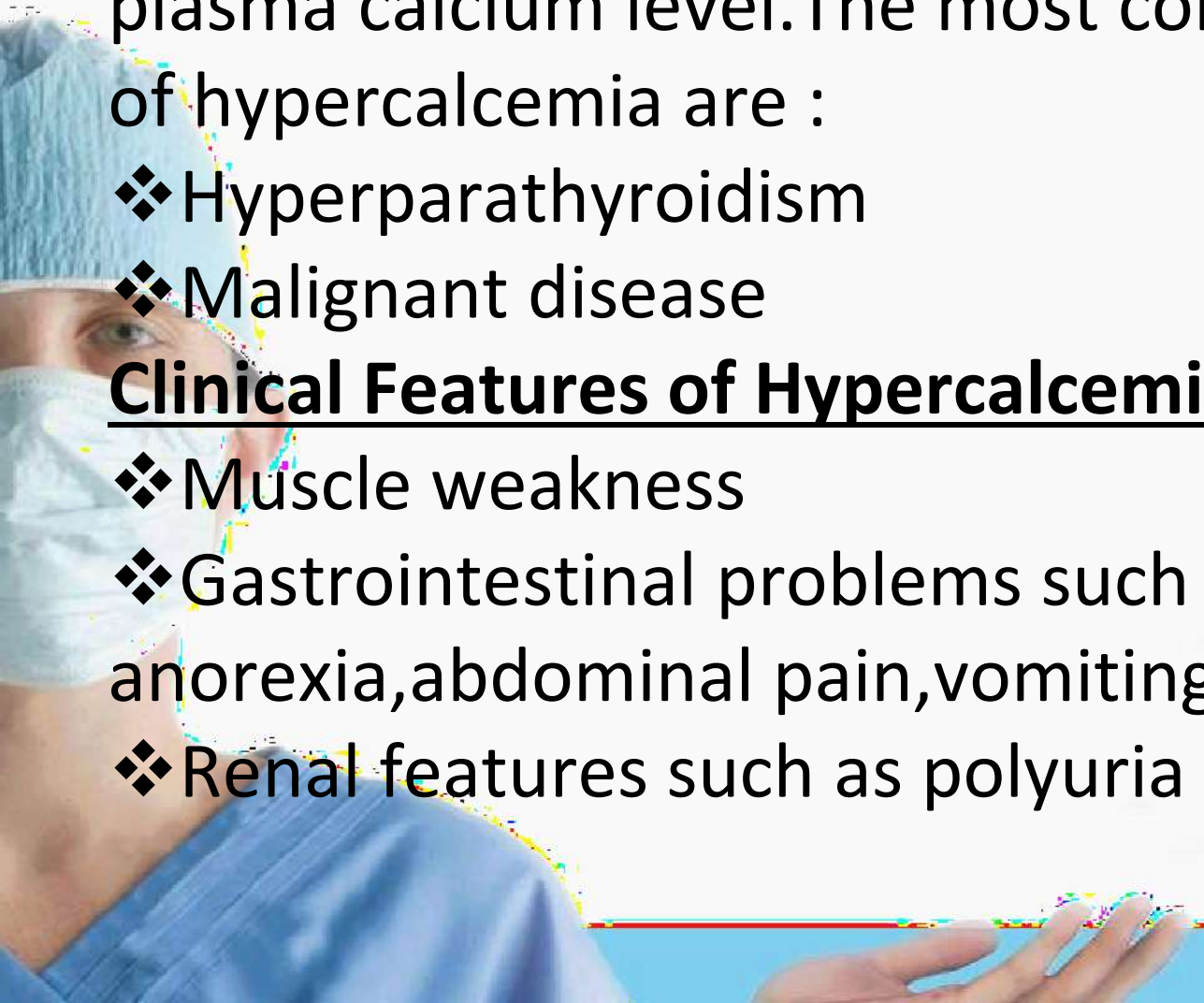
Hypercalcemia

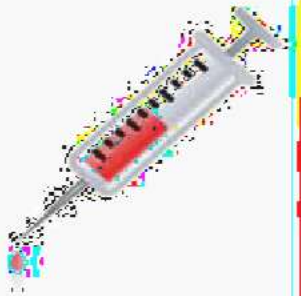
Hypercalcemia is characterized by increased plasma calcium level.The most common causes of hypercalcemia are :

- Hyperparathyroidism
- Malignant disease

Clinical Features of Hypercalcemia

- Muscle weakness
- Gastrointestinal problems such as anorexia,abdominal pain,vomiting.
- Renal features such as polyuria .



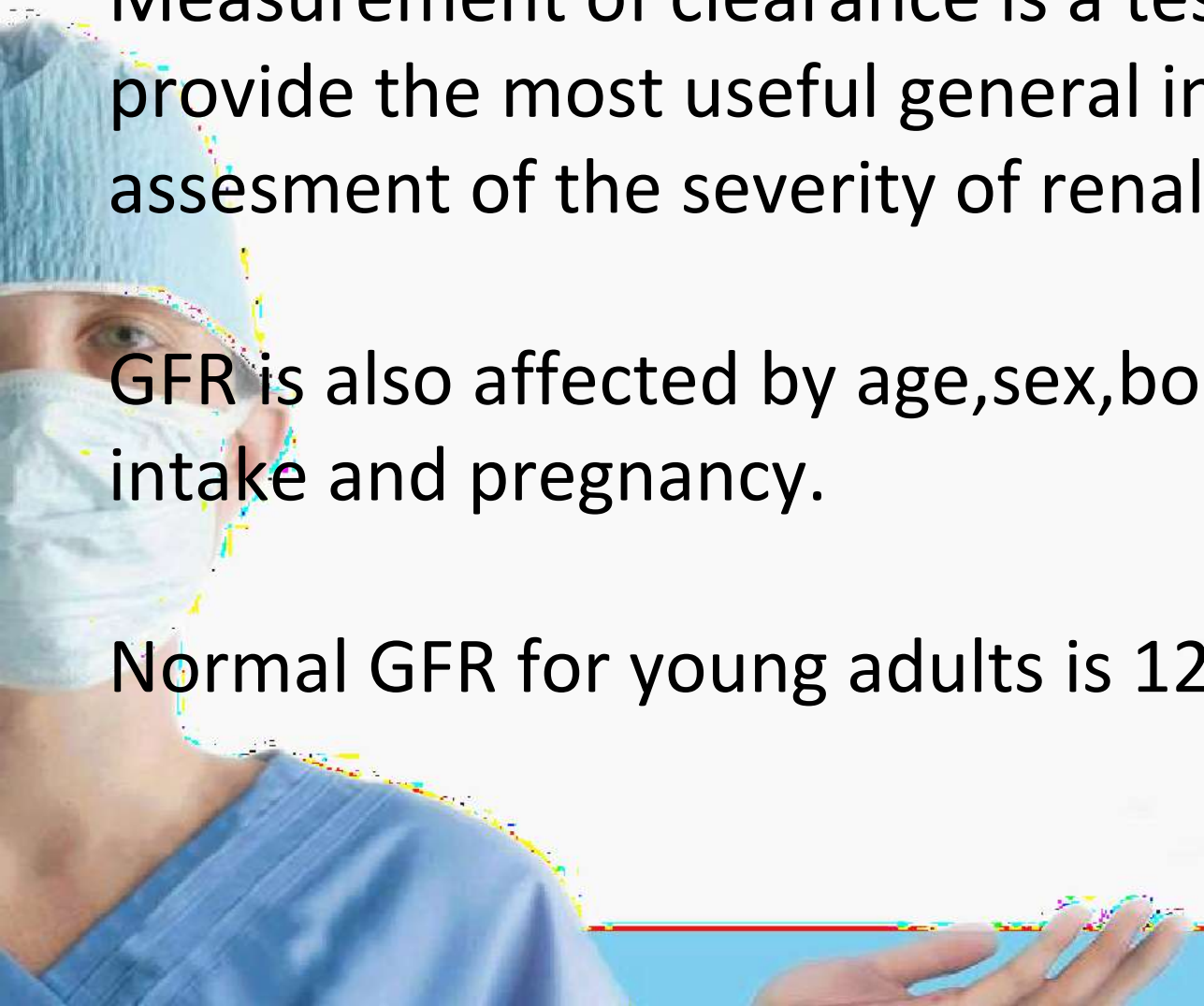


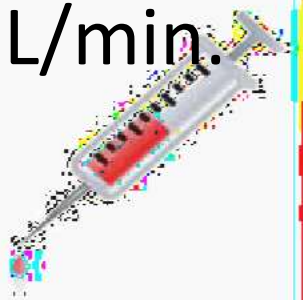
2.Glomerular function tests (Clearance Tests)

Measurement of clearance is a test of (GFR),it provide the most useful general index for the assesment of the severity of renal damage.

GFR is also affected by age,sex,body size,protein intake and pregnancy.

Normal GFR for young adults is 120-130mL/min.





Defination of Clearance test

Clearance is defined as the volume of blood or plasma **completely cleared of a substance per unit time.**

- It is expressed as a **mili liter of a plasma per minutes.**
- It is calculated by formula:

$$C = \frac{U * V}{P}$$

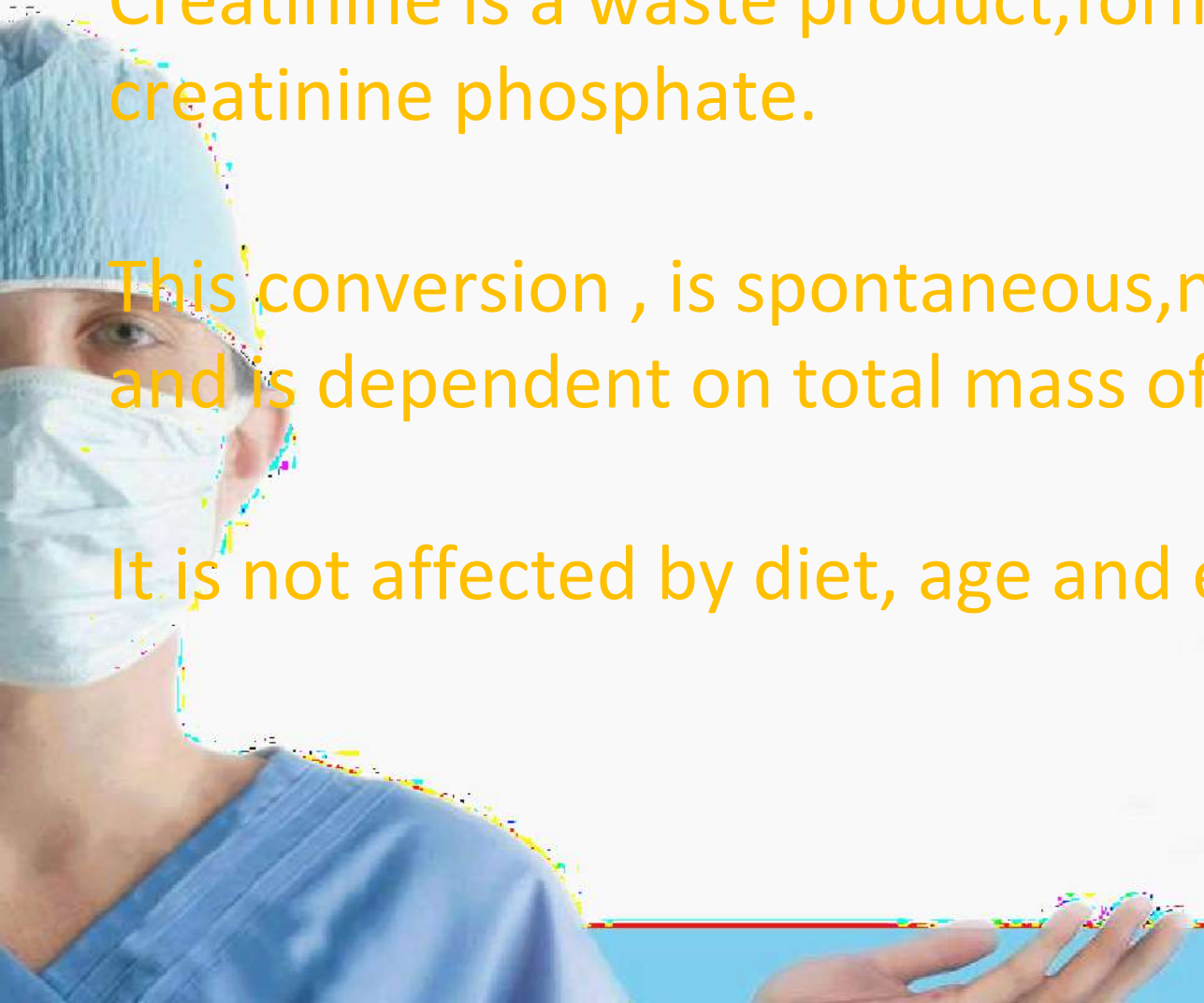
U=conc.of subtance in urine,P=conc of subs in plasma and serum,V=ml of urine excreated per min. the value is expresed in mL/min.

Creatinine clearance Tests

Creatinine is a waste product,formed from creatinine phosphate.

This conversion , is spontaneous,non-enzymatic and is dependent on total mass of the body.

It is not affected by diet, age and exerises.

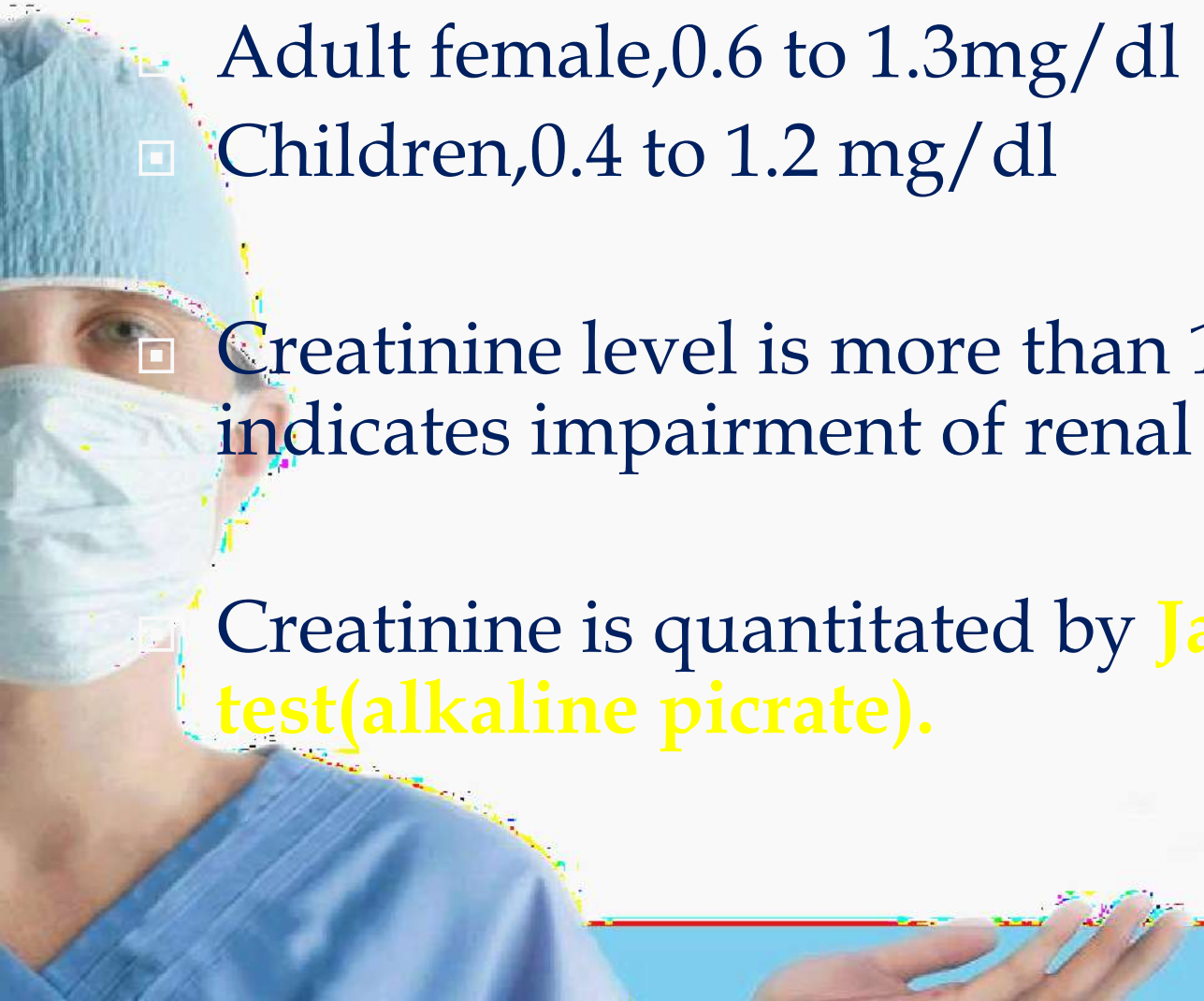


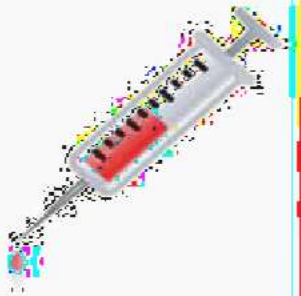
Refrence value of creatinine

- Adult male, 0.7 to1.4mg/dl
- Adult female,0.6 to 1.3mg/dl
- Children,0.4 to 1.2 mg/dl

- Creatinine level is more than 1.5 mg/dl indicates impairment of renal function.

- Creatinine is quantitated by **Jaffe's test(alkaline picrate).**

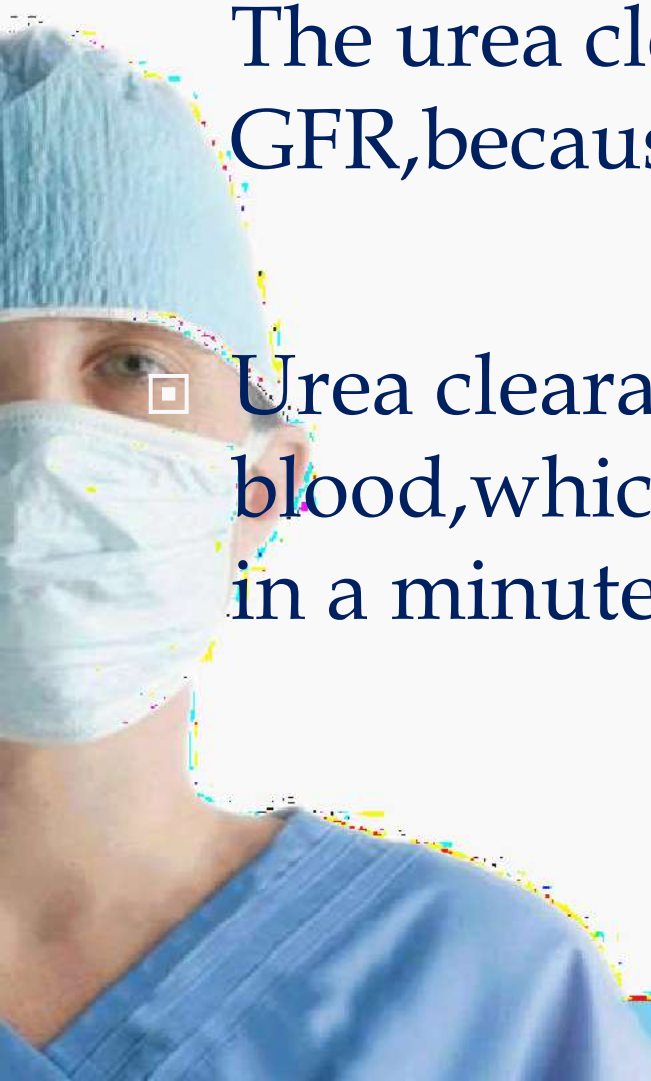


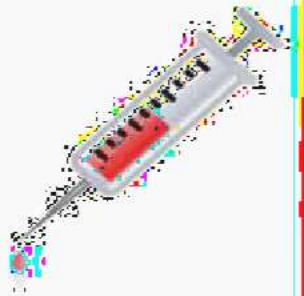


Urea clearance test

The urea clearance is less than GFR,because urea is partially reabsorbed.

- Urea clearance is the no.of ml of blood,which contain urea and excreated in a minutes by kidney.

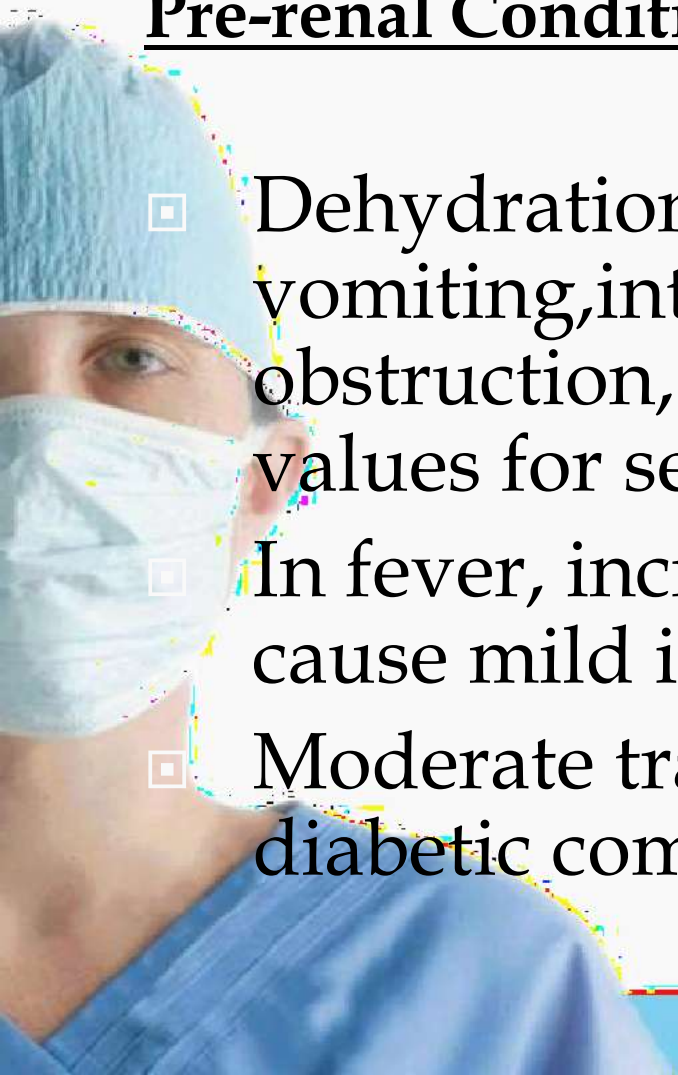




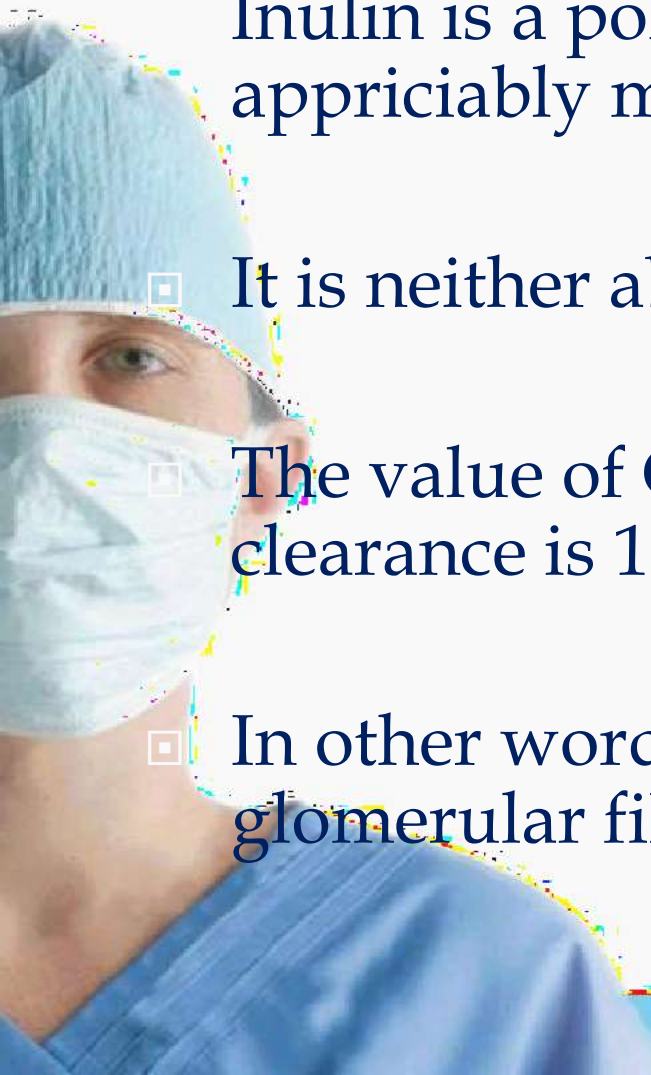
Clinical significance of urea clearance Test

Pre-renal Condition

- Dehydration,which may result from severe vomiting,intestinal obstruction,diarrhoea,etc may lead to high values for serum urea.
- In fever, increased protein breakdown may cause mild increase in serum urea value.
- Moderate transient increase will be seen in diabetic coma.



Inulin Clearance

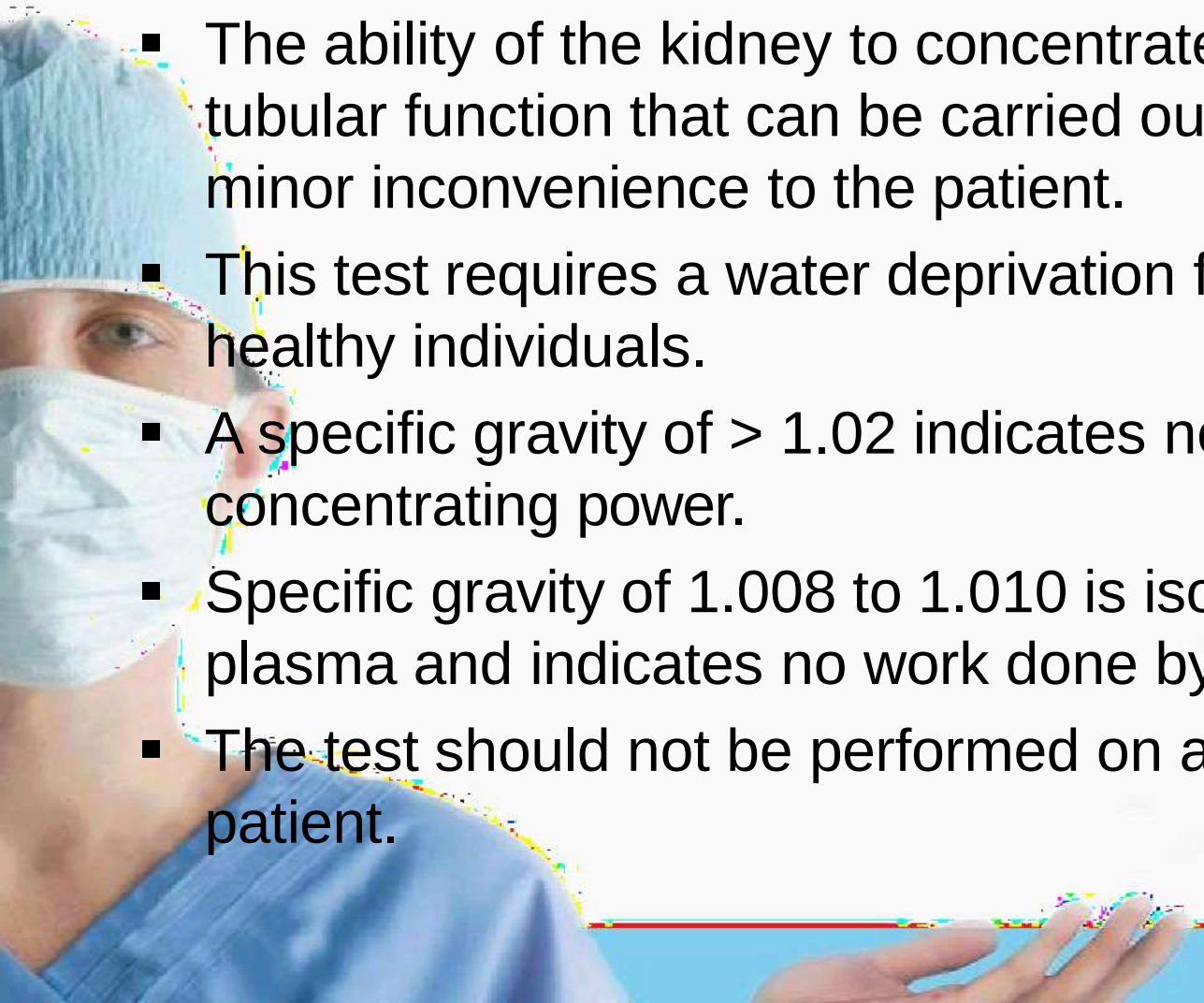


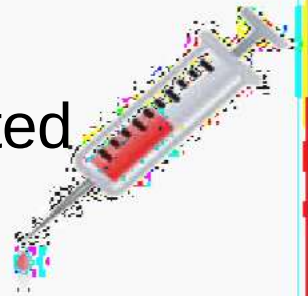
- Inulin is a polysaccharide of fructose.It is not appriciably metabolized by the body.
- It is neither absorbed nor secreted by the tubules.
- The value of GFR is measured by inulin clearance is 125 mL/min.
- In other words ,40% of urea presents in the glomerular filterate is reabsorbed in the tubules.

Tubular function tests

➢ *Urine Concentration Test*

- The ability of the kidney to concentrate urine is a test of tubular function that can be carried out readily with only minor inconvenience to the patient.
- This test requires a water deprivation for 14 hrs in healthy individuals.
- A specific gravity of > 1.02 indicates normal concentrating power.
- Specific gravity of 1.008 to 1.010 is isotonic with plasma and indicates no work done by kidneys.
- The test should not be performed on a dehydrated patient.





Thank you!