

PRACTICAL 1 KIDNEY:
PHYSICAL AND CHEMICAL PROPERTIES OF THE URINE: THE ROUTINE URINALYSIS

- Physical properties
- Chemical properties
- Microscopic examination
- Clinical importance
 - Information about
 - State of kidneys and urinary tract
 - Major metabolic functions
 - Monitor treatment and progress of disease

Kidney function

- Removal of metabolic waste products and toxic substances
- Regulation of volume and composition of body fluids by reabsorption and secretion
- Retention of nutrients
- Maintenance of water and electrolyte balance, acid-base balance;
- Maintenance blood pressure and erythropoiesis, producing substances important to the metabolism of other body tissues
- Hormone synthesis

Filtration

- Kidneys receive 22% of CO or ~ 1100 ml blood/min
- Glomerular filtration [glomerular capillaries (high-hydrostatic press ~ 60mmHg), filtration barrier, hydrostatic press. (~18 mmHg) and colloid osmotic press. (~0) in Bowman's capsule...]
 - Filtered: salts and organic molecules with low-MW in similar concentrations with the plasma ones
 - Not filtered: proteins (responsible of a colloid osmotic press of ~32 mmHg !!), cells, fatty acids and calcium bound to plasma proteins
 - Results in ultrafiltrate of plasma (protein-free, cell-free plasma)
GFR = 120-125 ml of filtrate/minute or 180 l/day, filtration fraction ~ 20% of renal plasma flow

Reabsorption

- In the proximal tubule certain elements from the glomerular filtrate are reabsorbed into the bloodstream [peritubular capillaries (low hydrostatic press ~ 13 mmHg)]
 - Ions / salts (partial reabsorbed)
 - Glucose, Amino acids (complete reabsorption)

Concentration

- Water is removed by osmosis in the loop of Henle
- Final concentration of urine is controlled by hormones in the distal tubule

Secretion

- Substances are removed from the blood also by secretion into the tubules
 - Maintain salt and water balance
 - Elimination of waste products
 - Regulation of acid/base balance

Composition of urine

96% water and 4% dissolved substances

- Normal organic substances
 - Urea
 - Uric acid
 - Creatinine
- Normal inorganic substances
 - Sodium -ammonium
 - Potassium

Urine formation

- In general, urine can be considered a fluid composed of the waste materials of the blood
- Urine is formed continuously in the kidney and excreted from the body by the urinary system

Physical properties

- Color

- Transparency
- Specific gravity
- Volume
- Odor
- Foam

Chemical tests

- Screening, semi-quantitative tests usually with reagent strips
- Ph
- Protein
- Glucose
- Ketones
- Bilirubin
- Blood
- Urobilinogen

Microscopic examination

- Helpful to diagnose kidney and urinary tract disease
- Red blood cells
- White blood cells
- Epithelial cells
- Casts
- Bacteria
- Crystals

Collection of urine specimens

- Random specimen
- Freely voided specimen collected anytime during the day
- First morning specimen clean catch - midstream
- From catheter

Physical properties of urine

Volume

- Not usually measured in routine urinalysis
 - Diuresis: in normal adults volume is 1,000 to 1,800 ml; can increase in volume, even temporary
 - Polyuria - over 2,000 ml/24 hr.
 - Oliguria- less than 500 ml/24 hr.
 - Anuria- complete absence of urine formation
 - Nocturia - excretion of urine at night

Color

- Normal color of urine is yellow caused by a pigment
 - Urochrome
 - Urobilin
- Intensity of color varies with the concentration
 - Other colors may be due to variations of diet, medication or disease
- Dark yellow/amber
 - Very concentrated and low volume
 - Fever / dehydration
- Brown
 - Bilirubin
 - Yellow foam
 - May become green
- Orange
 - May contain urobilin
 - Does not show in fresh specimens
 - No foam
- Bright orange:
 - Certain azo dyes
- Clear red
 - Hemoglobinuria

- Cloudy red
 - Hematuria
- Dark red brown
 - Myoglobin

Transparency of urine

- Fresh urine is usually clear - cloudiness may be caused by several factors
 - Amorphous urate or phosphate crystals
 - Mucous threads
 - Presence of white blood cells
 - Red blood cells
 - Cells are confirmed by microscopic examination
- Clear
 - No visible particulate matter
- Hazy
 - Some visible particulate matter: newsprint is not distorted
- Cloudy
 - Newsprint can be seen, but is distorted
- Turbid
 - Newsprint cannot be seen through specimen

Specific gravity

- Provides information about the kidneys ability to concentrate the glomerular filtrate
- Normal specific gravity ranges from 1.005 - 1.030
 - First morning urine will be the most concentrated of the day
 - Dehydration can cause urine to be highly concentrated

Measuring specific gravity -a measure of ionic concentration

Urinometer - traditional method

- Uses a glass float weighted with mercury and a stem with calibrations to measure the buoyancy
 - Relatively time consuming ; Required large volume of urine
- The specific gravity of a solution is dependent on temperature

The refractometer

- A measure of dissolved particles in solution:
 - Closely correlated with specific gravity
- Temperature compensated
 - Requires only a drop of urine
- Actually measures refractive index which agreed with specific gravity up to 1.035
 - Distilled water has a refractive index of 1.000

Chemical properties of urine

pH

- The lungs and the kidneys are the major regulators of the acid-base contents of the body
- There is no normal- urine pH can range from 4.5 to 8.0
 - Acid-base content of the blood
 - Diet
 - Renal function

Ph - clinical significance

- Systemic acid-base disorders
- Determines crystal formation
- Reagent strips use a double indicator system of methyl red and bromthymol blue

Protein

- Normal urine contains very little protein <100-150 mg/day
- Albumin is the major serum protein found in normal urine
 - Tamm-horsfall protein is produced by the tubules is not measured
- Elevation of protein is often the first indication of renal disease

Proteinuria: Clinical significance

- Does not always signify renal disease but always required additional tests to rule out

- Pathological causes of proteinuria
 - Glomerular membrane damage
 - Tubular reabsorption problem
 - Increased serum levels of low-molecular weight protein
 - Lower urinary tract infections

Glucose

- The most frequent test performed on urine
 - For diabetes mellitus
- Normal urine contains only minute amounts of glucose
 - A normal person may have glycosuria after a meal high in glucose
- Elevated blood glucose may exceed the "renal threshold" ~180 mg glucose/dl of blood and allow glucose to be detected in the urine

Oxidation reduction tests for glucose

- Less sensitive than reagent strip ; requires Fehling reagent (blue) which will turn brownish –red in contact with glucose
- Non-specific tests measures all reducing substances

Ketones

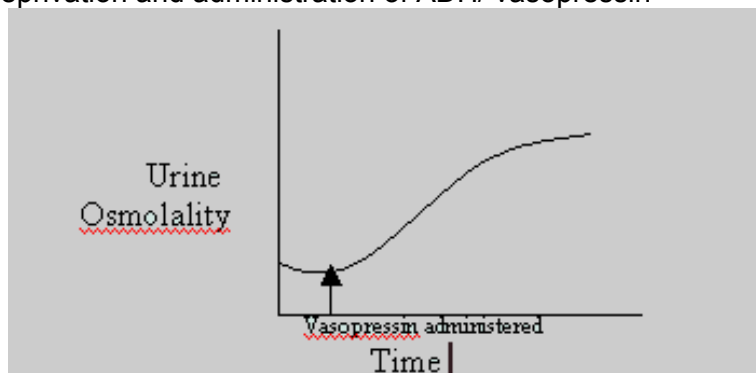
- Ketones represent three intermediate products of fat metabolism
 - Acetone
 - Acetoacetic acid
 - Beta-hydroxybutyric acid
- Normally fat is oxidized to CO₂ and H₂O
- Sodium nitroprusside reaction measures ketones
 - Acetoacetic acid reacts with indicator to produce a purple color

Increased fat metabolism

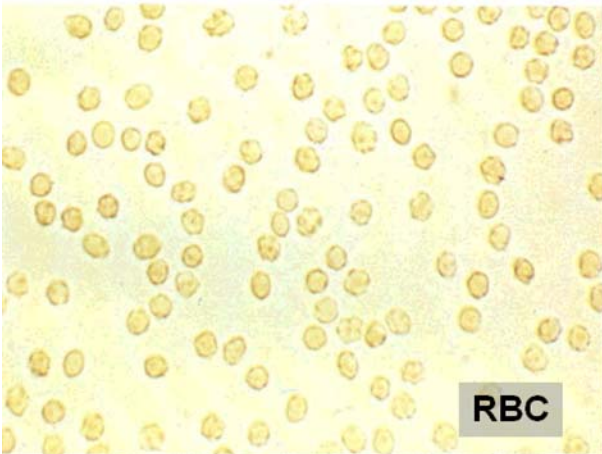
- Diabetes mellitus
- Severe vomiting
- Starvation diets
 - Accumulation of ketones in the blood causes acidosis
- Sodium nitroprusside reaction measures ketones
 - Acetacetic acid reacts with indicator to produce a purple color
- Test does not measure beta-hydroxybutyric acid and is only slightly sensitive to acetone

Dilution - Concentration test

- Stimulatory test on ADH production / kidney function
- Test measures the ability of the kidneys to conserve or excrete water appropriately.
- Changes - diabetes insipidus = inability of the kidneys to conserve water, which leads to frequent urination and pronounced thirst.
 - central (hypothalamic) = a lack of ADH
 - peripheral (nephrogenic) = a defect of the kidneys
- The specific gravity of urine is measured:
 - before and after water loading (urine should become dilute),
 - during water deprivation (urine should become concentrated),
 - for water deprivation and administration of ADH/ vasopressin



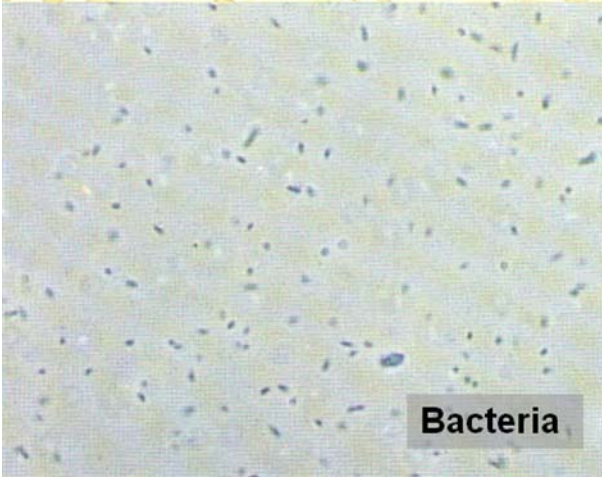
Urine sediment



RBC



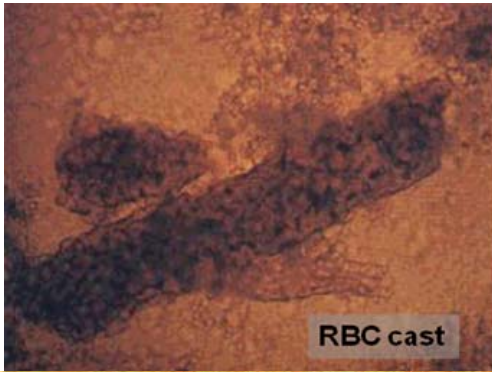
WBC



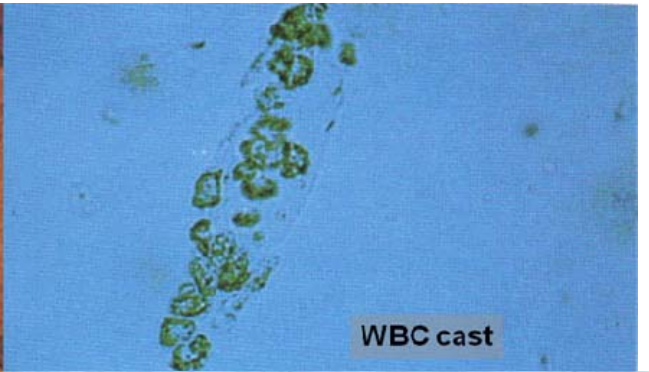
Bacteria



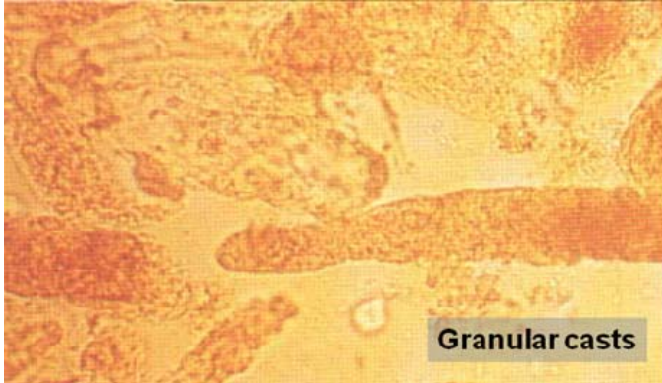
Squamous cells



RBC cast



WBC cast



Granular casts



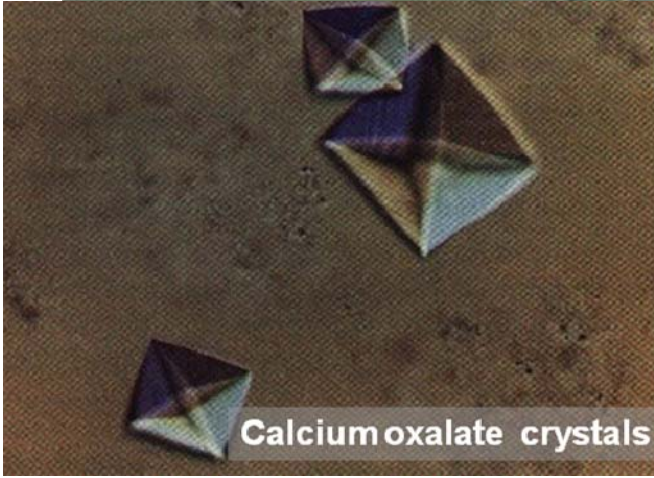
Waxy casts



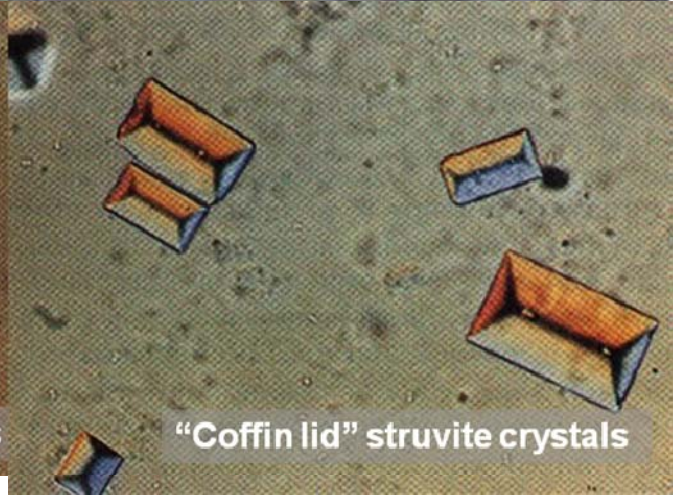
Cystine crystals



Tyrosine crystals



Calcium oxalate crystals



"Coffin lid" struvite crystals