KOMAR UNIVERSITY OF SCIENCE AND TECHNOLOGY (KUST)

DEPARTMENT OF MEDICAL LABORATORY SCIENCE

PHLEBOTOMY/DIAGNOSTIC TECHNIQUES (MLS 4440C)

LAB MANUAL

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PHD IN HEMATOLOGY AND CLINICAL BIOCHEMISTRY

SPRING 2017

Preface

This "Hand out" laboratory manual has been prepared mainly in light of three excellent manuals namely The Phlebotomy Textbook, Third Edition, 2011 by Susan King and Updated Phlebotomy Procedures, Sixth Edition, 2010 by Helen Maxwell. Some modifications has been applied based on the direction and requirements of the Medical Laboratory Science (MLS) department curriculum and study program.

This manual composed of 10 exercises in total focused on the basic concepts of Phlebotomy/Diagnostic Techniques and assists students to get necessary knowledge, skills, and practice in this field. In addition, students will learn how to work safely in Phlebotomy section labs. Each exercise composed of a short background about a specific topic followed by the principle, aims, required material, and procedures needed to perform that exercise. The results of each exercise will be recorded by the students and together with the answers of some review questions will be submitted to the lab instructor in the form of lab reports.

Exercises are written in a way to be easy to follow yet informative to the students. The overall laboratory experience reinforces the concepts of the theoretical lectures and together provide a comprehensive knowledge to the students in the field of Phlebotomy/Diagnostic Techniques.

Dr. Heshu Sulaiman Rahman

Spring 2017

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Course Objectives

-This course starts with an introduction of what science is, and how knowledge is gained by using the scientific method.

-After participating in the course, students would practice safe procedures within a laboratory.

-Students will understand and demonstrate the anatomical position and main sites for blood collection.

-The lab portion of this course provides a solid background to characterize different procedures and laboratory techniques.

-Effectively interpret the main and almost used diagnostic laboratory tests.

-Identify and utilize appropriate reference resources to clarify and expand knowledge Phlebotomy.

-This course will provide students with a solid foundation in the fundamental concepts and knowledge base of Human diagnostic techniques and related lab experiments.

-This course provides a coherent framework for understanding Phlebotomy and prepares students for their upper-level courses.

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TITLE OF THE EXPERIMENT

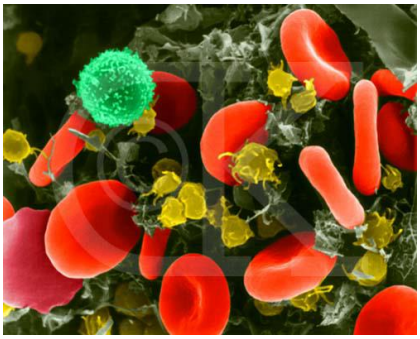
DATE

NAME

ID

1. **Aim of the Experiment**
2. **Materials**
3. **Methods**
4. **Results**
5. **Discussions**
6. **Conclusions**
7. **Supplementary Data**
8. **References if any**

LABORATORY 1: AN INTRODUCTION TO THE PHLEBOTOMY



Introduction

-The word Phlebotomy comes from the Greek words *phlebo-*, meaning "pertaining to a blood vessel", and *-tomia*, meaning "cutting of‘.

-It is the process of making an incision in a vein with a needle.

-The procedure itself is known as a venipuncture.

Phlebotomist

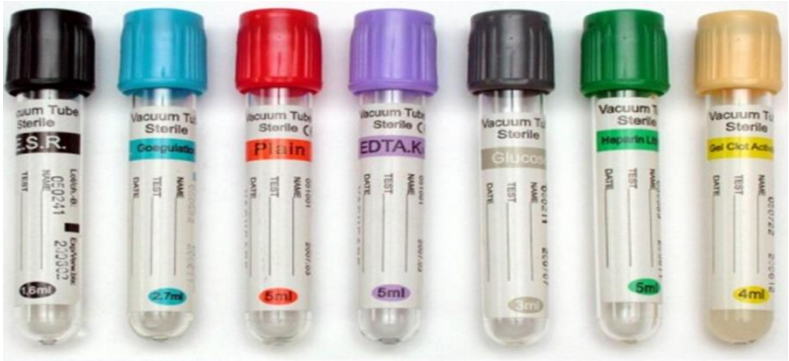
-Is a person who trained to draw blood from a patient for clinical or medical testing, transfusions, donations or research purpose.

-Phlebotomist may be doctors, nurses, medical laboratory scientists and others that do portions of phlebotomy procedures.

General Phlebotomy Lab Requirements

1. Test Tubes

Different types of collecting sample tubes with different containing additives and/or anticoagulants for various laboratory procedures should be available in the lab.



2. Anticoagulants

It refers to any substance that inhibits the blood coagulation. The choice of anticoagulant depends on the type of examination to be carried out, thus they are of many types, which include:

1. EDTA (ethylene diamine tetra acetic acid)

Dipotassium and disodium salts of EDTA prevent the coagulation of blood by combining with calcium.

It has the advantage of preserving the stain ability and morphologic characteristics of leukocytes. EDTA can be used in 2 forms, which are liquid and dry (powder) form.

2. Heparin

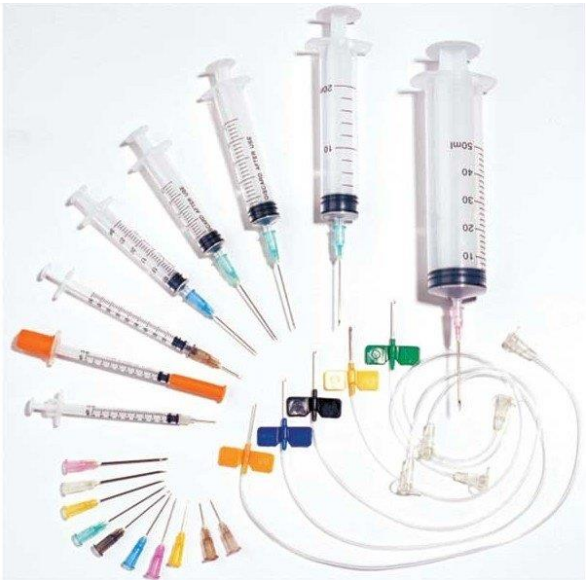
It prevents coagulation of blood by interfering with the conversion of prothrombin to thrombin. A 5 mL syringe can be rinsed with 1% heparin solution for highest anticoagulation activity. It has the disadvantage of adversely affecting the leukocyte stain ability.

3. Sodium Citrate

It is not commonly adopted for the preservation of blood for hematologic determination and can be used for blood transfusion.

4. Oxalates (Sodium and Potassium)

They also prevent coagulation of the blood by combining with calcium. They should not be used as an anticoagulant when blood non protein nitrogen and blood urea tests are required.



Classification[1]	Items[2]	Additive	Color[3]	Tube Material[4]	Main Intended Use[5]	Basic Tube size[6] (mm)
Serum Tube	No Additive Tube	/	Red	Glass	Determinations in serum for clinical biochemistry, immunology, and serology	Φ 13x75 Φ 13x100 Φ 16x100
	Pro-coagulation Tube	Clot Activator	Red	Glass/Plastic		
	Gel & Clot Activator Tube	Gel & Activator	Golden	Glass/Plastic		
Plasma Tube	Glucose Tube	Potassium Oxalate/Sodium fluoride or EDTA /Sodium fluoride	Grey	Glass/Plastic	Determinations in stabilised anti-coagulated whole blood or plasma for glucose and lactate testing	Φ 13x75 Φ 13x100
	PT Tube	0.109mol/L or 0.129mol/L Sodium Citrate (1:9)	Light Blue	Glass/Plastic	Determinations in citrated plasma for coagulation testing	Φ 13x75 Φ 13x100
	Heparin Tube	Lithium Heparin, Sodium Heparin	Green	Glass/Plastic	Determinations in heparinised plasma for clinical chemistry	Φ 13x75 Φ 13x100 Φ 16x100
	Gel & Heparin Tube	Gel & Lithium Heparin or Sodium Heparin	Green	Glass/Plastic	For plasma determinatons in chemistry.	Φ 13x100 Φ 16x100
	Gel & E DTA.K2 Tube	Gel & EDTA.K2	Lavender	Glass/Plastic	For use in molecular diagnostic test methods(such as but not limited to PCR).	Φ 13x100 Φ 16x100
Whole Blood Tube	EDTA Tube	EDTA.K2 EDTA.K3	Lavender	Glass/Plastic	Determinations in EDTA whole blood for hematology	Φ 13x75
	ESR Tube	0.109mol/L or 0.129mol/L Sodium Citrate (1:4)	Black	Glass	Blood cell sedimentation rate test	Φ 9x120 Φ 13x75
				Plastic		Φ 13x75

3. Needles

The size of the needle should be 19-21 gauges in adults and 21-23 gauges in paediatrics to avoid hemolysis during sample drawing from the patient and also during evacuation into the test tubes.

4. Disposables

They include syringe, needle, gauze, swab, gloves, plasters and lancets.

5. Consumables

They include various types of disinfectants and sterilizers such as 5% savlon solution, tincture iodine, or 70% alcohol.

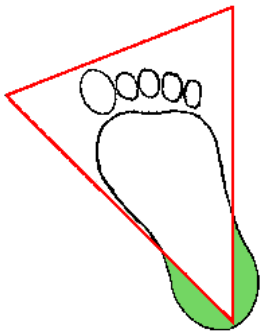
6. Missalenous

They include lab coat, gown, apron, permanent marker, vacuette and tourniquates.

Types of Blood Collection

1. Capillary (Skin) Blood Collection

Blood is collected from capillary network if few drops of blood are required such as measurements of Hb level, RBC count by microdilution method and preparation of thin blood film. Capillary blood cannot be used for platelet testing.

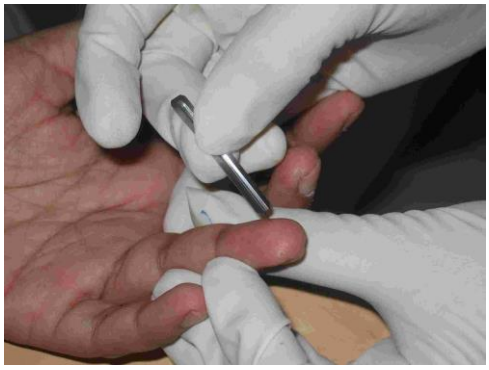


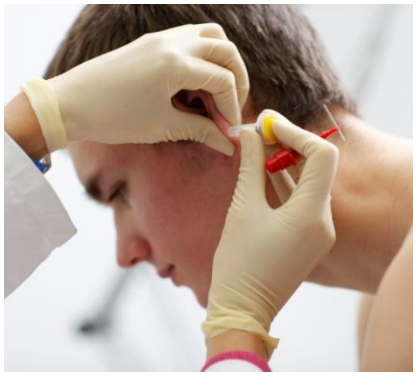
Major Capillary Blood Sampling Sites

a. Finger prick.

b. Ear lobe.

c. Sides of the heel especially in pediatric and neonatal patients.



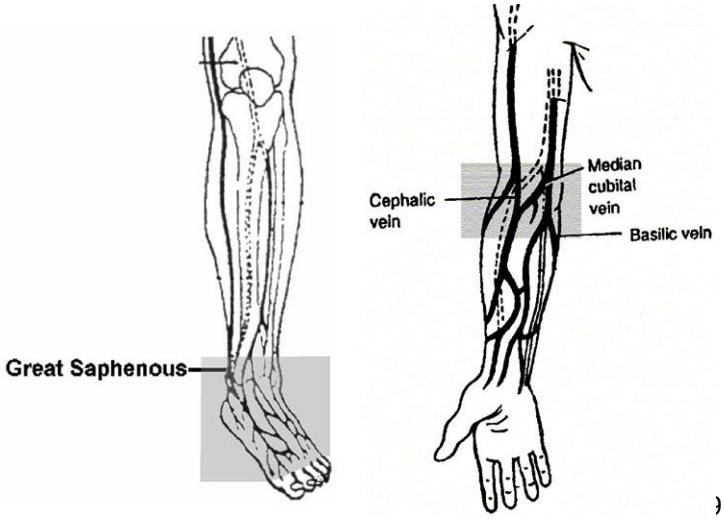


2. Venous Blood Collection

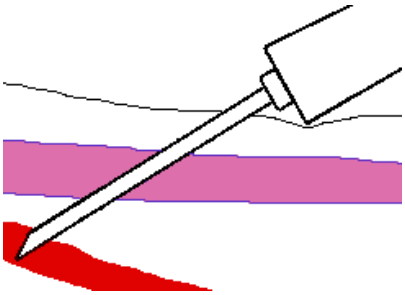
Blood is collected from the venous system of the patient when large amount of blood is required. Choose the veins that are large and accessible, and avoid bruised or scarred areas.

Major Venous Blood Sampling Sites

1. Median cubital veins.
2. Cephalic (dorsal hand) veins.
3. Basilic veins.
4. Great Saphenous (foot) veins.



3. Arterial Blood Collection



-Arterial puncture is used mainly for blood gas analysis (O2 and CO2) especially during emergency cases.

-The blood is bright red (arterial) rather than venous. Apply firm pressure for more than 5 minutes.

DO NOT TAKE BLOOD FROM:

-The upper extremity on the side of a previous mastectomy, lymphostasis can occur when a tourniquet is applied.

-Intravenous therapy (IV)/blood transfusions - fluid may dilute the specimen, so collect from the opposite arm if possible. Otherwise, satisfactory samples may be drawn below the IV by following these procedures:

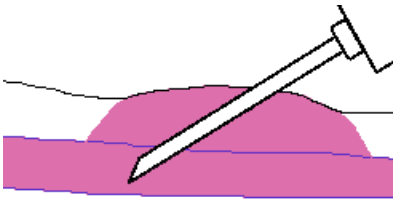
- Turn off the IV fluid for at least 2 minutes before venipuncture.
- Apply the tourniquet below the IV site. Select different vein.
- Discard first 5 ml of blood and draw the required blood.

-Cannula/fistula/heparin lock.

-Edematous extremities - tissue fluid accumulation alters test results.

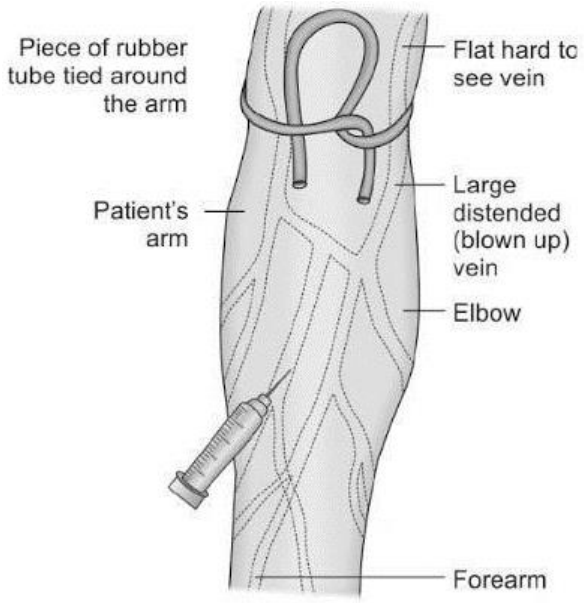
-A haematoma site, as abnormal results may occur.

-An arm with infection at the venipuncture site.



General Cautions/Procedure

1. Be quite with the patient and let him/her feel comfortable.
2. Verify that computer printed labels match requisitions. Check patient identification band against labels and requisition forms. Ask patient for his /her full name, address, identification number, and date of birth.
3. If a fasting specimen or dietary restriction is required, confirm patient has fasted or eliminated food from the diet as ordered by physician.
4. Position the patient on a chair or a bed properly.
5. Choose the appropriate tube for collection.
6. Apply a tourniquet 3-5 inches above the antecubital fossa for not more than 1 minute.
7. Ask the patient to make (clench) a fist without vigorous hand pumping. Select a suitable site for venipuncture.
8. Feel or palpate for any vein to determine its potential size, depth and direction that many be hidden. If still the vein is not visible or palpable, ask the patient to "pump" the hand 3 times and no more, as it may cause hemoconcentration. If all measures fail to palpate a suitable vein, ask for the opinion from another experienced technician.
9. Put on gloves with consideration of latex allergy for the patient.



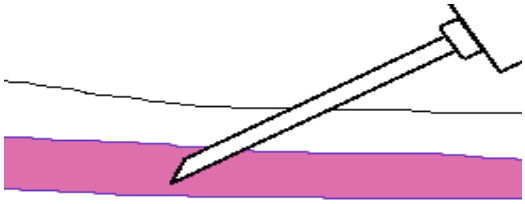
10. Cleanse the venipuncture site with 70% isopropyl alcohol. Allow the area to dry and anchor the vein firmly.
11. Enter the skin with the needle at approximately 30degree angle or less to the arm with the level of the needle up;

a. Follow the geography of the vein with the needle.

b. Insert the needle smoothly and fairly rapidly to minimize the patient discomfort.

c. If using a syringe, pull back on the barrel with a slow, even tension as blood flows into the syringe. Do not pull back too quickly to avoid hemolysis or collapsing the vein.

d. If using an evacuated system, as soon as the needle is in the vein, ease the tube forward in the holder as far as it will go, firmly securing the needle holder in place. When the tube has filled, remove it by gasping the end of the tube and pulling gently to withdraw and gently invert tubes containing additive and/or anticoagulant.



12. Draw the proper volume required for each test.

13. Release the tourniquet when blood begins to flow. Never withdraw the needle without removing the tourniquet.

14. Withdraw the needle, and then apply the pressure to the site. Cleaners to be available such as 5% savlon solution, tincture iodine, or 70% alcohol.

15. Apply adhesive bandage strip over cotton ball or gauze to adequately stop the bleeding and to avoid the hematoma.

16. Mix the inverted tube with anticoagulant; do not shake the tubes. Check the condition of the patient. Dispose of the contaminated material in designated containers (sharps container) use Universal precautions.

17. Label the tubes before leaving patients side with:

a. Patients first and last name.

b. Unique hospital Identification number and name of the department doing the test.

c. Date, time and place of collection.

d. Specimen type (whole blood, serum, plasma, body fluid, genetics, etc.).

e. Initial name of the sample collector.

18. Deliver the tubes of the blood for testing to appropriate laboratory section or central receiving and processing area.

19. Great care being taken to avoid self-injury with the needle. The needle should be removed from the syringe before expelling the blood into the specimen container. The needle should be put directly into a special receptacle for sharp objects without re-sheathing it.

Hemoconcentration

-It means an increased concentration of larger molecules and formed elements in the blood may be due to several factors:

-Prolonged tourniquet application (no more than 2 minutes).

-Massaging, squeezing, or probing a site.

-Long-term IV therapy.

-Sclerosed or occluded veins.

Prolonged Tourniquet Application

-Primary effect is hemoconcentration of non-filterable elements (proteins).

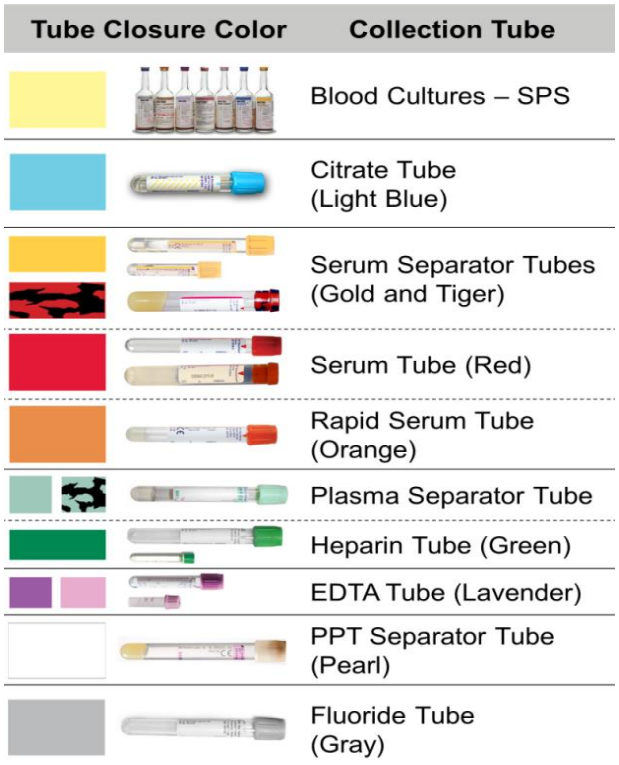
-The hydrostatic pressure causes some water and filterable elements to leave the extracellular space.

-Significant increases can be found in total protein, aspartate aminotransferase (AST), total lipids, cholesterol, and iron.

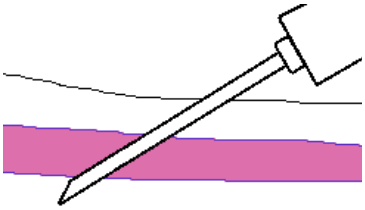
-Affects packed cell volume and other cellular elements.

The Order of Blood Sample Collection

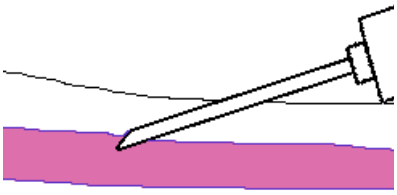
The order (sequence) of sample collection should be as indicated below if a patient has more than 1 test been ordered.



Sources of Error



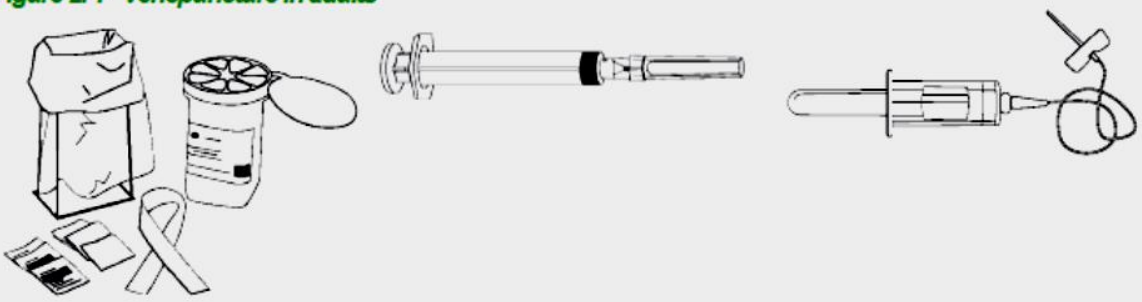
1. Difficult finding of a vein.
2. Malpractices of phlebotomist.
3. Improper needle size which leads to hemolysis of the blood.
4. Expelling the blood vigorously into a tube.
5. Shaking or mixing the tubes vigorously.
6. Performing blood collection before the alcohol has dried at the collection site.



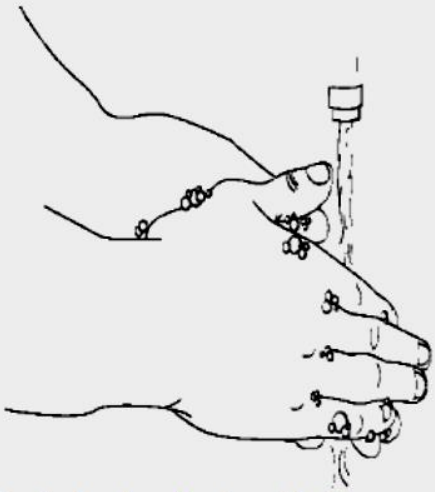
Consequences of RBC Hemolysis

Hemolysis can falsely increase blood constituents such as potassium, magnesium, iron, LDH, phosphorus, ammonium, and total protein**.** Because of the extremely important role of potassium in cardiac excitation, elevations due to hemolysis can be problematic, especially for emergency room patients who are at risk of hemolysis during a stressful blood collection.

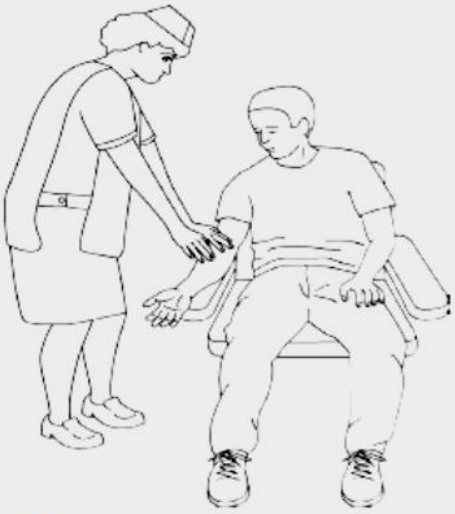
Figure 2. 1 Venepuncture in adults



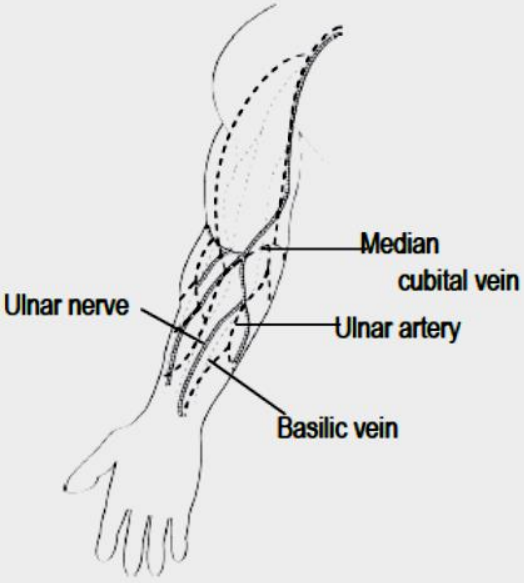
. Assemble equipment and include needle and syringe or vacuum tube, depending on which is to be used.



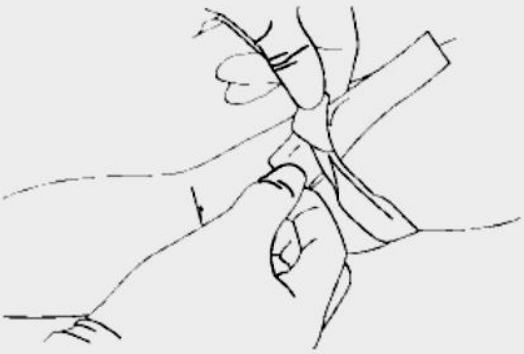
2. Perform hand hygiene (if using soap and water, dry hands with single-use towels).



3. Identify and prepare the patient.

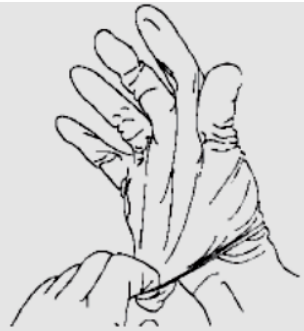


4. Select the site, preferably at the antecubital area (i.e. the bend of the elbow). Warming the arm with a hot pack, or hanging the hand down may make it easier to see the veins. Palpate the area to locate the anatomic landmarks. DO NOT touch the site once alcohol or other antiseptic has been applied.



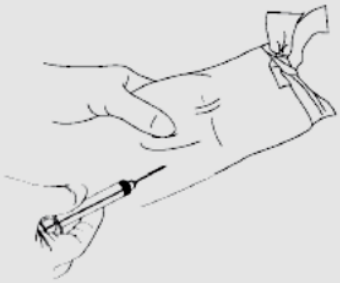
5. Apply a tourniquet, about 4–5 finger widths above the selected venepuncture site.

6. Ask the patient to form a fist so that the veins are more prominent.

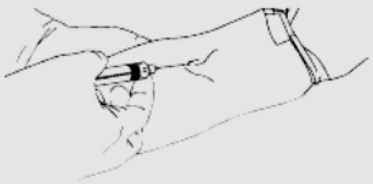


7. Put on well-fitting, non-sterile gloves.

8. Disinfect the site using 70% isopropyl alcohol for 30 seconds and allow to dry completely (30 seconds).

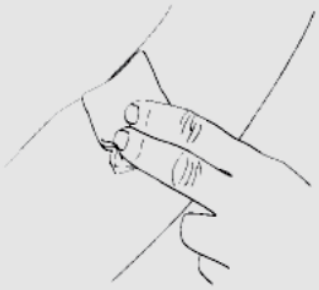


9. Anchor the vein by holding the patient's arm and placing a thumb BELOW the venepuncture site.



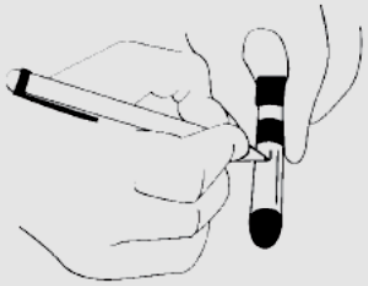
10. Enter the vein swiftly at a 30 degree angle.

11. Once sufficient blood has been collected, release the tourniquet BEFORE withdrawing the needle.



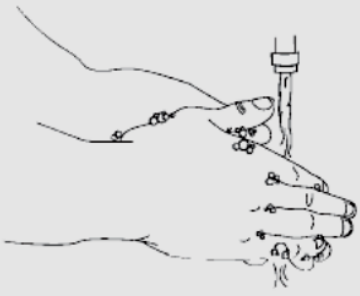
12. Withdraw the needle gently and then give the patient a clean gauze or dry cotton-wool ball to apply to the site with gentle pressure.

13. Discard the used needle and syringe or blood-sampling device into a puncture-resistant container.



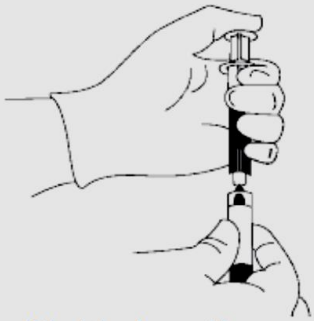
14. Check the label and forms for accuracy.

15. Discard sharps and broken glass into the sharps container. Place items that can drip blood or body fluids into the infectious waste.

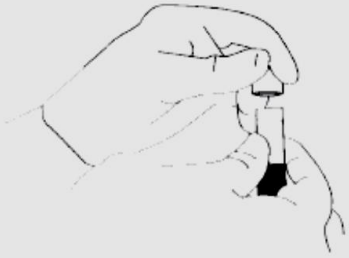


16. Remove gloves and place them in the general waste. Perform hand hygiene. If using soap and water, dry hands with single-use towels.

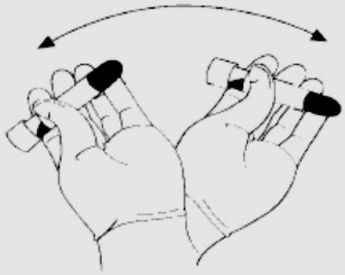
Figure 2. 2 Filling tubes



1. If the tube does not have a rubber stopper, press the plunger in slowly to reduce haemolysis (this is safer than removing the needle).

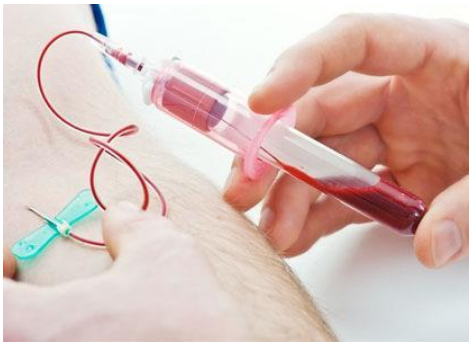


2. Place the stopper in the tube.



3. Following laboratory instructions, invert the sample gently to mix the additives with the blood before dispatch.

LABORATORY 2: BLOOD TEST ANALYSIS



Hemogram

-The hemogram or complete blood count (CBC) is a profile of tests that examines different parts of the blood.

-It is actually used as a broad screening test to check for general disorders such as anemia, infection, cancer, genetic disorders, and many other diseases.

	Order of draw	Stopper color	Additives	Laboratory Use
1	Plain Tube	Red Top Tube	no additive	Drug levels, blood bank
2	EDTA Tube	Lavender Top Tube	EDTA*	CBC*,HbA1c
3	Heparin Tube	Green Top Tube	Sodium Heparin	Plasma chemistry ,ammonia level
4	ESR Tube	Black Top Tube	Sodium citrate	Westergren sedimentation rate
5	Glucose Tube	Grey Top Tube	Sodium fluoride	glucose tolerance testing, alcohol level
6	PT Tube	Blue Tube	Sodium citrate	PT*,PTT*
7	Serum Tube	Yellow Top Tube	ACD* SPS*	Whole blood determination
8	Thrombin Tube	Orange Top Tube	Thrombin	Chemical testing
9	Gel Yellow tube	Serum Gel Tube	contains a clot activator and serum gel separator	various laboratory tests

EDTA=Ethylene diamine tetraacetic acid, ACD= Acid citrate dextrose, CBC=Complete blood count,PT=Prothrombin times, PTT=Partial thrombinplastin times, SPS=sodium polyanethol sulfonate

LABORATORY SERVICE - UNIVERSITY OF UTAH HOSPITAL

Patient Name: _____

Patient ID: _____

Patient Birthdate: _____ **Sex:** _____

Source of Specimen: _____

Date Collected: _____ **Time:** _____ **Phleb:** _____

Physician: _____ **Location:** _____

Diagnosis: _____

Tests Requested:

_____ **Electrolyte Panel** _____ **Complete Blood Count**

_____ **Hepatic Panel** _____ **Protime / PTT**

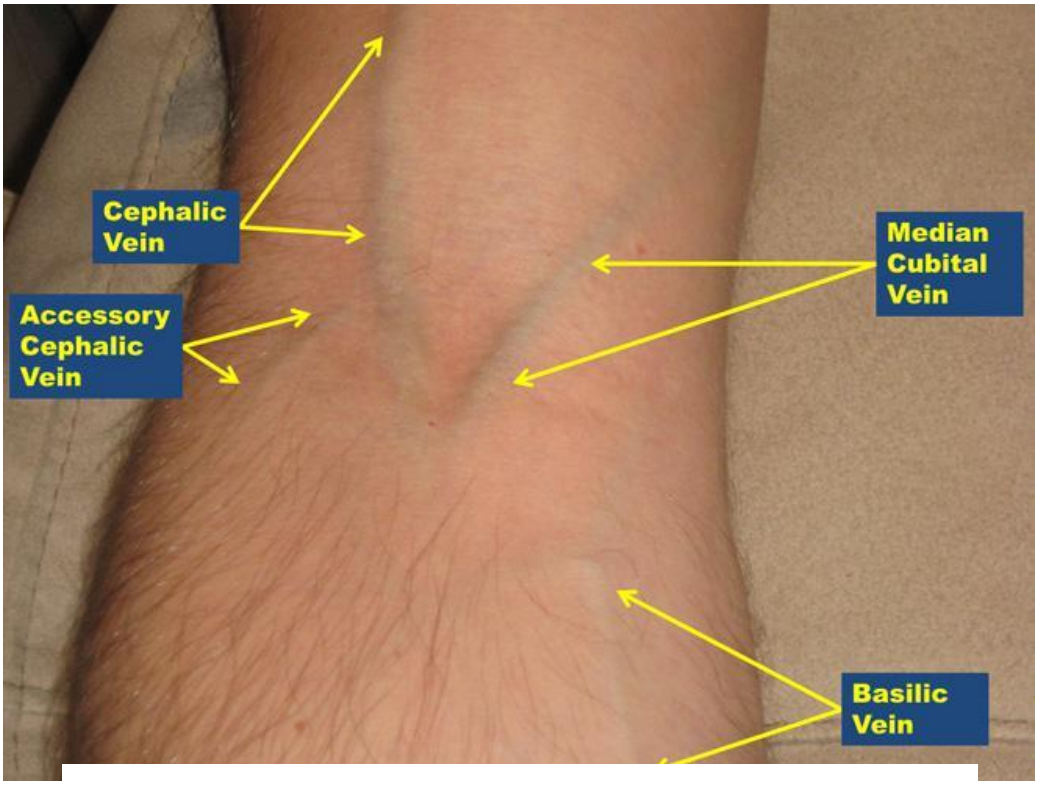
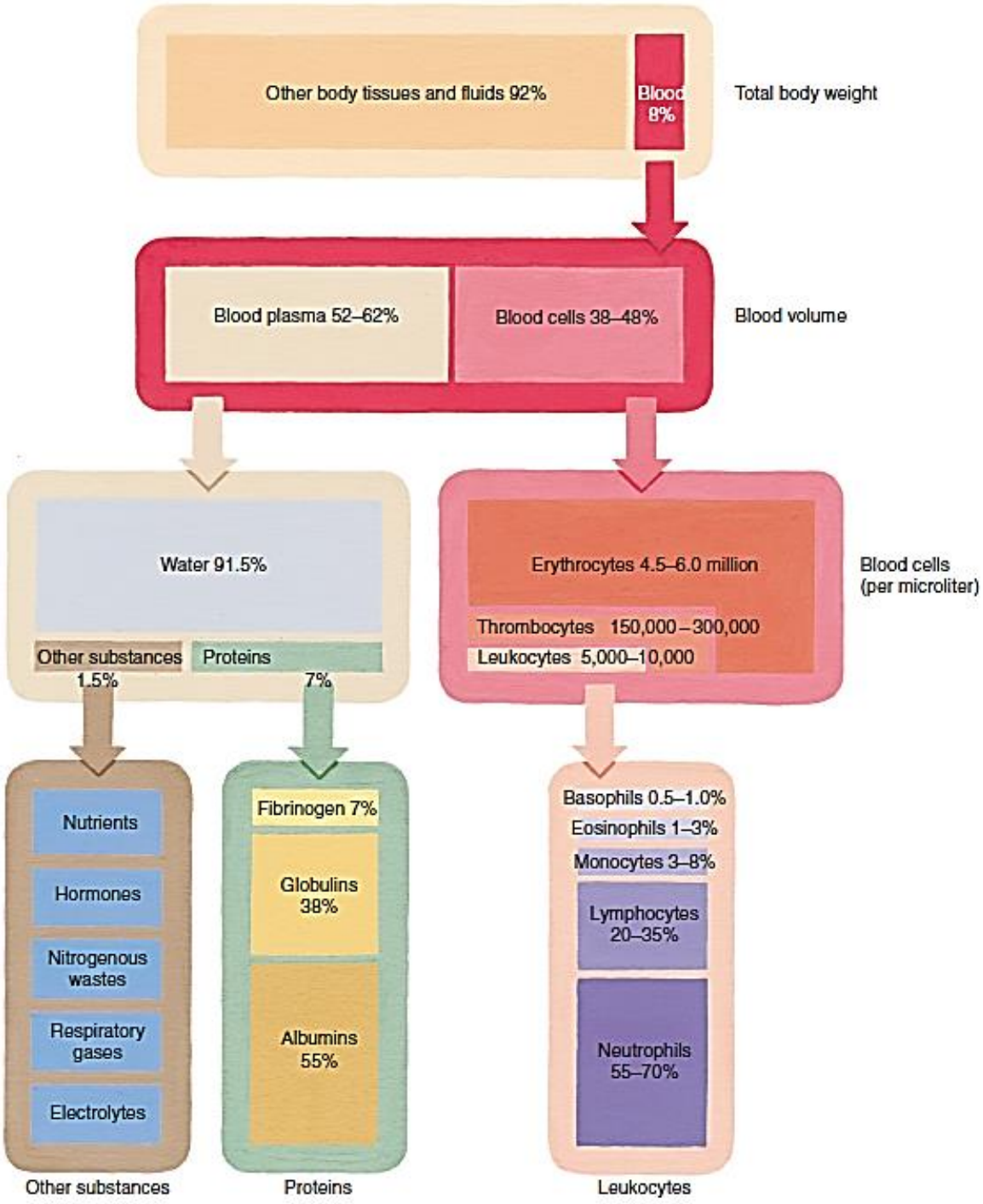


FIGURE 8-34 **A, Venoscope II transilluminator device.** *(With permission from Di Lorenzo, MS and Strasinger, SK: Blood Collection: A Short Course, ed. 2. FA Davis, 2010, Philadelphia.)* **B, A vein appears as a dark line between the light-emitting arms of the Venoscope.** *(Courtesy of Venoscope, LLC.)*


Other body tissues and fluids 92%
Blood 8%
Total body weight
Blood plasma 52–62%
Blood cells 38–48%
Blood volume
Water 91.5%
Other substances 1.5%
Proteins 7%
Erythrocytes 4.5–6.0 million
Thrombocytes 150,000–300,000
Leukocytes 5,000–10,000
Blood cells (per microliter)
Nutrients
Hormones
Nitrogenous wastes
Respiratory gases
Electrolytes
Other substances
Fibrinogen 7%
Globulins 38%
Albumins 55%
Proteins
Basophils 0.5–1.0%
Eosinophils 1–3%
Monocytes 3–8%
Lymphocytes 20–35%
Neutrophils 55–70%
Leukocytes

Tests of the Hemogram Profiling

1. Hematocrit (HCT) or Packed Cell Volume (PCV)

It measures the percentage of RBCs in a given volume of whole blood.

2. Hemoglobin (Hb, Hgb)

It measures the amount of oxygen-carrying protein in the blood.

3. Mean Corpuscular Volume (MCV)

-It is a measurement of the average size of RBCs.

-The MCV is elevated when RBCs are larger than normal (macrocytic), such as in anemia caused by vitamin B12 deficiency.

-When the MCV is decreased, RBCs are smaller than normal (microcytic) as is seen in iron deficiency anemia or thalassemias.

4. Mean Corpuscular Hemoglobin (MCH)

-It is a calculation of the average amount of oxygen-carrying hemoglobin inside the RBC.

-Macrocytic RBCs are large so they tend to have a higher MCH, while microcytic RBCs would have a lower value.

5. Mean Corpuscular Hemoglobin Concentration (MCHC)

-It is a calculation of the average concentration of hemoglobin inside the RBCs.

-Decreased MCHC values (hypochromia) are seen in conditions where the hemoglobin is abnormally diluted inside the red cells, such as in iron deficiency anemia and in thalassemia.

-Increased MCHC values (hyperchromia) are seen in conditions where the hemoglobin is abnormally concentrated inside the red cells, such as in burn patients and hereditary spherocytosis, a relatively rare congenital disorder.

6. Platelet Count

-It is the number of platelets in a given volume of blood.

-Both increases and decreases can point to abnormal conditions of excess bleeding or clotting.

7. Red Cell Distribution Width (RDW)

-It is a calculation of the variation in the size of the RBCs.

-In some anemias, such as pernicious anemia, the amount of variation (anisocytosis) in RBC size along with variation in shape (poikilocytosis) causes an increase in the RDW.

8. Red Blood Cell (RBC) Count

-It is a count of the actual number of the RBCs per volume of blood.

-Both increases and decreases can point to abnormal conditions.

9. White Blood Cell (WBC) Count

-It is a count of the actual number of white blood cells per volume of blood.

-Both increases and decreases can be significant.

10. WBC Differential

It is determining the percentage of each neutrophil, eosinophil, basophil, monocyte and lymphocyte.

Hematology Analyzer (Coulter Counter)

It is fully automated, standardized device that used to determine:

- White Blood Cell (WBC) or leukocyte count *103
- Lymphocyte percent (LYMPH percent), %
- Mononuclear cell percent (MONO percent), %

- Granulocyte percent (GRAN percent), %
- Lymphocyte number (LYMPH #) *103
- Mononuclear cell number (MONO #) *103
- Granulocyte number (GRAN #) *103
- Red Blood Cell (RBC) or erythrocyte count *106
- Hemoglobin (Hb) concentration, g/dL
- Hematocrit (relative volume of erythrocytes) (Hct), %
- Mean Corpuscular (erythrocyte) Volume (MCV), fL
- Mean Corpuscular (erythrocyte) Hemoglobin (MCH), pg
- Mean Corpuscular (erythrocyte) Hemoglobin Concentration (MCHC), g/dL
- Red Cell (erythrocyte volume) Distribution Width (RDW), %
- Platelet (PLT) or thrombocyte count *103
- Platelet distribution width (PDW)
- Relative volume of thrombocytes (PCT)
- Mean Platelet (thrombocyte) Volume (MPV), fL

Beneficial Links

https://www.youtube.com/watch?v=R_-nf0J3i1w

https://www.youtube.com/watch?v=IYH0bmpX0i8

https://www.youtube.com/watch?v=fMAvlM1js08

https://www.youtube.com/watch?v=RjEXpMHh8M0

LABORATORY 3: Using of Minividas as a Diagnostic Tool

Introduction

-The mini VIDAS® or Compact multiparametric immunoanalyzer is an automated immunoassay system based on the Enzyme Linked Fluorescent Assay (ELFA) principles that provides an accurate on-demand test results.

-It is greatly appreciated worldwide for its simplicity, flexibility, reliability and availability.

-The system requires minimal maintenance, needing only one-point recalibration every 14 days and providing an optimized cost per result.

Characterization

-The mini VIDAS provides a self-contained, complete immunoassay automation.

-Using pre-dispensed disposable reagent strips and specially coated Solid Phase Receptacles (SPRs).

-It can pipette, mix, incubate, control, analyze samples, washing and reading without user intervention.

-It performs the exact assay (test) that requested.

-Test results are transmitted to the computer to be analyzed and printed.

General Advantages

-Robust and reliable.

-User Friendly data entry and patient reporting.

-Rapid analysis result.

-Simple processing, easy to use and rapid processing: Perform up to 36 tests per hour with a capacity to process over 200 samples per day.

-Multiparametric and compact: over 100 parameters available in single-test ready-to-use format.

-Optimized test loading.

-Single dose reagents.

Parameters

The mini VIDAS offers routine batch or random access (mixed) testing for:

1. Serology.
2. Immunochemistry.
3. Antigen detection.
4. Industrial microbiology.
5. Immunohemostasis.

Components

The components can be divided into three categories:

1. Hardware.
2. Software.
3. Consumables.

Hardware

-It is composed of 1 or 2 analytical modules.

-Each module containing 2-5 sections (A, B, C, D, E) of 6 positions each, in which 30 tests can be performed simultaneously.

-Each section is microprocessor-controlled and consists of:

1. A transport tray for reagent strips.

2. A pipetting system.

3. A SPR block for pipetting.

4. An incubation system.

-Each section operates independently, enabling the analytical module to handle a wide range of tests at one time.

-An indicator light on each section shows the current status.

-The indicator light is on when a section is performing an assay.

-The indicator light flashes when the assays are completed.

-The indicator light goes off when the reagent strips and SPRs are unloaded.

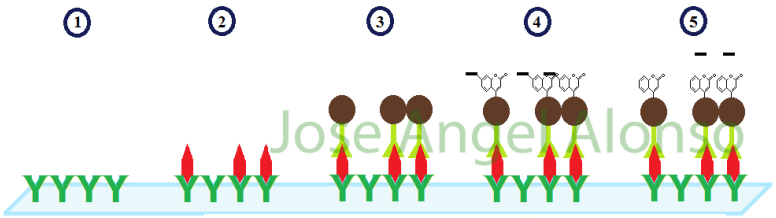
-The scanner is used to scan and entering a correct data of a tested sample.

Software

-The software is multi-task and provides for:

1. Entry of patient data and assays.

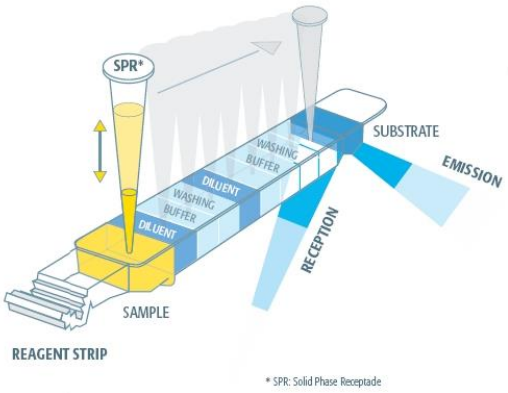
2. Storage of calibrations and results in memory.



3. Display and validation of results.

4. System operation and self-tests.

5. Management of patient records.

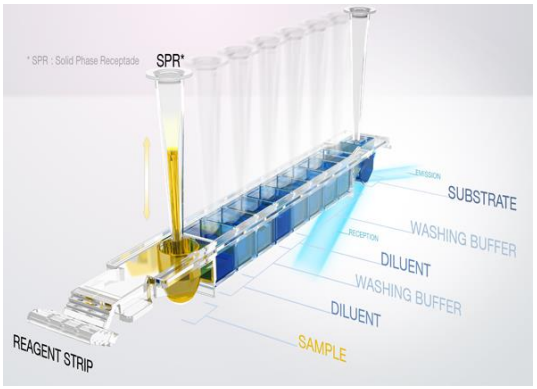


Consumables

Assay kit (60, 30 or 10 tests).

Specific Benefits

-Over 100 parameters in single-test format for the diagnosis of cardiovascular and infectious diseases, cancers, infertility, pregnancy and thyroiditis diseases



-On-demand testing: 1 patient, 1 test, 1 result.

-Ready-to-use reagents.

-Results in 17 to 90 minutes.

-One order reference per test: kits include all components needed.

Available Links

-https://vimeo.com/9317449

-https://www.biomerieuxuniversity.com/routine-use-of-the-minividas.html

Range	Parameter	Reference*	Code	Sample Volume
Thyroid	TSH	30400	TSH	200 µl
	TSH3	30441	TSH3	200 µl
	FT4	30459	FT4N	100µl
	FT3	30402	FT3	200 µl
	T4	30404	T4	200 µl
	T3	30403	T3	100 µl
	Anti-TPO	30461	ATPO	100µl
	Anti-Tg	30462	ATG	100µl
Allergy	Total IgE	30419	IgE	100 µl
	Stallertest	30800	STA	200 µl
	Stallergy®	30801	ST	200 µl
	Stallertroph®	30830	STO	200 µl
Reproduction Fertility	HCG	30405	HCG	100 µl
	LH	30406	LH	200 µl
	FSH	30407	FSH	200 µl
	Prolactin	30410	PRL	200 µl
	Estradiol II	30431	E2II	200 µl
	Progesterone	30409	PRG	200 µl
	Testosterone	30418	TES	200 µl
Tumor Markers	CEA S	30453	CEAS	200 µl
	TPSA	30428	TPSA	200 µl
	FPSA	30440	FPSA	200 µl
	AFP	30413	AFP	100 µl
	CA 125 II™	30426	125	200 µl
	CA 19-9®	30427	199	200 µl
	CA 15-3®	30429	153	100 µl
Immuno-Hemostasis Cardiovascular	D-Dimer Exclusion® II®	30455	DEX2	200 µl
	Protein C	30115	PC	100 µl
	CK-MB	30421	CKMB	250 µl
	Troponin I Ultra	30448	TNIU	200 µl
	Myoglobin	30446	MYO	150 µl
	NT-proBNP	30449	PBNP	200 µl
	NT-proBNP2	30458	PBNP2	200 µl
Others	Ferritin	30411	FER	100 µl
	Cortisol S	30451	CORS	100 µl
	B2 Microglobulin	30420	B2M	100 µl

LABORATORY 4: Using of ELISA as a Diagnostic Tool

LABORATORY 5: Using of Florescent Microscope as Diagnostic Tool

LABORATORY 6: Using of Flow cytometry as Diagnostic Tool

LABORATORY 7: Using of Rapid Tests as Diagnostic Tool

LABORATORY 8: Using of Staining as a Diagnostic Tool

LABORATORY 9: Using of Spectrophotometer as Diagnostic Tool

LABORATORY 10: Using of Serological Tests as Diagnostic Tool

Normal Clinical Laboratory Test Values

Blood

Coagulation (Hemostasis)	Back to Top
Bleeding time (Ivy)	< 9 minutes
International Normalized Ratio (INR)	0.9-1.2
Partial thromboplastin time (PTT)	28-38 seconds
Prothrombin time (PT)	10-13 seconds

Hemogram	Back to Top
Hematocrit (Hct)	
Female	0.370-0.460
Male	0.380-0.500
Hemoglobin (Hb)	
Female	123-157 g/L
Male	130-170 g/L
Mean corpuscular volume (MCV)	80-100 fL
Mean corpuscular hemoglobin (MCH)	27-34 pg
Platelet count	130-400 X 10^9/L
Red blood cells (RBC)	
Female	4.0-5.2 X 10^{12}/L
Male	4.4-5.7 X 10^{12}/L
Red cell distribution width (RDW)	11.5-14.5%
Reticulocyte count	20-84 X 10^9/L
Erythrocyte sedimentation rate (Westergren)	
Female	< 10 mm/hour
Male	< 6 mm/hour

White blood cells & differential	Back to Top
White blood cell count (WBC)	4-10 X 10^9/L
Segmented neutrophils	2-7 X 10^9/L
Band neutrophils	<0.7 X 10^9/L
Basophils	<0.10 X 10^9/L
Eosinophils	<0.45 X 10^9/L
Lymphocytes	1.0-4.0 X 10^9/L
Monocytes	0.1-1.0 X 10^9/L

Chemical Constituents	Back to Top
Albumin (serum)	35-50 g/L
Alkaline phosphatase (serum)	38-126 U/L
Aminotransferase (transaminase) (serum)	
Alanine (ALT; SGPT)	17-63 U/L
Aspartate (AST; SGOT)	18-40 U/L
Gamma-glutamyl transferase	

Female	10-30 U/L
Male	10-48 U/L
Ammonia (plasma)	9-33 µmol/L
Amylase (serum)	<160 U/L
Base excess	-2 to +2 mEg/L
Bicarbonate (HCO_3) (serum)	24-30 mmol/L
Bilirubin (serum)	
Direct (conjugated)	<7 µmol/L
Total	<26 µmol/L
C-reactive protein	<8 mg/L
Calcium (serum)	
Total	2.18-2.58 mmol/L
Ionized	1.05-1.30 mmol/L
Chloride (serum)	98-106 mmol/L
Cholesterol (serum)	<5.2 mmol/L
Low density lipoprotein (LDL)	<3.37 mmol/L for low risk
Low density lipoprotein (LDL)	<2.0 mmol/L for high risk
High density lipoprotein (HDL)	>0.9 mmol/L
Cortisol	160-810 mmol/L
Creatine kinase (CK) (serum)	20-215 U/L
Creatinine (serum)	
Female	50-90 µmol/L
Male	70-120 µmol/L
Ferritin	
Female	11-307 µg/L
Male	24-336 µg/L
Folic (Folate)	>15 nmol/L
Glucose fasting (serum)	3.3-5.8 mmol/L
Random glucose	3.8-11.1 mmol/L
Hemoglobin A_1C	4-6%
Iron (serum)	11-32 µmol/L
Lactate (serum)	1-1.8 mmol/L
Lactate dehydrogenase (LDH) (serum)	95-195 U/L
Lipase (serum)	<160 U/L
Lithium	0.6-1.2 mmol/L
Magnesium (serum)	0.75-0.95 mmol/L
Osmolality (serum)	280-300 mmol/kg
Oxygen saturation (arterial blood) (S_aO_2)	96-100%
P_aCO_2 (arterial blood)	35-45 mm Hg
P_aO_2 (arterial blood)	85-105 mm Hg
pH	7.35-7.45
Parathyroid hormone (PTH)	1.6-9.3 pmol/L
Phosphorus (inorganic) (serum)	0.8-1.5 mmol/L
Potassium (K) (serum)	3.5-5.0 mmol/L
Prolactin	4-30 µg/L
PSA (Prostate Specific Antigen)	0-4 µg/L

Protein (serum)	
Total	60-80 g/L
Albumin	35-50 g/L
Sodium (Na) (serum)	135-145 mmol/L
Thyroid-stimulating hormone (TSH)	0.4-5.0 mU/L
T3 (free)	3.5-6.5 pmol/L
T4 (free)	8.5-15.2 pmol/L
Total Iron Binding Capacity (TIBC)	45-82 µmol/L
Transaminase - see Aminotransferase	
Triglycerides (serum)	<1.7 mmol/L
Troponin T (TnT)	<0.01 µg/L
Urea nitrogen (BUN) (serum)	2.5-8.0 mmol/L
Uric acid (serum)	180-420 µmol/L
Vitamin B_{12}	133-674 pmol/L

Cerebrospinal Fluid

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Cell count	<10 x 10^6/L
Glucose	2-4 mmol/L
Leucocytes	0.5-10^6/L
Lymphocytes	0
Polymorphs	<5 x 10^6/L
Proteins (total)	0.20-0.45 g/L

Urine

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Calcium	<7.3 mmol/day
Chloride	110-250 mmol/day
Creatinine	6.2-17.7 mmol/day
Osmolality	100-1200 mOsm/kg
Potassium	25-120 mmol/day
Protein	<0.15 g/day
Sodium	25-260 mmol/day