

Chapter - 42

Bio- Medical Technologies

In modern medical science many advanced technologies are used for investigation and diagnosis of different diseases. Blood, urine, cough, and stool are tested, so in order to determine the proper cause and nature of diseases, it can be treated properly. In last few decades, due to advanced in technologies, there have been many revolutionary changes in tools and equipment used in testing disease and testing methods are significantly improved. Today diseases testing methods are more accurate, reliable and provide expected result in less time consuming, as compared to olden times. Description about some tests and equipment used in medical examination are given in this chapter.

Haematological Examinations

We know that blood is an important component of human body which is made of blood corpuscles and plasma. Availability of useful substances to all tissues and cells of body through blood and transport of substances is ensured through blood circulation. Any kind of structural and physiological abnormalities in tissues are also reflected in blood. Therefore physical and physiological condition and abnormality of organism can be estimated through blood testing. That's why the blood related inquiry of patient examined by doctor is a common test. Though there is a long list of parameters in blood test, but information about common blood related tests are mentioned here-

1. Estimation of Haemoglobin in blood

Measurement of haemoglobin present in blood

is known as Haemoglobinometry. It is respiratory pigment present in erythrocytes (RBCs). Chemically it is a chromo protein which is used in transportation of oxygen and carbon dioxide is necessary to have proper amount of haemoglobin to perform this important action. If the amount of hemoglobin in blood becomes less than normal by any reason working capacity of a person is adversely affected; Amount of haemoglobin less than normal is an indicator or sign of anaemia. Normal volume of haemoglobin is as follow-

Age group	Haemoglobingm/ 100 ml blood
Healthy adult man	15.5 ± 2.5
Healthy adult woman	14 ± 2.5
Children (3 months)	11.5 ± 2.5
Children (3-6 years)	12 ± 1
Children (10-12 years)	13 ± 1.5

Haemoglobin is measured by haemoglobino-meter. Sahli's Haemoglobinometer is used in traditional methods, whereas in advanced methods Photo haemoglobinometer or Auto analyzer is used.

There is a graduated tube in Sahli's haemoglobinometer and two standard comparison tubes in one stand. Between both standard tubes measurement nozzle is kept at one place. N/10 HCl is filled up to zero (2 gm%) mark in measurement nozzle. Now 20 µl (0.02 ml) of blood is taken in haemoglobin pipette and added into HCl kept in measurement nozzle. When blood is thoroughly mixed with HCl, haemoglobin present in blood is

converted into brown coloured Haematin. Now measurement nozzles are kept at centre place of comparison tube and distilled water is added drop wise and it is stirred. On adding distilled water when colour of measurement nozzle is matched with standard tube's colour then reading of measurement nozzle is taken and amount of haemoglobin is noted.

There may be many reasons for anemia in body, in which excessive bleeding in an accident, malnutrition, deficiency of folic acid deficiency of vitamins and iron elements or genetic disorders are mains.

2. Total Leucocyte Count TLC –

White blood cells are important for immune system of our body, which act like a soldier in body. Its calculation has special significance in diagnosis of diseases. White blood cells are of Neutrophils, Basophils, Eosinophils, Lymphocytes and Monocytes type. Generally their number is 5000-10000 per cubic mm in blood. White blood cells present more than required is known as Leucocytosis and its presence less than normal is known as Leucopenia. The process of calculating of total Leucocyte count (TLC) is as follows-

(I) Neubaur's Haemocytometeris - used for calculation of white blood cells in which white blood cells counting chambers are present at four corners of counting room. This counting room is focused under microscope.

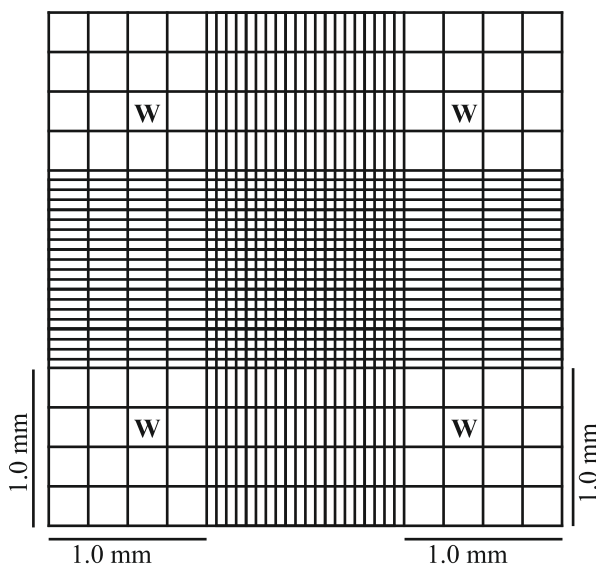


Fig. 42.1 : Hemocytometer, showing counting chamber (W=Leucocyte counting chamber)

(ii) Blood is taken in WBC pipette up to 0.5 marked point.

(iii) WBC diluting fluid is pulled up to 11.0 marked point on pipette. Fluid is mixed with blood by stirring thoroughly. (iv) A cover slip is put on Neubaur's counting chamber and it is filled with diluted blood with the help of the pipette. Cells are left to be stabilized for 5 minutes.

(v) As shown in figure 42.1 white blood cells are counted by 4 large squares (total 64 small squares). To calculate leucocytes per cubic mm following formula is used – Total Leucocytes = Number of Leucocytes in four large squares x dilution X depth factor of counting chamber.

Per cubic mm = counted WBC counts x 20 x 10 x 0.1 Representing W (Leucocyte Counted Square).

Count of total white blood cells is changed in some specific diseases. For example Count of WBC is highly increased in blood cancer, whereas counting decreases in typhoid, tuberculosis, chicken pox, dengue fever, Kala ajar etc. diseases.

3. Differential Leucocyte count (DLC) -

Percentage of different type of leucocytes is found out in this blood test. This blood test is more important than total leucocyte count test because count in specific type of leucocytes is increased or decrease in different diseases; therefore it is important in diagnosis of disease.

A smear of patient's blood is prepared and stained with a suitable stain such as leishmann stain or Geimsa stain in this test. Stained slide is observed under microscope and different type of leucocytes are identified and calculated. Blood cell counter can be used for it. Percentage of different type of leucocytes is found out in calculated 100 leucocytes.

In the blood of healthy human, normal count of different types of leucocytes are found as follow –

Neutrophils	=	40 – 75 %
Eosinophil's	=	0 – 6 %
Basophils	=	0 – 2 %
Lymphocytes	=	20 – 45 %
Monocytes	=	2 – 10 %

Abnormality is observed in differential leucocytes count indicates the presence of some special diseases, for which undergo for further investigation diagnosis may be possible. Some such type of conditions are given here –

Nature of abnormalities in differential count of leucocyte	Indication of possible disease
(i) Increases in Neutrophils count	Indication of infection and inflammatory action causing normal pus.
(ii) Increase in Eosinophil's count	Hypersensitivity or allergy disease and indication of parasitic infection.
(iii) Increase in Basophils count	Chicken pox disease
(iv) Increase in lymphocytes count	Whooping cough
(v) Increase in monocyte count	Indication of TB (Tuber culosis) disease
(vi) Excessive deficiency in T_4 Lymphocytes	Indication of AIDS disease.

(T_4 Lymphocytes can't be calculated in normal differential leucocyte count).

4. Erythrocyte sedimentation Rate – ESR

If whole blood mixed with anticoagulant like trisodium citrate is kept in a vessel (Glass measurement nozzle used for ESR) erythrocytes start settle down at bottom of the nozzle as they are heavier than plasma. The rate of sedimentation of erythrocytes of blood is called erythrocyte sedimentation rate (ESR). There are two methods prevailing to measure it –

- Westergren method
- Wintrobe method

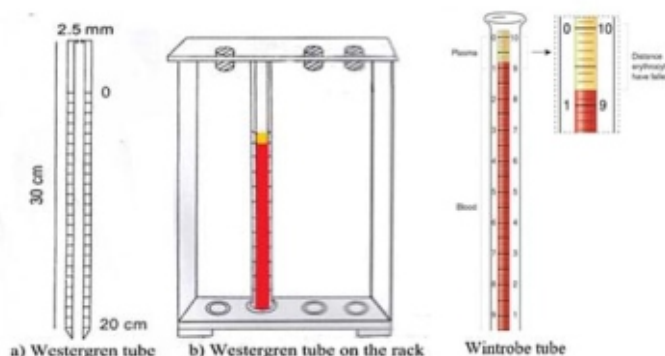


Fig. 42.2 : (a) Westergren tube (b) Westergren on the stand (c) Wintrobe tube

In most of the pathological laboratories, westergren method is used for its testing therefore brief description of this method is given -

- Westergren nozzle is filled with uncoagulated blood up to O mark and is kept vertically in suitable way in E.S.R. stand.
- Reading of upper level of erythrocytes is taken after one hour. It is the value of erythrocytes sedimentation rate.

The ESR value of a healthy person is as follow-

Male = 0 -16 mm per hour

Female = 0 -20 mm per hour

If the value of ESR is more than normal then it is an indication of any kind of abnormality or disease in the body. The value of ESR increases in many types of chronic diseases such as tuberculosis and inflammatory activity diseases such as Rheumatoid, Arthritis, multiple myeloma or tumor, lymphoid tumor etc. Apart from this ESR value also increases during pregnancy, anemia and with age.

To ensure more accuracy in ESR, today it is tested by Automated Mini ESR method in which ESR is measured at a controlled temperature of C. In traditional method, 25 - 30% error is expected due to inability to control temperature.

Apart from above there are many other blood tests which are useful to diagnose function of different organs, biochemical and physiological conditions of body (Table 42.1).

Auto analyzer

Today different biochemical and structural parameters of blood such as total erythrocyte count, WBC count, shape of erythrocytes, amount of haemoglobin, amount of glucose, urea, cholesterol, enzymes, proteins etc. testing of these computer controlled devices and equipment's are available which are known as auto analyzer. Analysis of many parameters at one time is possible in it.

Major Techniques and Instruments used in Medical science

1. Electrocardiography

It is one of the most important techniques of medical science, in which electrical signals generated by nerves and muscles of functioning or beating heart condition is studied and recorded. Instrument used for this work is known as Electrocardiograph and graphical record of electrical signals is known as Electrocardiogram (ECG).

In this technique three electrodes of the instrument are tied on patient's chest, wrist and legs by using conducting jelly. Signals obtained from it are of low amplitude, which are amplified by suitable system of the instrument and recorded in sensory chart recorder. 12 or more electrodes are used in modern and advanced electrocardiograph, which can be put at 6 different places and three dimensional images can be obtained. It is known as **Vector cardiography**.

In ECG, electrical activity indicated during contraction and relaxation of different chambers or parts of heart is represented in the form of waves. These waves are known as PQRS and T. Each letter is a symbol of condition occurred in heart muscles (fig. 42.3).

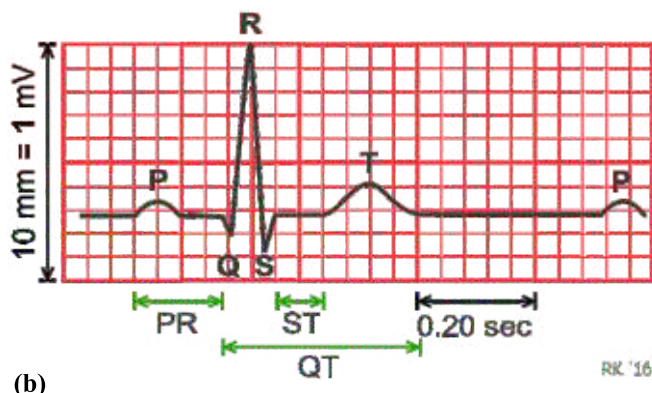


Fig. 42.3 : (a) Modern E.C.G. machine (b) A normal E.C.G.

Knowledge about abnormality of heart can be obtained by their study. Coronary artery related diseases such as coronary artery disease, coronary thrombosis, pericarditis, cardiomyopathy, myocarditis etc. are diagnosed by E.C.G.

Echocardiography - Image of heart structure can be obtained by using ultrasound waves from this device.

Doppler Echocardiography- Velocity of flow of blood passing through heart can be measured indirectly by using this technique.

2. Electroencephalography, EEG

In electroencephalography technique, electrical activity of brain are measured and recorded in magnified form. In 1875 Satton had first discovered electrical activity in exposed brain. First of all in 1929 Hans Berger also succeeded for tracing record of electrical activity of intact brain. In electrical activity of brain, transient waves of micro volt levels are obtained which are amplified before recording them to become more clear and sensitizing. In this way obtained record is known as Electroencephalogram.

Table 42.1 Some Blood related Bio-chemical Examinations and their Importance in diagnosis

Parameter of Blood / Plasma / Serum	Utility
1. Blood sugar or Blood glucose	Excess than normal – hyper glycaemia, Indicative of Diabetes mellitus.
2. Serum cholesterol	Excess quantity than normal – Atherosclerosis, Renal diseases probable indicative of Diabetes and Myxedema. Amount less than normal – Indication of infarction, Anemia, Hyper thyroidism.
3. Investigation of serum lactic dehydrogenase isoenzymes (LD_1 , LD_2 , LD_3 , LD_4 , LD_5)	Excess of LD_1 and LD_2 - indicator of myocardial infection. Excess of LD_4 and LD_5 - Indicator of hepatitis disease.
4. Serum glutamic oxaloacetic transaminase (Aspartate transaminase SGOT or AST) enzyme	Normal and excess value – Indicator of myocardial infarction and hepatic abnormality.
5. Serum glutamic Pyruvic transaminase or Alanine transaminase (SGOT or ALT).	Value more than normal level – Indicator of infectious hepatitis, toxic hepatitis and circulatory shock.
6. Blood urea	More than normal value – Indicator of Nephritis (Renal related disorder).
7. Serum Bilirubin	More than normal value – Indicates Haemolytic jaundice and pernicious

	anaemia.
8. ELISA test (based on antigen – antibody reaction)	Infectious disease such as AIDS, hepatitis, rubella, thyroid abnormality and used for test of sexually transmitted diseases used for sex related disease.
9. Vidal test - serology	Positive Vidal test result – an indicator of typhoid (enteric fever)

Electroencephalography technique is painless and is free from any unwanted side effects. 16 to 30 small electrodes are put on different parts of the scalp in it. All electrodes are connected to main device. Electrodes transmit electrical signals of different parts of the brain to the main device where they are recorded. This Process takes approximately 45 minutes.

Today study of weaker magnetic field of brain is possible by devices of advanced technique. This device is known as Super Conducting Quantum Interference Device (SQUID).

Along with brain, any abnormality in spinal cord can also be diagnosed by Magneto encephalography.

Pattern of EEG gives reflection of condition of consciousness of patient's brain (Fig. 42.4) and is also helpful in diagnosis of many brain related abnormalities. Its main uses are as follow-

- EEG is helpful in diagnosis of diseases related to structural abnormality such as brain tumor, epilepsy, encephalitis etc.

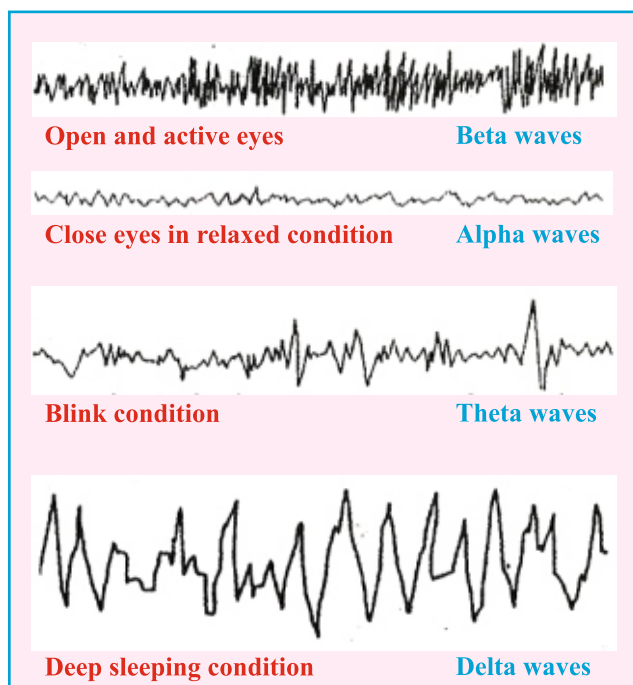


Fig. 42.4 : Electroencephalogram in different condition

- (ii) It is helpful in diagnosis of brain infection, metabolites, and effects of medicines on brain, sleeping disorders etc.
- (iii) EEG is useful in determining brain death.

3. Computed Tomographic Scan, CT scan

It is one of the most important techniques of medical science in which image of two or three dimensional cross section of any body part can be obtained by using X-rays to combine with computer technology. All parts of the body are observed separately in this image. This technique was developed by an electrical engineer **Godfrey Hounsfield** of Britain in 1968. He was awarded Nobel Prize in 1979 for this invention.

Interpretation of theoretical basis of this technique was presented by Indian scientist MR. Gopal Samudram N. Ramchandran (G.N. Ramchandran). In CT scan technique (which is also known as computed axial tomography scan CAT scan). Small quantity of X-ray beams passes through a thin cross section like part of human body on rotation. At this time tissues absorb some amount of radiation according to their density, when these radiation beams come out of the body, they are converted into electronic signals through a detector

which are transmitted to computer scanner. This process is carried out till the level of body section is observed from all angles. This data is then analyzed through computer. In this test, series of picture are formed at small distances of cross section levels, therefore they are known as scan.

CT scan can be used to obtain image of any part of the body. This technique has proved to be helpful in diagnosis of brain, spinal cord, chest, abdomen etc. related diseases. It gives much important information related to tumours and their spreading in nearby tissues by this test.

4. Magnetic Resonance Imaging (MRI)

Credit of invention of MRI technique goes to Felix Bloch and Edward M. Purcell who were awarded with Nobel Prize in 1952. In medical science its use was started by Raymond Damadian. It is more appropriate and secured testing technique as compared to CT scan where patients do not expose to any ionized rays like x-ray. Three dimensional image of any part of the body or tissues are obtained more clearly in this method. MRI technique works on the principle of nuclear magnetic resonance. Electrical charge of nuclei of hydrogen atoms and small magnetic properties generated in atmosphere of strong magnetic field and radio waves are used in this method. Hydrogen atoms are used as source of protons in the body which are found in water molecules. In MRI test patient is lie down in about 2 meter wide room. This room is surrounded by large and cylindrical electrical magnets which generates strong magnetic field and waves in a short time



Fig. 42.5 : M.R.I. Machine

period. Due to this magnetic field hydrogen nucleus (Protons) of tissues of patient's body become active and produces radio signals. These signals are received by computer and analyzed, and a thin section compatible image of patient body is obtained. Image obtained from MRI is excellent and shows clear contrast as compared to CT scan. Image can be possible in any plane in it. Though MRI is an expensive testing technique but is more useful in investigation and study of brain and spinal cord. White matter and grey matter are clearly differentiated in it.

5. Ultrasound Scanning

This technique is also known as Echography or Sonography. Lead zirconate named crystals are present in transducer named device in sonography. When electric potential is used, sound waves of high frequency are generated through piezoelectric

effect. These waves are beyond the audible range of human. These waves are known as ultrasound waves. Their frequency is more than 20 KHz.

When this ultrasound is placed on tissues and organs of human body, they hit back in return and are received by transducer as a series of echoes. This transducer converts them into electrical signals which are reflected on screen by a monitor. It appears as a two dimensional image.

The images reflected on the screen by sonography can be obtained in the form of photos. It is known as sonogram. The position, shape, size and texture of any organ/ tissue can be traced by sonogram.

Sonography technique is affordable and comfortable than radiography and it has many uses. It is helpful to know the growth and find any abnormality of infant. Stones in kidney and gall bladder, obstruction in intestine, any abnormality in uterus, fallopian tubes etc. are identified by sonography. It is mainly used in diagnosis of delivery and labour problems. Image of blood flow during heart throbbing can also be obtained by using Doppler Effect in sonography.

6. Radio Immuno Assay (RIA)

Radio Immuno Assay is an analytical method which is used since many years. In this method some parts of analyzed substances (which act as antigen) are marked or labelled by radioactive substance then normal and marked antigens molecules react with antibodies are comparatively studied. Radioisotope substance is used as an indicator in this method.

This technology was invented by Rosalyn and Yalow. This method is much important diagnostic technique in medical science. It is useful in analysis of specially such type of biochemical components which are present in minute quantity (on level of microgram, nanogram, picogram) in body and their analysis is not possible through traditional gravimetric and volumetric methods. The radio isotopes used in radio Immuno assay are of high specificity as resulting this technique represents high sensitivity.

In this method, standard solutions of different



Fig. 42.6 : Sonography Machine

concentration of molecules are to be analyzed and used with labeled solutions of equal concentrations and are reacted with antibodies. Antigen antibody complex is completely absorbed by suitable reagents when equilibrium is obtained. Precipitated and supernatant parts are separated and correct quantity of substances is found out by measuring their radioactivity.

Radio antibody analysis has main quality that patient does not have any doubt of harmful effect, and patient is not required to treat with radioisotope substance because all the activities are performed outside the body. Main benefits of radio immuno assay is as follow-

- (i) By this method, quantity of important bio chemical components can be found out such as vitamin (Follic acid), hormones (Thyroxin, Tri-iodothyronine cortisol, testosterone, estrogen, tropic hormones etc.); drugs (Digoxin, Digitoxin etc) and antigen substance like Australia antigen.
- (ii) Radio immuno assay is proved important technique in diagnosis of disorders of endocrine system. For example excess amount of any specific hormone in blood, is a result of hyper activity of that endocrine gland which secretes it or due to effect of tropic hormone. Such types of questions are possible to be solved by this technique.
- (iii) Diagnosis of insulinoma, sexual hormone sensitizing, tumors etc. is possible through this method by which helps in proper treatment of them.

Apart from above bio medical techniques, many other medical techniques and methods are available. Description of all these is not possible here because they are away from perimeter of prescribed curriculum. Although for reader's knowledge only the names of these techniques are mentioned here-

1. X-ray Radiography
2. Angiography
3. Positron Emission Tomography
4. Polygraphy

5. Endoscopy
6. Laser Microsurgery
7. Tissue / organ transplantation
8. Hemodialysis
9. Prosthesis
10. Replacement surgery
11. Cryosurgery
12. Gene therapy

Important Points

1. Many types of advance techniques are used in diagnosis of different type of diseases in modern medical science.
2. Physical and physiological stage and abnormality can be identified by blood test.
3. Haemoglobin present in blood is measured by Haemoglobinometer. Less than normal value of haemoglobin is an indicator of anemia.
4. Total leucocytes in blood cells are counted by Neubaur's Haemocytometer.
5. The percentage number of different types of leucocytes is counted by differential leucocyte count.
6. Sedimentation rate of red blood cells is known as erythrocyte sedimentation rate. It is known by westergren and wintrobe method.
7. Electrical signals generated by nerves and muscles of and functional condition of heart are recorded by electrocardiography (ECG). Heart related diseases are diagnosed by it.
8. Electrical activity of different parts of the brain is measured and recorded by electroencephalography. It is helpful in diagnosis of brain related abnormalities.
9. Two or three dimensional image of cross section of any part of body can be obtained by combining x-rays and computer technology in computed tomography scan. It is helpful in diagnosis of diseases related with brain, spinal cord chest abdomen etc.
10. Magnetic Resonance Imaging (MRI) is superior and secure technique as compared to

CT scan, in which patient does not have danger of ionized radiations. Clear and excellent image of any part of the body can be obtained by this technique. This technique is useful in checking of brain and spinal cord.

11. In sonography or ultra sound scanning high sensitive sound waves are used, they convert ultra sound waves into electrical signals and a two- dimensional image is obtained. It is more useful in delivery and labour problems and in checking of infant.
12. By using substances of radioactive isotope as indicator very small amount of any important bio chemical component can be measured in Radio Immune Assay technique on antigen-antibody principal.

Practice Questions

Multiple choice Questions -

1. What is used to measure haemoglobin present in blood—
 (a) Haemocytometer
 (b) Haemoglobinometer
 (c) Westergren method
 (d) Wintrob method
2. Number of leucocytes are increased in which disease—
 (a) Tuberculosis (b) Typhoid
 (c) Measles (d) Blood cancer
3. By which the heart related diseases are diagnosed?
 (a) E.E.G. (b) ECG
 (c) RIA (d) CAT scan
4. Which radiations are used in C.T. scan?
 (a) α - rays (b) β - rays
 (c) γ - rays (d) x – rays
5. Full form of M.R.I. is—
 (a) Multiple Resonance Imaging
 (b) Magnetic Radio Imaging
 (c) Magnetic Resonance Imaging
 (d) Multiple Radio Imaging

Very short Answer Questions -

1. By whom total Leucocyte count (T.L.C.) is counted?
2. What is leukocytosis?
3. In which diseases the value of E.S.R. is increased?
4. Write the name of equipment used for recording heartbeating.
5. E.E.G. is related to diagnose with which disease?
6. What is used in place of x-rays in M.R.I.?
7. Whose crystals are used in sonography?
8. Who acts as indicator in R.I.A.?

Short Answer Questions -

1. Describe in brief westergren method used to measure E.S.R.
2. What is medicinal importance of differential leucocyte count (D.L.C.)?
3. Write the uses of E.C.G.
4. Write the importance of sonography technique.
5. Explain the importance of E.S.R. in diagnosis of diseases.
6. Why MRI technique is superior and safe than C.T. scan.

Essay type Questions -

1. Explain in detail hemoglobin measurement in blood.
2. Explain E.E.G. with diagram and mention its uses.
3. Write notes on M.R.I. in detail.
4. What is R.I.A.? Explain in brief its methodology and uses.

Answer Key-

1. (b) 2. (d) 3. (b) 4. (d) 5. (c)