RENAL FUNCTION TESTS

Objectives of exploration

A. Physical-chemical analyses of urine
B. Measurement in blood of substances which are normally excreted in the urine
C. Renal clearance measurements

A) Physical-chemical analyses of urine

1) Color.
   The normal urine has a yellow color. There are pathological conditions which modify the color of urine. For instance:
   - brown color like the black beer occurs in jaundice because of the presence of bile pigments
   - pink-red like the water in which the meat was washed in hemoglobinuria, myoglobinuria
   - muddy when there is pus in the urine
   - colorless in renal sclerosis

2) Diuresis means the volume of urine excreted in 24 hours.
   Normal diuresis = 1000 - 1500 ml
   Polyuria = more than 2000 ml urine excreted in 24 h. Polyuria occurs in diabetes mellitus.
   Oliguria = under 400 - 500 ml urine/24 h.
   Anuria = under 100 ml urine/24 h.
   The diuresis increases after ingestion of fluids in great quantities, and also after diuretics.

3) Density
   Normal, the urinary density ranges between 1,001 and 1,030, but usual it is between 1,015 - 1,022. The density increases in the period of fever and decreases after diuretic administration.
   Work technique: 100 ml urine is put in a graduated cylinder and then the urodensimeter is introduced (carefully not to touch the walls of the cylinder). The value is read directly on the graduated scale of the densimeter. If there is not enough urine, one can use 50 ml urine which is diluted with water and the result is multiplied with 2. In pathological conditions:
   a) isostenuria = the density equals 1,010 all the time, indifferent of water ingestion;
   b) hypostenuria = density below 1,015 - 1,018
   c) hypoisostenuria = density under 1,010
   To appreciate correctly these density changes, one can resort to measure the density as part of dilution and concentration test of Volhard.

   ■ The dilution test of the urine: the patient drinks 1500 ml tea in 30 minutes. Then each 30 minutes, during 4 hours, the density is measured. Normally in 4 h, the patient must excrete minimum 1300 ml urine having the density of 1,001 - 1,003.

   ■ Concentration test of urine: is performed after the dilution test. The patient is submitted to a dry diet: eggs, green ewe cheese, and ham. The density and the volume are established during 24 h. In the first 8 h, the urine samples are collected each 2 h. The normal volume of urine/24 h ranges between 500-700 ml and the density must be greater than 1.028.

   ■ It can be renounced at the dilution test and the concentration test can be performed directly: the patient drinks no fluids 12-24 h. At the end of the test, the urine density is normally between 1.028-1.030.
Interpretation of the dilution and concentration tests:

1) When there are no pathological elements in the urine (albumins, pus, Glucose) and the density = 1.028, there is no important functional deficiency.

2) If the density = 1.024 in the morning urine, there is still a normal tubular function.

3) Isostenuria shows an important renal lesion (renal sclerosis).

4) When the density = 1.015 - 1.022, the renal functional deficiency cannot be appreciated.

5) Ph of urine: ranges normally between 5.5 - 6.5. The pH decreases at 4 to 4.5 in acidosis and in alkalosis the value increases being more than 8. The measurement of the urine pH is performed using the indicator paper.

6) Proteinuria: There is a physiological proteinuria of 25 - 150 mg/24 h. always when the protein excretion exceeds 150 mg/24 h, the tests become positive. 
   Work technique: 5 ml urine and 1-2 drops of sulphosalicylic acid 20% are introduced in a test tube. To have a comparison term, in parallel there is performed a sample of urine without reagent. The test is positive (proteinuria) if the urine precipitates in the moment of adding the reagent. Proteinuria expresses the increase of the permeability of the glomerular membrane and is pathognomonic in nephrotic syndrome. False positive reactions are obtained after penicillin, sulphamides, contrast substances used at X-ray examinations.

7) Pus in urine: To establish the presence of pus in urine, one has to put 5 ml urine in a test tube. Then 2 ml of NaOH 20% are added. The end of the test tube is covered and it is suddenly upset and then brought back in the initial position. The reaction is positive when a lot of persistent bubbles are present in the urine. In this case, in the urine there put into evidence leukocytes. This aspect (pus +) is characteristic for the urinary infections, and it requires to performed the uroculture and antibiotic sensitivity test.

8) Glycosuria means the presence of glucose in the urine. 
   Work technique: it can be performed after the pus test. 2 ml CuSO₄ 10% are added in the test tube. The mixture is warmed till it boils. The reaction is positive when a yellow-brick color appears.

9) Ketonuria = the presence of ketone bodies in urine.
   Work technique: 5 ml urine + Legal reagent. Ammonia is then layered on the top. Positive reaction = a violet ring is formed at the interface of the two layers.

10) Urobilinogen in urine is put into evidence in following way: 5 ml urine + 1-2 drops of Ehrlich reagent. Positive reaction: a red characteristic color appears.
   This is a test which aids us in the differential diagnosis between a complete and incomplete obstruction of the biliary tract. Increases of urobilinogen (a breakdown product of Hb) occur in many conditions, including hemolytic disease, liver damage and severe infections. In complete obstructive jaundice without infection, there is ordinarily no excess of urobilinogen.

11) Bile pigments in urine
   Technique: 5 ml urine + iodate alcohol is layered on the walls of the test tube. Positive reaction = between the 2 layers, a green ring has to be watched.

12) Bile pigments in urine occur in obstructive jaundice and hepatitis.
**Microscopically exam of urine**

The microscopically exam of the urine has to be performed when the color of urine is changed and when the urine contains pus or proteins.

*Work technique:* the urine is centrifuged 5 minutes at 3000 rotations/minute. 1 drop from the urine sediment is put between the slide and the lamella and examination at the microscope.

**Hematuria** = the presence of erythrocytes in the urine. It occurs after renal bleedings.

**Leukocyteuria** = the presence of leukocytes in the urine.

**Addis Test** is a method for determining the kind of kidney disease. The number of cells (present in the urine sediment) excreted in a minute is counted. After approx. 12 h without fluids, the patient urinates and the number of cells (erythrocytes and leukocytes) is counted.

Normal values: maximum 1000 erythrocytes/min and maximum 2000 Leukocytes / min.

**B) Measurement the blood concentrations of substances which are normally excreted in the urine**

**Urea:** the concentration of urea in the blood equals 26 mg%, but this can rise to 300 mg% in severe renal insufficiency.

**Creatinine:** the normal concentration in the blood is 1.3 mg%, but the value increases as much as ten folds in renal insufficiency.

To establish the degree of metabolic acidosis resulting from renal dysfunction, one can use the measurement of the standard bicarbonate and the pH of the blood. Normal values: standard bicarbonate = 24-27 mEq/l and blood pH = 7.35-7.45.

**Uremia** = accumulation in the blood of urea and other micro molecular toxic substances. Symptoms= no appetite, nausea, vomiting, muscle contractions, convulsions, mental confusions, coma.

**C) Renal clearance tests**

The clearance measurements inform about the glomerular filtration, the tubular transport, the renal blood flow. To measure the glomerular filtrate, there are used inuline, tiosulphate, and with not so exact results endogenous creatinine, manitol. Clearance inuline = 125 - 130 ml/min

The maximum secretion and excretion capacity of the renal tubes are established by means of PAH, which blood concentration must reach 40-50 mg%. To obtain only the PAH secreted in the tubes/min, one has to subtract from the excreted urine the nitrated one. The filtrated urine is obtained by calculation the inulin clearance.

The maximum tubular reabsorption capacity is appreciated by measuring the tubular reabsorption of glucose, when its blood concentration is over the renal threshold (glycaemia reaching even 500-800 mg %). The glucose reabsorbed in a minute is obtained by subtracting from the filtrated glucose/min the glucose excreted in urine/min.

The nitrated glucose can be calculated by multiplication the plasma concentration of glucose with the inuline clearance.
The maximum transport of glucose = (glucose concentration in plasma x clearance inulin) - (glucose conc. in urine x urine volume/min).

The plasmatic renal flow is established by means of the PAH clearance, when the PAH concentration in the blood is maintained between 1-2 mg%.

The filtration fraction represents the ratio between the glomerular filtration rate (established by means of inulin clearance) and the renal plasma flow. The normal value = 120/600 = 0.2, that is, 20% from the plasma which passes through the kidney is filtrated in the glomeruli.