Venipuncture and the examination of blood

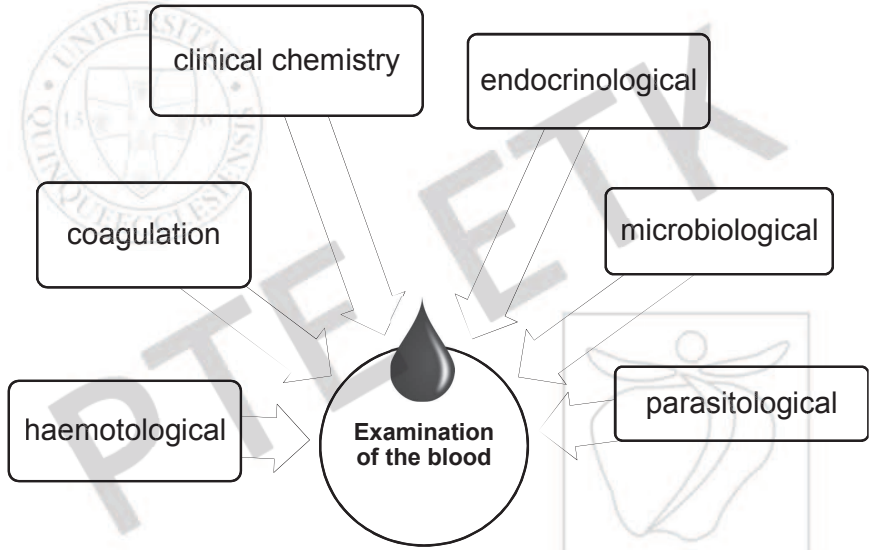
University of Pécs, Faculty of Health Sciences
Institute of Nursing Sciences, Basic Health Sciences and Health Visiting

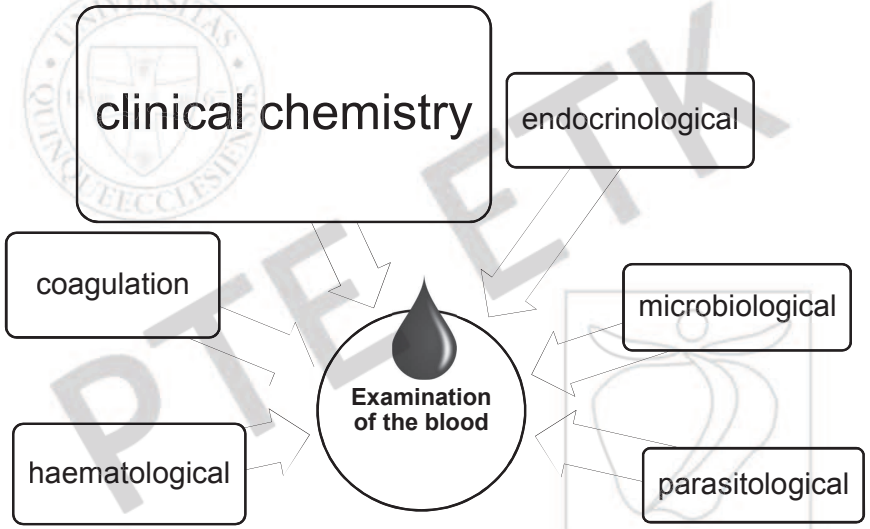
Dr. András Oláh[1], Noémi Fullér[2], Zsuzsanna Germán[3], Gyula Szebeni-Kovács[3] Szilvia Szunomár[3]

[1]Associate Professor, vice-Dean, Head of Institute
[2]Assistant Lecturer
[3]Subject Teacher

Laboratory diagnostics

- Laboratory diagnostics plays a significant role in the field of medical care
- It examines the different body fluids, secretions and tissue samples **in vitro** from the living body (the test is conducted outside the organism's body)



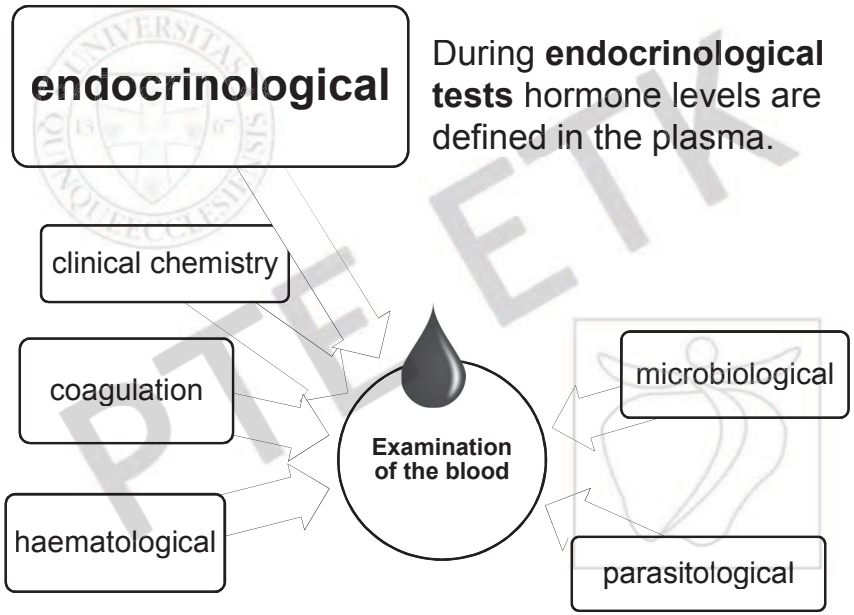


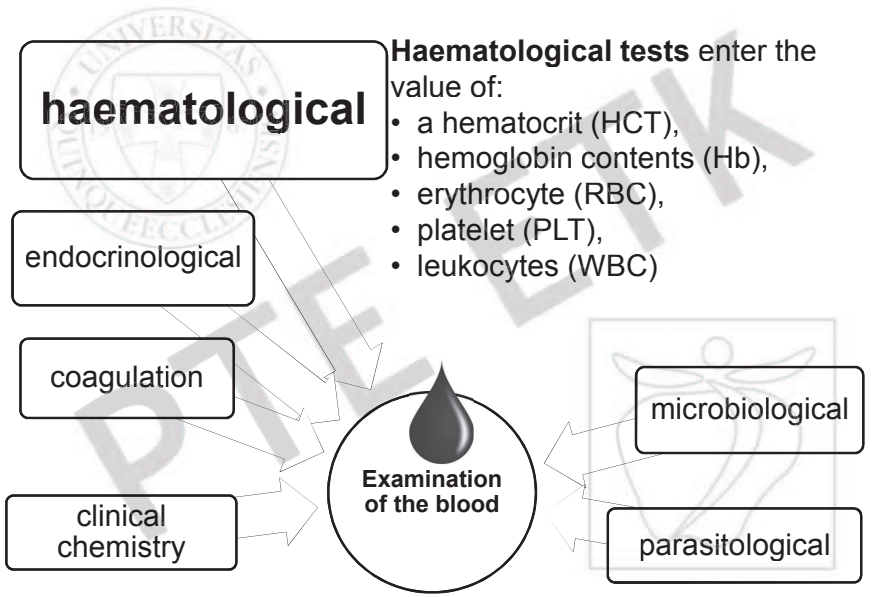
Clinical chemistry tests

- electrolytes (Na^+, K^+, Cl^-)-, osmolality-,
- enzymes (pl.: GOT, GPT, γ-GT, LDH, CK, amylase, lipase)-,
- proteins (albumin, prealbumin, globulins, haptoglobin etc.)-,
- lipids (total lipid, triglyceride, cholesterol, free fatty acids, ketone materials)-,

Clinical chemistry tests

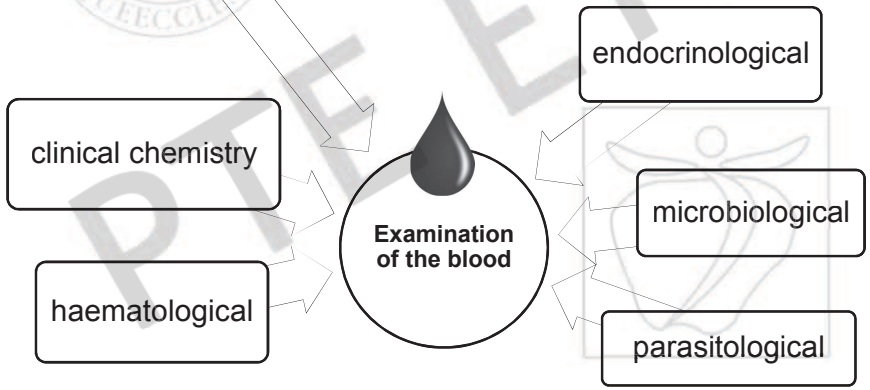
- macroelements (Ca, P, Mg)-,
- microelements (Cu, Co, Se, Fe etc.)-,
- acid-base balance (pH, blood gas analysis)-,
- carbohydrates (glucose, lactic acid)-,
- carotene-, bilirubin-, uric acid-, ammonia-, creatinine- etc. examinations.





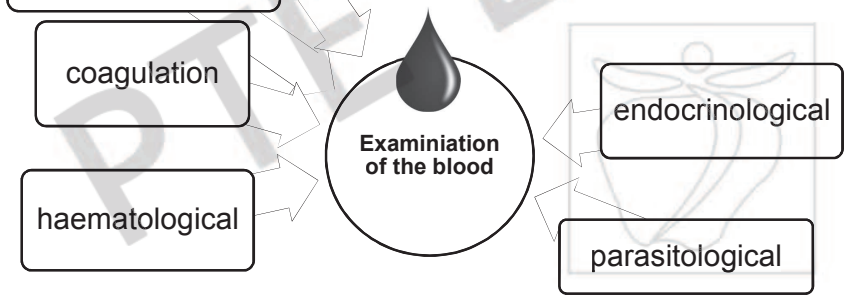
coagulation

Analysis of blood coagulation (hemostasis) provides information on bleeding, clotting, prothrombin and thrombin time.

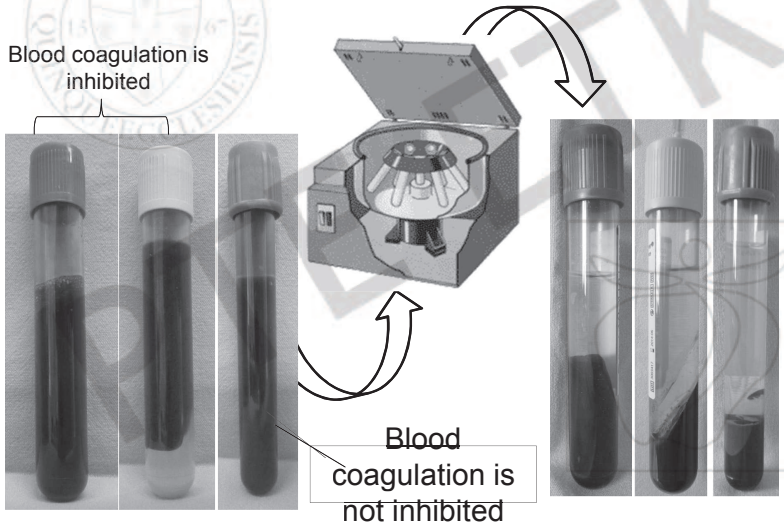


microbiological

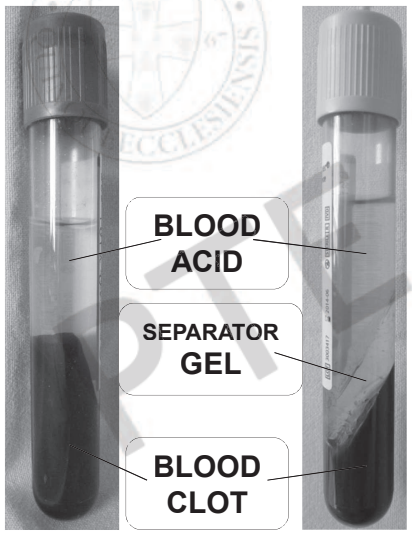
Microbiological tests include eg. Performing immune serological tests



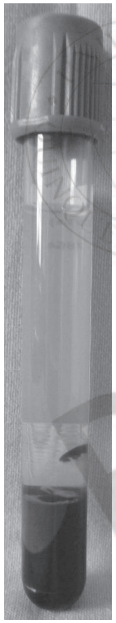
Serum or plasma



Serum



- Separator gel: forms an impermeable layer between the blood cot and the serum
- Following spin accelerated blood is differentiated into blood acid and blood clot
- Serum forms the supernatant factor. Test is being done from this

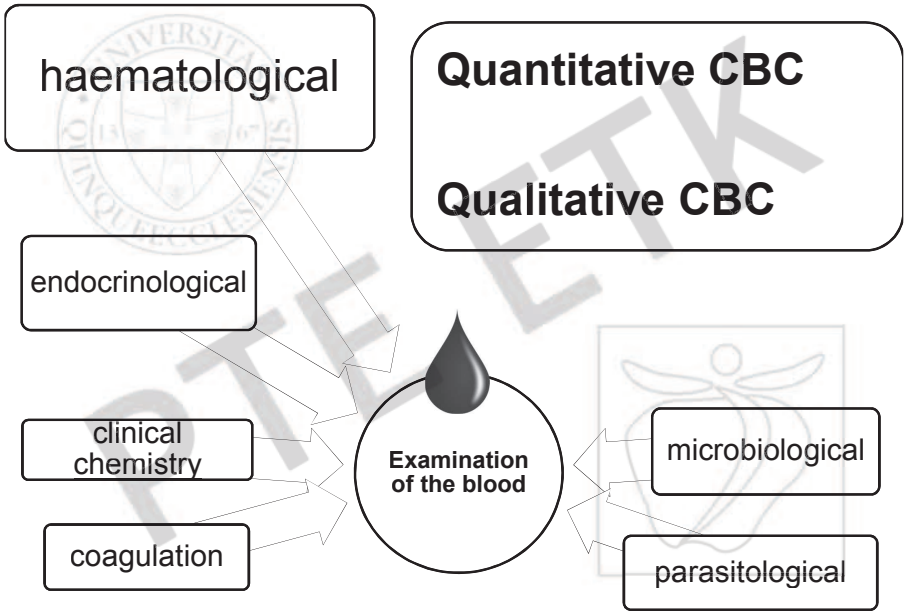


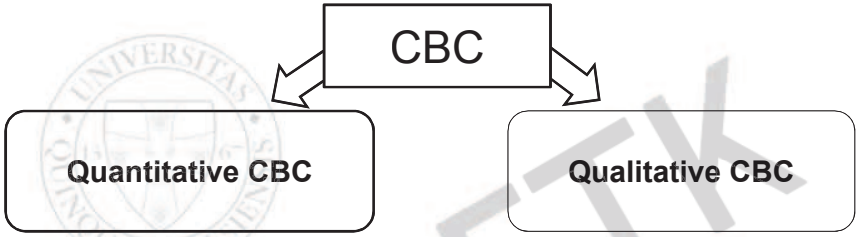
Plasma

The sample is put into a test tube with an anticoagulant,

- Na-citrate,
- EDTA (ethylene diamine tetraacetate),
- K-oxalate,
- CTAD (citrate-theophylline adenosine dipyridamole),
- CPDA (citrate-phosphate-dextrose-adenine),
- Na-heparin, NH_4-heparin, Li-heparin)

Plasma is the supernatant fraction after the deposition of the formed elements.





- RBC count,
- WBC count,
- PLT count,
- HGB level,
- Average RBC volume (MCV),
- Average amount HGB on RBC (MCH),
- Average HGB concentration on RBC (MCHC)

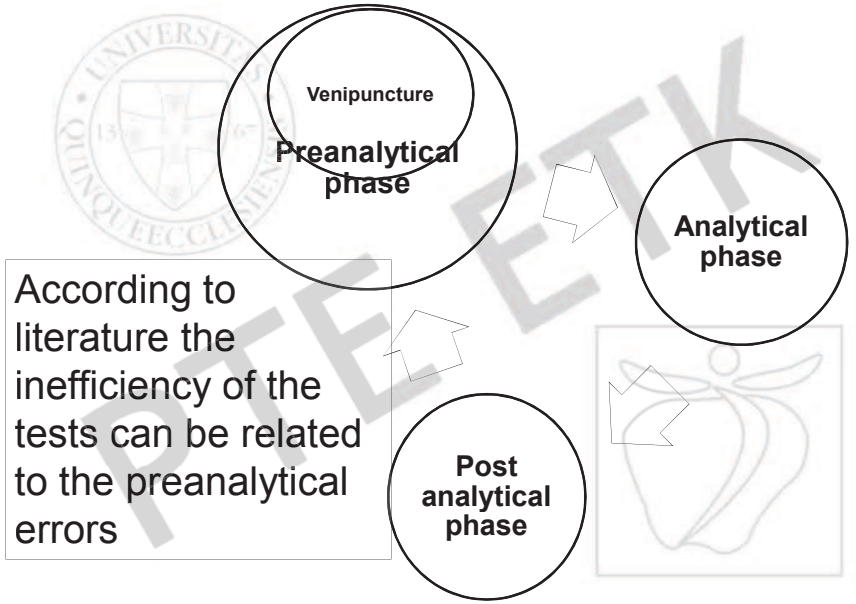
The percentage of WBC (neutrophil-, eosynophil-, basophil granulocyte, lymphocyte, monocyte) within the total of WBC belonging to quantitative CBC

The purpose of the laboratory tests

- the diagnosis, confirmation, and/or clarification
- assessment of the severity of the disease
- monitoring the progression of the disease
- monitoring the effectiveness and side effects of therapy
- carrying out screening
- determination of the reference range.

Laboratory testing process

- **Preanalytical phase:**
  - test selection
  - patient preparation
  - sampling
  - storage and transport of samples
- **Analytical phase:**
  - sample identification
  - refusal in case of problem
  - preparation of the accepted sample,measurement and recording of results
  - preparation of findings
- **Post analytical phase:** preparation of the accepted sample,measurement and recording of results.



According to literature the inefficiency of the tests can be related to the preanalytical errors

Preanalytical errors

- incomplete medical history
- filling the test application form is inaccurate
- inadequate formulation of the test request
- deficient patient preparation
- incorrect execution (eg. poor strangulation, poor sampling, poor test tube, inadequate choice of sampling sequence, wrong time of sampling, improper storage, improper transport of samples)

Factors affecting the accuracy of laboratory findings

- **factors for analytical measurements**
- **biological (non analytical factors)**
- **and sampling techniques**

Factors affecting the accuracy of laboratory findings

- age
- time of day
- menstrual cycle
- climate temperature
- weight
- geographical position
- posture
- hydration
- nutrition
- physical activity
- medications
- alcoholic beverages and tobacco products
- stress
- diagnostic tests and therapeutic interventions

Affecting factors of oprthostasis on venipuncture parameters

parameter change associated with a rise less than 10%	Hb,WBC, all Ca, AST,ALT,IgA,IgG,IgM, thyroxine, albumin, (AKB) total protein, total cholesterol, HLD, LDL cholesterol, triglycerides
parameter change can occur between 10-20%	HCT, VVT, aldosterone, apolipoproteins
parameter changes can occur over 20%	epinephrine, norepinephrine, renin

Geographical location

Pollution
- reduced Hgb (CO-Hgb) quantity increases
- Pn, Zn concentrations may increase

Elevation relative to sea level:
RBC count an Hgb rise

Mg2+ and high lipid levels may be caused by „scaled" water consumption

Hydration

Dehydration (the water content of plasma reduces)

- exiccosis (dehydration),
- Persistent vomiting,
- diarrhea,
- acidosis induced by diabetes mellitus, enemas of hypertonic solution (several times)

may lead to the reduction of the water content of plasma

Haemoconcentration: the concentration of several substances increases in blood

Hydration

Haemodilution may occur in cases of:
- water intoxication,
- diseases that cause salt retention,
- haemodilution is associated with very large quantities of intravenous infusion administration

⇩

during **haemodilution** the water content of plasma increases

⇩

Blood dilutes resulting in reduced levels of substances in the blood.

The most common parameters that show a change are blood chemistry parameters and **CBC** in body postures

Nutrition

- After a meal, some physiological parameter values differ from the values of fasting
- The basic requirement is that the sampling should be done on an empty stomach
- Diatary constraints may be required prior to each test

Nutrition

- After meals certain values **will be higher** eg.:
  - glucose, bilirubin, triglycerids, cholesterol, iron, phosphate, ALT, AST.
- The **composition of food** can affect the values:
  - the triglycerids value after a fatty meal and
  - the concentration of urea in case of a significant protein intake may be increased.

Nutrition

- The influence of hunger:
- glucose value is reduced,
- the levels of triglycerid and bilirubin increase

Gilbert's disease:
Reduced production of UDP glucoronile transferase enzyme engaged in indirect bilirubin conjugation

⇩

Excretion of bilirubin is slower, therefore its concentration rises in the blood

⇨ **icterus**

Nutrition
Dietary constraints

- A **minimum 12-hour-long** food deprivation is needed prior to the determination of inorganic phosphate, glucose, triglycerids, iron, cholesterol, urea, uric acid

- The **photometric measurements** (eg. total protein, ALB, AST, ALT, CK, ALP, LDH, cholesterol,triglycerids, glucose, iron,) are disturbed by lipemia (increased fat in the blood)

Nutrition
Dietary constraints

Glucose stress test (OGTT):

- A **normal diet** should be kept **for 3 days** before the test,
- Carbohydrate content of the diet should be at least **150 grams per day**
- And the patient should fast for at least **10 hours** before the test
- Based on recommendations 30 to 10 hours before the start of fasting the suggested meal should contain **30-50 grams of carbohydrates**

Nutrition
Dietary constraints

In case of serum uric acid examination:

- a diet poor in purine is recommended for **3 days**
  - chocolate,
  - hazelnuts,
  - walnuts,
  - legumes,
  - mushrooms,
  - sardines,
  - offals

Nutrition
Dietary constraints

Before a lipid metabolic test:

- a mixed diet **for at least 3 days** is recommended,
- animal fats, fatty dairy products, meats should be avoided,
- the stability of the patient's body weight is important, the test may be affected by the increase or decrease in body weight.
- No food, but water can be consumed by the patient **12 hours before the venipuncture.**

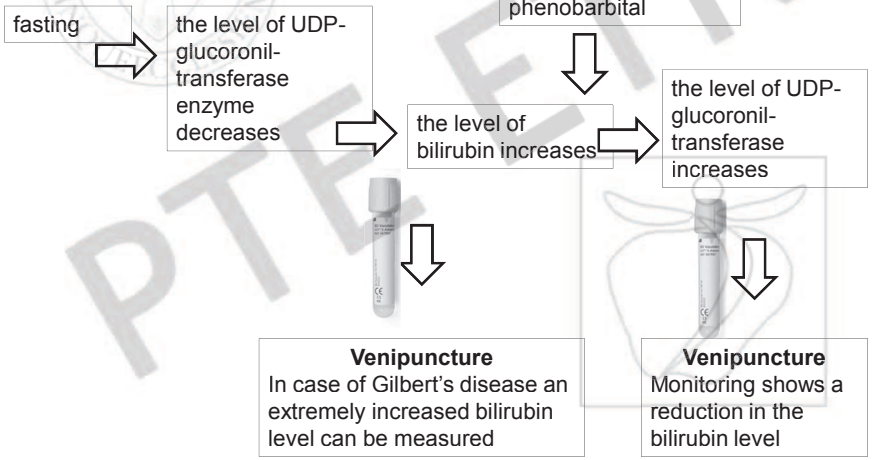
Nutrition

Dietary constraints

During the fasting test used for the diagnosis of Gilbert's disease:

- up to 400kcal of energy can be taken for 2 days prior to venipuncture,
- daily, regular meals are important to have after the diagnosis
- diet low in fat is recommended that includes animal and vegetable fat reduction, restriction

The presence of glucose is essential for the operation of UDP-glucoronil-transferase enzyme



Physical activity

On taking medical history the professional should be informed about:	
• any physical work over the past 24 hours • type and frequency of doing sports • regular exercise, increased urea due to physical labour, HDL cholesterol levels	
Strenuous exercise causes a greater amount of access of the following items to the blood:	
cellular elements	leukocytes, platelets
ions	Na^+, K^+, Ca^{2+}
metabolites	lactate, pyruvate, uric acid, urea, creatinine
enzymes	CK (MB), GOT (ASAT), LDH
Decreasing values include pH, glucose, ALB, iron	
Because of the practice it is also essential that bone resorption is increased due to the long-term immobilization, which leads to increased excretion of Ca2+.	

Medicaments

- medicaments affect:
  - analytical reactions
  - enzyme levels
  - metabolite concentrations
  - function of organs (eg. Liver function)
- the effects of certain drugs are not yet known
- if possible medication administration should be discontinued before venipuncture
- or, blood sample should be taken when the blood concentration of the drug is the lowest

Medicaments	
increase levels of GGT	antiepileptic drugs
may increase the level of AST,ALT,ALP,LDH	a number of hepatotoxic drugs: valproic, methotrexate, tetracycline, amiodarone, paracetamol
can increase the amount of creatinine and CN	drugs excreted by the kidneys can damage the kidneys, can have nephrotic effect : aminoglycosides, tetracyclines, lithium carbonate, salicylates, cyclosporines, contrast media
INR is raised, the BTR is reduced	warfarin,thyroxin binding globulin derivatives
raises APTT value	Low molecular weight heparin (LMWH)

Medicaments	
may increase the level of glucose and may reduce that of Na+, K+	thiazid diuretics
may increase the value of iron, GOT,GPT, prealbumin, protein C, proteinS,copper (Cu), cholesterol, triglycerides, fibrinogen, thyroxine binding globulin, a-1 atitripsine and may reduce the value of ALB,LH, INR and vitamin B2	oral contraceptives, estrogens
may reduce the value of bilirubin	aspirin
may affect the activity of protein C and protein S	vitamin K antagonist drugs

Alcoholic beverages and tobacco products

- how much coffee, tea, energy drinks are consumed by the patient per day
- it is advisable to ignore alcoholic beverages and tobacco products before testing the liver, kidneys and stomach
- Smoking:
  - higher amylase, cholesterol, glucose, HGB, HTC,RBC,WBC, ferritin, CRP,CEA values,
  - lower bilirubin, platelet aggregation,triglycerides, vitaminB12 and vitamin C values are measured

Alcoholic beverages and tobacco products

Alcohol

- During the consumption of large amounts of alcohol GGT increases in the blood
  - Blood sampling can show small amounts of alcohol consumed within 24 hours
- GOT, GPT increase
- LDH activity increases slightly
- Uric acid and triglycerides increase

Alcoholic beverages and tobacco products

Alcohol

- Due to damage of hepatocytes
  - Albumin and prothrombin values may decrease,
  - bilirubin rises
- Long-term changes in hematological parameters:
  - Macrocyter anaemia develops due to the lack of folic acid and vitamins B, which can be differentiated by examining the mean erythrocyte volume (MCV)

Stress

- Anxiety, fear as emotional reactions:
  - they may cause an intermittent increase of WBCs,
  - **increase** ALB, fibrinogen, glucose, cholesterol, and insulin concentration in blood,
  - iron **may decrease**, **changes** in hormones' (cortisol, aldosteron, renin, TSH, prolactin) value
- due to hyperventilation:
  - a deviation of the acid-base balance
  - elevated lactate levels
  - increased level of fatty acid

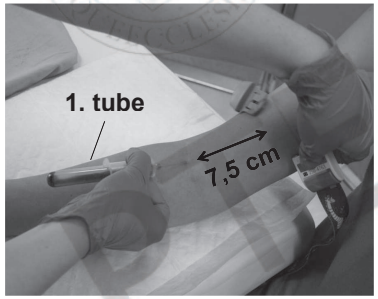
Diagnostic tests and therapeutic interventions

- breast examination of women can raise the level of PRL
- manual examination of the prostate increases the level of PSA
- K,PO4,Mg2+ concentration rises during glucose load
- due to muscle tissue damage CK activity and myoglobin concentration rises (IM.inj.)
- haematoma increases the value of D-dimer

Diagnostic tests and therapeutic interventions

- due to surgery acute phase protein concentration increases (ESR)
- the glucose content of the blood product raises the blood sugar given in transfusions
- infusions may cause electrolyte changes and thinning of the blood sample leading to erroneous results

Sampling tecniques strangulation



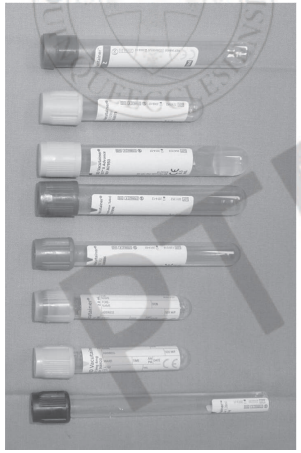
- Strangulation time should be minimized
- Avoid puncture close to strangulator (7.5cm least)

Sampling tecniques

it is important that heavy aspiration from blood should not happen

- during blood sampling the parient must not fist pump
- venous pressure increase causes haemoconcentration
- flow through the blood sampling needle is accelerating causing hemolysis

Sampling tecniques order of blood sampling tubes

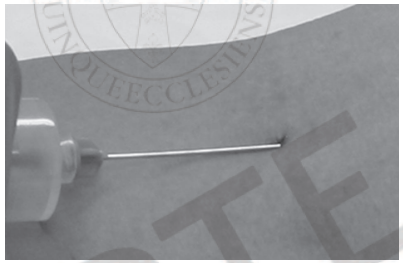


- during sampling, the order of tubes is important to keep because of the transfer of trace substances from one tube to another may cause a change in some parameters

Sampling tecniques shock and vibration

- hemolysis in blood sample can occur due to shock and vibration
  - it must be kept in mind during transport, treatment (eg. labeling, laboratory work).
- blood sampling should be avoided from cannula or the proximal vessel section
  - the sample is contaminated by the infusion solution, and can be diluted due to drug/infusion solution/drug interference

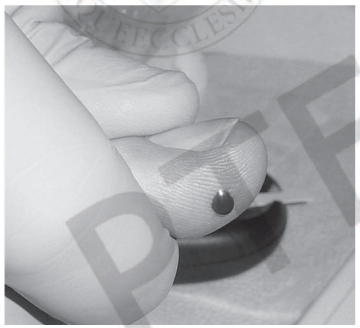
Sampling tecniques



- The presence of large amounts of skin disinfection on the injection site may cause hemolysis

During blood sampling the puncture of the tattooed areas should be avoided because the dye may confound the laboratory test

Sampling tecniques



- Capillary pressure and compression for sampling should not be used, because it causes hemolysis and sample can be mixed up by tissue fluid.

Sampling tecniques
charge of tubes

- Fewer samples compared with the requirements can hazard laboratory analysis
- In vitro parameter change may occur due to inappropriate additive-sample rate
- In case of coagulation samples, the optimal ratio is 1:9 for the anticoagulant citrate and blood sample
- For blood gas analysis test, the capillary tubes can be filled up to the given sign,
  - charge may cause blood clot
  - under charge may result in morphological changes in the cells

Sampling tecniques
mixing of samples

Inadequate mixing:

- mixing of the sample with additives is not homogeneous in the tubes, capillary, syringe
- the additive as an anticoagulator, or accelerating coagulation, and inhibiting glycolysis will be ineffective
  - (eg. coagulation parameters, blood tests, chemical tests, blood gas analysis, blood sugar tests)

Sampling tecniques

- **Air bubbles** in the sample cause the incorrect measurement of blood gases during blood gas analysis, so care must be taken for air-free samples
- Blood type test from anticoagulant blood, **heparin must not be used for anticoagulation**
  - In case of heparinized blood samples, pseudoagglutination phenomenon develops a few hours after coagulation, which makes evaluation uncertain.

Storgae time and mode

- blood samples should be protected from strong light
- particularly light-sensitive samples
  - Bilirubin
  - Vitamin D,
  - Vitamin A,
  - Vitamin B_{12},
  - Vitamin B_6

- wrapped in aluminium foil
- use of tinted blood sample tube

Storgae time and mode

- In order to avoid the distortion of results the blood sample should be brought in the laboratory as soon as possible

  - Bilirubin
  - Vitamin D,
  - Vitamin A,
  - Vitamin B_{12},
  - Vitamin B_6

- wrapped in aluminium foil
- use of tinted blood sample tube

Storgae time and mode

separation should occur in less than two hours in case of

- K^+,
- ACTH,
- cortisol,
- catecholamines,
- LDH,
- Homocystein

to avoid analyt exchange between RBC and the liquid phase

Storgae time and mode

- the citrated blood samples stored at room temperature for 4 hours,
- blood samples containing EDTA anticoagulant should be sent to the laboratory within 6 hours
- blood samples should be examined promptly within a maximum of 15 minutes, or immediately placed on ice, can be stored in anaerobic conditions for a maximum of an hour in icy water in order to study the acid-base balance

Storgae time and mode

the sample should be placed and transported on ice:

- ACTH
- Homocysteine
- Ammonium

Pre-cooling of the blood sample tube is required in case of ACTH

Special tools required for venous blood sampling

some chairs can have hydraulic lift

phlebotomy chair

- a safe and comfortable positioning
- easy to wipe and disinfect surfaces
- the armrest can be set positioning the arm
- additional elements may be supplemented by, head, neck and leg supports, tilting backrest

Special tools required for venous blood sampling

Phlebotomy spline, armrest

- in the absence of phlebotomy chair it can help ideal positioning
- the arm can securely be positioned
- it sets arm in the ideal outstretched position
- it is important that the surface have to be easy to clean and disinfect

Special tools required for venous blood sampling

Vein search tool

- attached to the arm provides real-time image depending on the equipment
- it makes the displacement of the vein difficult facilitating the management of needle into a vein
- it is applied most commonly in neonatalogy, in children and patients, wherein the veins are difficult to be detected
- comprises light-emitting diodes, whose light is absorbed in the tissue in different ways, thus veins are discernible

Special tools required for venous blood sampling

Disinfectant

Skin disinfection is designed to eliminate and inactivate the transient micro flora of the skin surface.

Disinfection of the skin puncture site should be carried out with disinfectant, which uses:

- contact time (usually 5 to 30 sec) that can not be defined universally and uniformly
- the antiseptic solution should not be wiped off
- you have to wait for the disinfectant to dry on skin, because it can cause haemolysis and therefore may influence the parameters studied
- the disinfected skin area should not be touched again

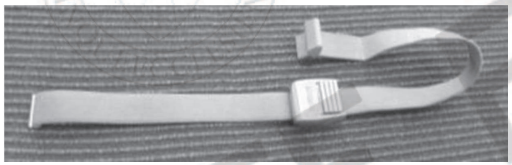
Special tools required for venous blood sampling

Srangulator

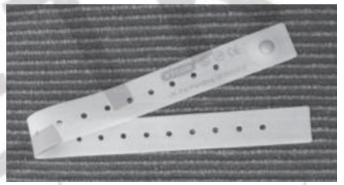
- strangulators in practice are reusable and disposable
- researches have demonstrated that many strains of bacteria and fungi species were found on strangulators
- design with fixing device and one with fixing-free device

Special tools required for venous blood sampling

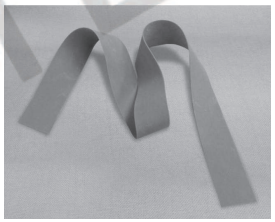
Srangulator



Reusable design with fixing device



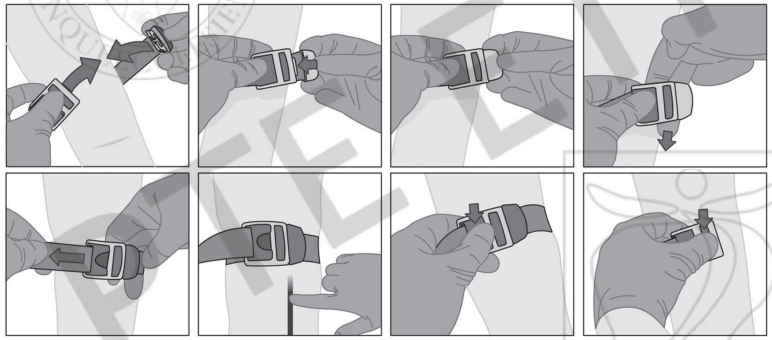
Disposable design with fixing device



Disposable design with fixing-free device

Special tools required for venous blood sampling

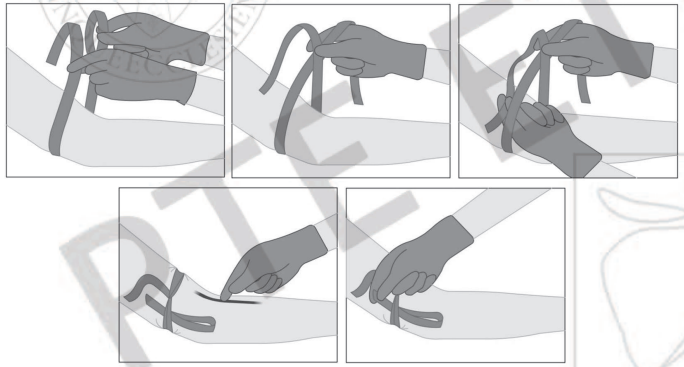
Srangulator



Placement of reusable strangulator with fixing device

Special tools required for venous blood sampling

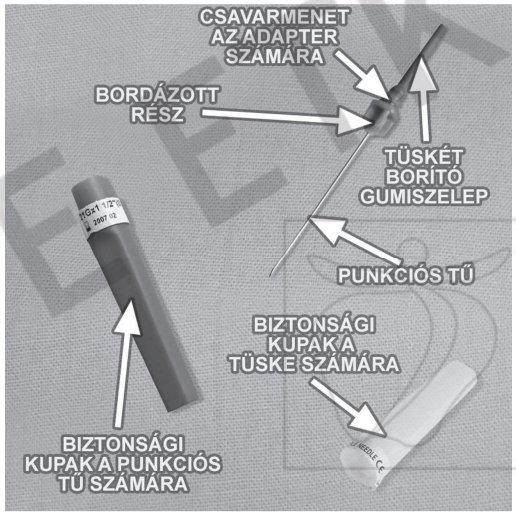
Srangulator



Placement of disposable strangulator with fixing-free device

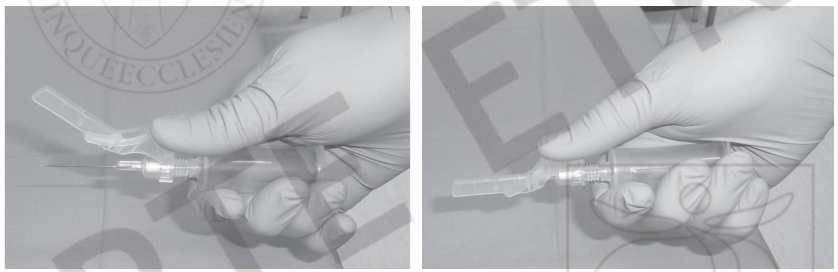
Special tools required for venous blood sampling

Venipuncture needle



Special tools required for venous blood sampling

Venipuncture needle with active safety system



Activating safety system after venipuncture

- to prevent needle stick accidents the safety system should be activated after the blood sample is needed
- after activation the safety cap cannot be removed from the needle

Special tools required for venous blood sampling
Winged needle

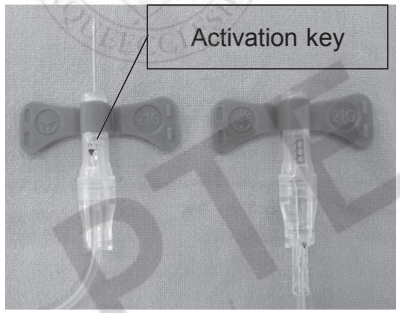
- 7-35 cm long flexible tube connector
- wings:
  - allow for a firm grip
  - facilitate easy attachment of needle
  - prevent needle displacement during infusion.
- good for superficial and vulnerable vein puncture
- commonly used type of needle in paediatric and elderly care

Special tools required for venous blood sampling
Winged needle

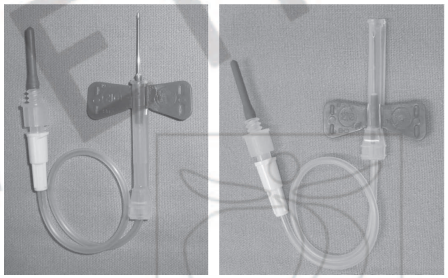
- effective puncture can be seen due to the plastic wire
- the active safety systems of winged needles prevent needlestick accidents
- after use a plastic needle guard should be pulled or snapped on needle
- the safety system is due to the spring structure

Special tools required for venous blood sampling

Operation of the winged needle safety system



After the activation of the safety system the needle retracts due to spring system



During activation of the safety system, the plastic needle guard should be put on needle

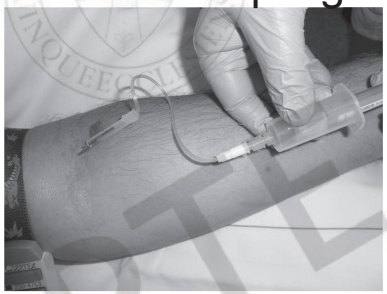
Special tools required for venous blood sampling
Winged needle

- 21,23,25G-sized needles are used for venipuncture
- the use of 25G needle size should be avoided due to any hemolysis of the sample
- prior to blood sample tube charge it is necessary to pre- charge the flexible tube,
  - with the usage of a sample tube not sent to examination or with a so-called sample waste tube
- to prevent needlestick injuries it is necessary to connect the cylinder to the winged needle

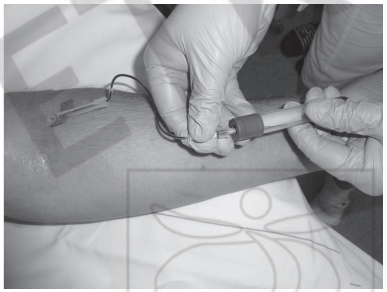
Special tools required for venous blood sampling

Winged needle

Incorrect sampling



Use of winged needle without re-charge wire



Use of winged needle without cylinder

Consequence

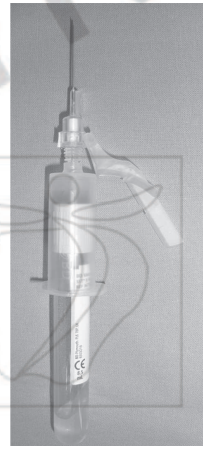
Insufficient sample
The ratio of the additive substance is not appropriate

Needlestick injury

Special tools required for venous blood sampling

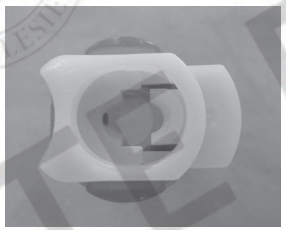
Adapter, tube holder, cylinder

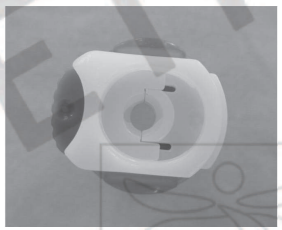
- transparent plastic adapters from different manufacturers is marketed with different appearances
- manufacturers generally require to use the adapter systems they sell
- different size
- reusable and disposable
- continuous replacement of vacuum tubes is ensured by these devices



Special tools required for venous blood sampling

Adapter, tube holder, cylinder





Cylinder with needle trigger

It allows to remove the needle from the cylinder without touchinbg the needle after venipuncture

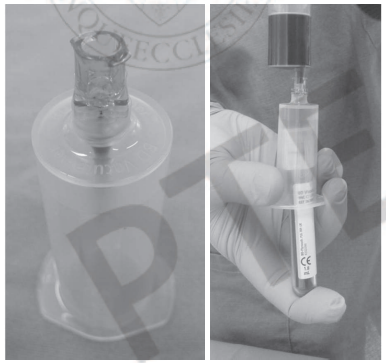
Special tools required for venous blood sampling

Transmission device equipped on syringe

- it allows blood transmission from syringe into blood sample tube
- the device is connected to the syringe cone (slip or luer lock connection)
- similarly to cylinder,the blood sample tube can be inserted and adequate supply of blood is charged by the vaccuum
- after the procedure it is disposed with the syringe in the hazardous waste

Special tools required for venous blood sampling

Transmission device equipped on syringe



The plunger should not be pushed during or after the transfer

- overcharge can occur
- by the pressure the syringe can drop and blood splash may occur.

Special tools required for venous blood sampling

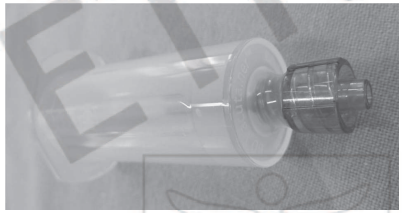
Luer Adapter

- makes it possible to use a closed venipuncture system connected to cannula with luer adapter (luer lock and slip version)
- the cylinder assembled adapter can be placed directly to the end of cannula
- blood can be obtained without the use of syringe
- pre-washing and re-drawing of cannula is needed to avoid contamination

Special tools required for venous blood sampling

Luer Adapter

Luer slip adapter



Disposable cylinder welded by luer lock adapter

Cylinder with luer lock adapter

Special tools required for venous blood sampling

Blood sampling tube, vacuum tube

- the safety blood sampling tubes have different coloured caps which are hermetically sealed
- the tube contains a vacuum necessary for the prescribed and indicated amount of blood taken
- sterile tube
- the rubber seal recessed into the cap is punctured by the spike opposite to the cylinder of the needle
- the tubes are labelled according to the colour-code of the safety plug, based on the ISO standard

Special tools required for venous blood sampling

Blood sampling tubes

Native tube

Red or white plugged tube

Additive-free tube

- for blood group serology, body fluid tests
- for puncture examination

Special tools required for venous blood sampling

Blood sampling tubes

Serum tubes:

- contain silicone coating which prevents the red blood cells adhering to the wall of the tube and include SiO2 particles for activation of coagulation, which takes 60 min. (chemical tests)

Special tools required for venous blood sampling

Blood sampling tubes

Serum tubes:

- SiO2 sputter tube containing a separator gel
- Used for chemical and serological tests in clinics
- Allowing the sample to clot within 30 min

Special tools required for venous blood sampling

Blood sampling tubes

Serum tubes:

Serum tube with orange coloured plug:

- function is that of the tube with red and yellow/gold separator gel
- in addition to serum separator gel it comprises thrombin
- clotting in the tube can be achieved within 5 min
- in urgent cases it allows rapid serum analysis

Special tools required for venous blood sampling

Blood sampling tubes

Tube with purple plug (EDTA):

- for hematological tests
- aim at detecting ammonium, molecular diagnostic tests (PCR, polimerase chain reaction)
- anticoagulant (EDTA) in the tube prevents coagulation by CA2+ binding
- the types of tube can be: K2EDTA and K3EDTA

Special tools required for venous blood sampling

Blood sampling tubes

Tube with green plug (heparin, plasma):

- acid-base parameters, blood gas analysis,
- osmotic fragility,
- chromosoma tests,
- ammonium tests
- for histocompatibility tests
- the tube contains Na-,NH4-, Li-,heparin which blocks coagulation by the activity of antithrombin
- the sample results in plasma and not serum

Special tools required for venous blood sampling

Blood sampling tubes

Tube with grey plug (glucose):

- used for glucose and lactate tests
- contains stabilizator (NaF for the inhibition of glycolysis)and
- anticoagulant (EDTA, K-oxalate, Na/Li heparin)
- hematological (EDTA) tube is used for glucose sampling containing no NaF except for anticoagulant, therefore glucose becomes unsteady resulting in incorrect result

Special tools required for venous blood sampling

Blood sampling tubes

Tube with blue plug (citrate blue):

- for hemostasis tests: prothrombin, fibrinogen, thrombin time, partial thromboplastin time, D-dimer
- contains 3.2% and 3.8% citrate solution
- its double-walled version is called „sandwich-tube" that provides a safer vacuum for a sufficient sample
- besides Na citrate the CTAD tube contains theophyllin, adenosin,dipridamol for stabilizing the sample

Special tools required for venous blood sampling

Blood sampling tubes

Tube with black plug (sedimentation tube):

- used for testing the sedimentation speed of blood cells based on Westergren method
- used for demonstrating the non specificity of inflammatory processes . 3.3% Na citrate solution for detecting coagulation can be found in the tube

Special tools required for venous blood sampling

Blood sampling tubes

Sample waste tube:

- the tube is not for analytical use
- additive-free
- for taking the first sample
- for pre-charge of the wire of the winged needle

Order of sampling tubes

- transfer of additives can be prevented from sample to sample
  - coagulant activator additive (**red/yellow** serum tube) should not enter the tube (**blue**) containing citrate
- the ingredients of the anticoagulant and the sampling order is important (pseudohypernatraemia)
  - contamination by Na chlorid that may come from Na2EDTA or Na citrate tubes
  - contamination by K-EDTA may cause pseudohyperkaelemia

Order of sampling tubes

According to the recommendation of the Clinical and Laboratory Standards Institute (CLSI), the order of charge of tubes are as follows:

1. haemoculture bottles
2. separatorgel-free and additive-free native tube (red,white)
3. coagulation tube (blue)
4. serum tube with or without separator gel (yellow/gold,red)
5. heparin tube (green)
6. tube containing EDTA (purple)
7. tube for glucose sampling (grey)
8. all the others (sedimentation)

Capillary blood sampling

Capillary blood sampling can be applied in the following cases:

- The patient has no suitable vein for puncture
- The condition of veins or other contraindications provide no chance for puncture
- Small amount of blood can be used for laboratory diagnostic tests (bedside tests, into blood gas capillary sampling tube)
- For collecting extremely small amonut of blood for newborns, infants, or adults to avoid iatrogenic anemia

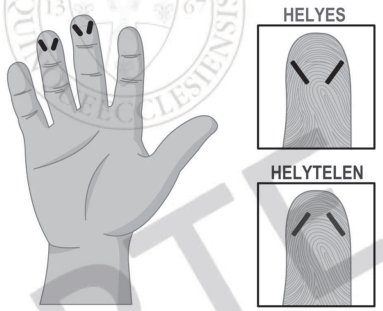
Capillary blood sampling

- the site of puncture is most commonly the fingertip, earlobe, or the heel for newborns and infants
- disposable, semi-automatic microspear is applied
  - depth and strength of pricking is known
  - if spear is not touched the chance for needlestick accident decreases
- the adequate amonut of blood is the pre-condition of effective intervention (warming up, massage)
- we should prick the skin fold forming the fingerprint perpendicularly in lateral direction from the middle of the fingertip

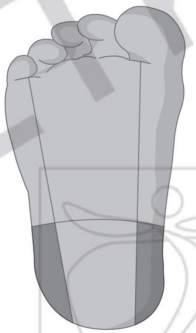
Capillary blood sampling

- after pricking the first blood drop should be wiped off because it contains tissue fluid
- charge of the Astrip capillary tube and the appropriate micro capillary blood sampling tube
  - removing the plug, the opening for collecting the blood sample should be touched with the blood drop, by which blood runs down the bottom of the tube. The tube should be sealed after collecting the adequate amount of sample
  - sampling without opening the tube makes it possible charge with the help of a capillary tube

Capillary blood sampling



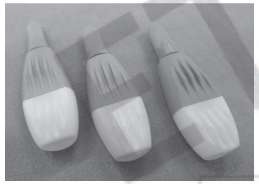
Site of pricking for capillary sampling on an adult hand



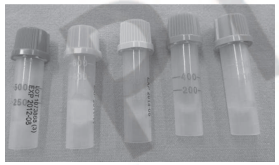
Site of pricking for capillary sampling in case of a newborn or infant

Capillary blood sampling Devices

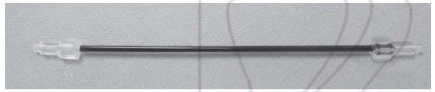
semi.-automatic heel pricking device



semi-automatic finger pricking device



microcapillary tubes



Astrup capillary tube after charge

Dry diagnostics and bedside tests/ point of care testing (POCT)

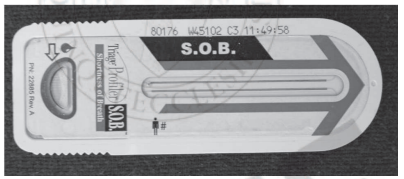
- it may help fast decision-making
- set fast diagnosis in emergency cases
- blood loss decreases
- no need for spin
- simple use characterizes devices and tests
- easy to use surface, fast analysis
- less precise than the chemical tests done in laboratory

Dry diagnostics and bedside tests/ point of care testing (POCT)

Some POCT tests:

- For separating and confirming the disorders of dyspnoe
- In the diagnosis of cardiovascular disease to determine triglycerides and cholesterol
- Following-up the oral anticoagulant therapy by determining the INR value
- Checking the blood sugar level and determining glycaled hemoglobin
- Blood gas analysis
- Urine drug tests
- Determining urine albumin

Dry diagnostics and bedside tests/ point of care testing (POCT)



for differentiated diagnostics of bedside dyspnoe

INR bedside test

Glucometer (blood sugar meter)

- The first portable blood sugar meter was available in 1969
- Advantage: more frequent blood sugar check as comapared with laboratory measurements
- More effective glycemic control can be achieved
- Decreases morbidity and mortality of glycemic complications

Glucometer

Functioning principles

- The glucose content of blood drop with specific enzymes to glucose on the test strip react to the enzyme
- The blood sugar value can be measured by detecting the product due to enzyme reaction photometrically and electrochemically
- It is based on the reaction of glucose,-oxydase, glucose-dehydrogenase enzymes

Glucometer

Affecting factors

- Most POCT blood sugar meter examines the glucose concentration of plasma showing higher glucose values than that of the total blood and affects:
  - Haemotocrite value
  - The systolic BP, which should not be lower than 80 Hgmm, because only a small amount of capillary blood gets in the sample if the value is lower, the majority of it is the interstitial fluid

Glucometer

Affecting factors

- Many drugs(dopamin, drugs with maltose and fructose content) may confound the glucose-oxydase reaction
- Anemia is raised incorrectly, polycytemia shows reduced glucose value
- the glucose-oxydase reaction needs oxygen therefore the analysis of some devices based on glucose-oxydase reaction is affected by the blood gas parameters of the patient
- measurement based on glucose dehydrogenase method is insensitive to the presence of O2 , thus this method is suitable for determination from arterial,venous, capillary blood

Glucometer

- The device can be used only with specific test strips
- It should be synchronized with the code number of the test strips
- Mechanic and chip calibration
- **„Lo”** message appears in case of low blood sugar value
- **„Hi”** message appears in case of high blood sugar value
- the measurement time corresponding to the modern demands is 5 sec

Glucometer

- The amount of sample volume depends on the device with the compatible test strip
- Modern devices need little sample:0.6-2 ul capillary blood
- The memory of devices is variable, suitable for storing 100-500 data
- Transferring data to PC is developing
- With the help of the pictogram attached to the values the patient can distinguish the parameters

Glucometer

Inserting chip with code into the device

An error message is displayed

Important aspect in blood sugar measurement

- checking the code number of test strip on the panel of display
- pricking is carried out by an automatic microspear and using no needle (puncture strength and depth controlled)
- the first blood drop is diluted due to great amonuts of tissue fluid resulting in incorrect measurement
- too little sample may lead to incorrect result
- if the device shows an error message (usually letter”E” and number „1”), repeated measurement is needed

Possible complications of venipuncture

- pain
- heavy bleeding
- hematoma
- infection, sepsis
- collapse
- allergy
- nerve injury
- anemia
- vein collapse
- mesenchymal transformation of the vein wall
- skin scarring
- petechiae
- accidental arterial puncture
- artery aneurysm
- artery spasm
- arterio-venous fistula