Laboratory Tests Interpretation

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Course Objectives

Global Course Objectives:

At the end of this course, each participant will be able to:

1. give better patient care due to an enhanced knowledge of laboratory tests and the interpretation of the results of these tests.
2. perform satisfactorily on an objective examination at the end of this course (70% or better).

Specific Behavioral Course Objectives:

At the end of this program, each participant will be able to:

1. name and discuss at least 3 lab specimen collection considerations and their nursing implications.

2. name and discuss at least 5 hematology lab tests and coagulation tests and their nursing implications.

3. name and discuss at least 2 cardiac enzyme lab tests and 3 serum electrolyte and blood group tests and their nursing implications.

4. name and discuss at least 3 components of the urinalysis lab test and describe the nursing implications.

5. name and discuss at least 3 components of the cerebrospinal fluid analysis lab test and the nursing implications.

6. name and discuss at least 5 components of the liver function lab test and the nursing implications.

7. name and discuss at least 2 components of the thyroid function lab test and the nursing implications.

8. name and discuss at least 2 serological lab tests and their nursing implications.

9. name and discuss at least 2 lab tests used to detect HIV antibodies in the blood and 2 additional tests used

to indicate levels of HIV antibodies in the blood and their nursing implications.

10. name and discuss at least four components of the arterial blood gas interpretation lab test, describing how the test is performed, the results of the test, and the nursing implications of the test.

CHAPTER I

INTRODUCTION TO THE COURSE

Terms and Abbreviations

Amniocentesis--is a procedure that includes the insertion of a needle into the suprapubic area after the fetus has been located and manually elevated and the aspiration of 5 to 15 ml of amniotic fluid. Ultrasound may be used to locate the placenta and fetal position so that needle contact may be avoided. Amniocentesis is usually performed from the 14th to 16th week of pregnancy; usually never before the 14th week due to insuffi-cient amounts of amniotic fluid.

Anatomic Pathology--This field of pathology deals with structural changes. These changes may be apparent to the examiner with the naked eye, or a microscopic examina-tion may be needed.

Blood Bank (Immunohematology)--We all know of the responsibility of the blood bank in obtaining, storing, and dispensing blood for trans-fusions. There are other functions including: obtaining and handling other blood products, some of which are rare; and also research in blood transmitted diseases.

Bronchography, Bronchogram--Bronchography is an X-ray examination that visualizes the trachea, bronchi, and the bronchial tree.

Clinical Chemistry--This section of the lab performs analyses on whole blood, serum, plasma, urine, and other biological specimens like cerebrospinal fluid, am-niocentesis fluid, pleural fluid, periton-eal fluid, and feces.

Clinical Microbiology--This section of the lab is involved with a variety of biological specimens such as: urine, feces, blood, sput-um, CSF, drainage, exudates, nail, skin, tissue, and swabs from throat, wounds, and other such specimens.

Clinical Pathology--Clinical pathology refers to the section of the pathology lab which applies to the problem of find-ing solutions to the problems found in the clinical areas. The members of this team in-clude medical tech-nologists, medical scientists, tech-nicians and pathologists. Together they perform tests and inves-tigations into all aspects of disease, including preven-tion, diagnosis, and treatment.

Cytology--Cytology is the study of the individual cells. This department has cytologists and cyto-technologists who are trained to perform prelimi-nary screening on cells. Any of these suspicious cells are then usually examined by the pathologi-st.

Cytogenics--Cytogenics is the branch of genetics that studies cellular components concerned with heredity; primarily the structure, function, and origin of the chromosomes.

Diagnostic Test--A Diagnostic Test is an inquiry into a pathological condition. A diagnostic test can be thought of as any test used to help diagnose a pathological condition.

However, for our text, we will say that a diagnostic test is a test that involves some type of sophisticated diagnostic equipment and/or lab tests. We will not refer to simple blood and lab tests as diagnostic tests. (Although you could argue that these blood tests, etc. are simple diagnostic tests.) For our text we will reserve diagnostic tests for those more sophisticated tests and procedures.

Erythrocyte--An erythrocyte is a mature Red Blood Cell. Immature red blood cells cannot carry oxygen. Immature red blood cells are true cells and contain a nucleus. The erythrocyte has lost its nucleus and then it "technical-ly" cannot be called a cell. It is a corpuscle. However, many persons still refer to erythrocytes as Red Blood Cells or RBC's.

Fasting Specimen--Instruct the patient not to eat or drink after midnight the night before the test. Do not eat or drink in the morning before the specimen is collected. It is usually a good idea to place a sign on the bed to be sure no one gives the patient food. Again, check with hospital policy, and lab policy. The patient may be allowed small amounts of water prior to some tests.

First Voided Specimen (First morning specimen)--As the name implies, the first specimen of the day is to be obtained. However, some facilities insist the specimen be at a certain time in the morning. Be sure to check policy at your facility.

Hematology--This department is responsible for the quantification of cellular elements, including red and white blood cells and platelets. Many of the tests are today performed by electronic means. However, some of the tests are performed by manual means. Many nurses may have closer contact to this depart-ment than most other departments of the lab. The reason for -this is that the hematology section performs those tests often seen in patients who are on chemothera-py, an-ticoagulant therapy, and cardiac therapy, and have frequent blood cell evalua-tions. Blood coagulation studies are also performed in this section of the lab. The diagnosis and treatment of blood clotting disorders are the two most important functions of this section.

Hemoglobin--Hemoglobin is the main component of Red Blood Corpuscles (RBC's). Hemoglobin is a conjugated protein that "carries" oxygen and transports it to all the body cells. Hemoglobin also carries carbon dioxide from the tissues to the lungs for excretion. Three major types of hemoglobin are found in normal blood; they are: Hgb A, Hgb A2, and Hgb F.

Histology--Histology is the study of the microscopic structure of tissues and cells. Histology technicians prepare frozen sections and surgical and autopsy tissues by slic-ing them to less than paper thickness, mounting them on slides, and finally staining them with special dyes. The slides will then be examined and inter-preted, usually by a path-olo-gist.

Pathology--is the study of disease, its nature and cause. Roles of the pathologist:

1. Provide supervision in the medical laboratory
2. Evaluate laboratory results
3. Identify disease
4. Evaluate treatment
5. Ascertain the cause of death by means of autop-sies
6. Advance medicine through research

Plasma--Plasma is the liquid portion of whole blood after centrifuging. Whole blood is spun in a centrifuge removing the solid portions of the blood, such as red and white blood cells and other solid particles. The plasma is thick and rich with dissolved chemicals and other substances such as proteins and other chemicals.

Random Sample--The term random, refers to taking a sample (any sample) at any time during the day (or night). Random means that you do not have to take the sample at a particular time. Sometimes the sample may have other stipulations. You might have to take the sample on a certain day. If the test is ordered today, you generally take the sample today (unless ordered differently).

Second-Voided Urine Specimen--This is a urine sample obtained after the patient has emptied his/her bladder. Generally the second sample is obtained 30 minutes after the patient has emptied the bladder. However, some hospitals have different policies for this time interval. Some hospitals will have you wait until the patient is ready to void again. Always check with your hospital policy.

Introduction to the Course:

This course presents the latest updates on select **LABORATORY TESTS** and **Diagnostic** tests used in most health care facilities today. Not ALL Lab Tests will be included in this course. Our objec-tive with this text is to present nurses with a guide to the nursing consider-ations of some of the most commonly used laboratory tests and some select diagnos-tic tests. We will also include ***updates*** on some ***less frequently used*** tests. This course was not designed to be a lab manual that you carry in your pocket at the hospital. You should study each section of this text, in order to gain new informa-tion about lab tests. Keep in mind that lab testing proce-dures will vary from state to state and even from one hospital to another hospi-tal. Different facilities even use different standards from one another. Therefore, a "NORMAL" value at one facility may not be the same at another facility. If a par-ticular lab test is not being used in your facility, you may still find the nursing consider-ations of value to you in your nursing practice.

This text is divided into large sections which present a group of similar lab tests. For example, Coag-ulation studies represent the large group of blood tests performed on whole blood, and they are used for the detect-ion of abnor-malities in the blood's clotting abilities. If the test results are abnormal, it could indicate one or more of many different problems. When you are studying the text, keep in mind that the tests in each group may have far-reaching implications for the nurse.

Be prepared to include lab tests in your daily care plan. Many nurses do not recognize the impor-tance of lab tests because they feel that the doctor is respon-sible for interpreting the tests. This is not entirely true. The nurse must also have basic knowledge of lab tests in order to recognize trends that affect patients and in order to develop a good nursing care plan.

It is vitally important that you understand the difference between our use in this book of the terms Diagnostic Tests and Laboratory Tests. We will therefore repeat the definitions as we will use them in this text. In general, a diagnostic test is a very broad term. A Diagnostic Test is any inquiry into a pathological condition.

However, in this text, we will use diagnostic test to refer to the more sophisticated studies involving more than just examining a patient or just analyzing blood.

Yes, you could say that a blood test is a diagnostic test.
Yes, you could say that a physical examination is a diagnostic test.
Yes, you could say that taking a patient history is a diagnostic test.

However, for our text, we will say that a diagnostic test is a test that involves some type of sophisticated diagnostic equipment and/or lab tests. We will not be referring to those simple blood tests under our category of diagnostic tests. We will use simple blood tests and other simple lab tests as separate categories. We do this because in most acute hospitals today, blood tests have become very "routine" proce-dures. In the clinical area, they are not commonly referred to as diagnostic studies.

Introduction to Normal Values (Reference Ranges)

Your patient, Mr. Jones, a 54-year-old male was admitted this morning with GI bleeding. It is 11:30 p.m. and his CBC results from earlier this evening (5:00 p.m.) have just been placed on his chart. The results reported on the lab slip are within "normal" range. However, the

results are in the "low normal" range. The RBC count is 4.6, the total Hgb is 14.5, and Hct is 42.5%.

The patient (at 11:30 p.m.) has become slightly lethargic, sleepy, and slightly pale. The lab test results were not called to the doctor because they were within the normal limits. However, this was at 5:00 p.m. and it is now 11:30 p.m. What do you do? Do you call the doctor at 11:30 p.m.? Do you wait until the morning when another CBC is scheduled?

Well, in this case it is obvious that the patient is getting worse and you should take immediate action. However, the lab test results were still in the "normal range" even though the patient was getting worse. Keep in mind that you should evaluate the test results with ***many other factors***; such as the patient's condition, previous results, patient's position, and many other factors.

What is a "normal" lab test result?
What factors influence the results of lab tests?
How do you interpret "normal" test results?
Do normal results HAVE TO BE interpreted?

The nurse should always keep in mind that the "normal" values given in this workbook (and in ***any*** reference book) should be considered only as "guidelines" of what is normal or abnormal. There are many variables that must be considered when ***interpreting the results*** of any laboratory or diagnostic test.

Patient factors:

The time of day, fasting, postprandial, supine, upright, age, gender, climate, effects of drugs, and the effects of diet may all affect test results.

The characteristics of test population may also affect results. It is essential that the nurse use the reference ranges from the laboratory that is performing those particular tests, which have been determined for the laboratory's own procedures, patient population, and so forth. Too many misunderstandings occur from attempts to apply reference ranges from one laboratory to test results from another laboratory. Misinterpretation of laboratory data due to this error, as well as from overemphasizing the significance of borderline values, has caused immeasurable emotional pain and economic waste for innumerable patients.

Also, variations of the normal range of results affect the reported test results. Based on the statistical definition of "normal" as within the 95% range of values, 5% of independent tests will be outside this normal range in the absence of disease.

If 12 tests are performed, at least one abnormal result will occur in 46% of normal persons; for 20 tests, 64% of normal persons will have at least one abnormal result. The greater the degree of abnormality of the test result, the more likely that a confirmed abnormality is significant or represents a real disorder. Most slightly abnormal results are due to pre-analytic factors.

Laboratory factors:

Lab situations to consider are: instrumentation (lab equipment used and blood draw equipment used), child or adult, laboratory methodology for performing the tests, laboratory techniques used, the actual lab procedure may yield false-positive or false-negative results, chemicals or reagents used in the lab may be out-dated or contaminated or defective, clerical errors may occur that will give wrong test results, technical errors (problems with the machines that perform some automated tests) may occur that give false results, a variety of human errors in the lab may occur (mixing the wrong chemicals, wrong proportions, etc.).

Clinical Factors:

Special notations should be made on the laboratory test request form when it is particularly germane to a test: time when the blood is drawn, relation to meals (glucose), intravenous infusions (electrolytes), source of specimen (arterial, venous, capillary). An individual's test values tend to remain fairly constant over a period of years. When performed in a good laboratory with comparable technology; comparison of results with previous values obtained when the patient was not ill (if available) are often a better reference value than normal ranges.

Summary:

In regards to “normal” lab values, the nurse should remember to be suspect of **ALL** lab results. Remember that if the results are normal, you should still assess the patient for any abnormal signs and symptoms. If the lab results are out of the normal range, be sure to again, assess for any possible adverse signs and symptoms related to the abnormal values. Each nurse still has the obligation to carefully assess the patient even if the lab results are normal and especially if they are abnormal.

Look for “trends” in lab results. A trend, for example, means that you notice the Hemoglobin is “normal,” but it is slowly going down. This could indicate that there is a slow GI bleed or similar problem. Assess for patient conditions or patient

factors that may indicate a problem; even if the lab results are normal. In summary, I guess I am saying, don't always believe the lab results. Use your assessment skills and the nursing process before you believe that the patient is “normal.”

CHAPTER II

Collection Techniques

Collection Considerations

There are many factors to consider when collecting lab specimens; and prior to diagnostic tests. Preparation of the patient prior to the test or diagnostic measure is vitally important to the results of the test. Many laboratory tests and diagnostic tests do not require any extensive preparation. However, the nurse should pay very close attention to those tests that do require preparation.

The type of blood sample needed is very important. The type of blood depends upon the test ordered. Different types of blood samples include Whole Blood, Plasma, Serum, Venous Blood, Capillary, or Arterial Blood.

In most common lab tests, venous blood is used. The lab will then extract serum or plasma, depending upon the test to be performed. Venous blood is a good indicator of the physiological conditions throughout the body. It is also relatively easy to obtain. Therefore, venous blood is used most frequently for testing.

Be sure to collect the specimen in the correct blood tube. Certain blood specimens must be collected in tubes with no anticoagulant. Some specimens must be collected in a tube with anticoagulants. Be sure to handle the specimens correctly. Some blood specimens must be gently mixed with the anticoagulant in the tube. Some blood specimens must not be shaken in the tube.

In addition, the collection procedure itself may cause problems. Hemoconcentration may occur due to prolonged tourniquet constriction. Hemodilution may occur due to drawing the blood sample from the same arm with an intravenous infusion of fluids running. Hemolysis may occur due to rough handling of the sample or from drawing the blood through a small-gauge needle.

Arterial blood samples are necessary for obtaining the blood pH and the levels of dissolved Oxygen and Carbon Dioxide in the blood. Arterial blood sampling will be discussed later in the text in detail. However, it is well known that arterial sampling carries a higher risk to the patient than does venous sampling. Arterial puncturing carries a higher risk of hematoma and arterial spasm and hemorrhage.

Patient Identification:

Probably the most important factors regarding laboratory tests and/or procedures are patient identification and sample identification. The nurse should be very careful to properly identify the patient and the specimens obtained. If the nurse is not going to

directly gather the specimen, then the nurse should be sure the lab tech has the correct patient. Be sure that the tech has the correct room number of the patient. Be sure to inform the lab of any changes in room numbers. The lab requisition slip may have a room number that is incorrect because the patient was moved to another room.

This happens very commonly. However, the lab tech is supposed to check the patient's name band, but we all know that many times they are in a rush and the name band is not checked careful-ly. Be sure to check the patient's wrist band for name and patient admission number. Be sure to accurately label all specimens obtained with the patient's name, admission number, and time obtained. Also be sure to identify the source of the specimen, such as blood, sputum, wound, arterial blood, etc.

Many busy laboratories today, receive a very large number of specimens that are not labeled at all, or are improperly labeled. This places a huge burden on the laboratory and upon the patients. Improperly labeled specimens must be discarded. This means a tremendous waste of time and money for the facility and for the patients. In addition, the patient must have the specimen drawn again. This could lead to delays in treatments.

Every hospital is different in their procedure for handling specimens. However, there are some common factors that should be considered. In the end, always follow the procedure at your hospital. When in doubt about a lab test or diagnostic procedure, consult your laboratory procedure manual or contact the lab or the department responsible for the test. In most cases, they are more than glad to inform you concerning any special consider-ations needed for a test or procedure.

Quantity of Samples

The amount of the sample needed depends upon many factors. Each lab is different in the amount of blood or other body fluid or tissue required to perform the analysis. Generally speaking, if the blood is run using modern automated analyzers, the amount of blood may be 10 ml or less for each test. If the tests are run individually, or if the tests are complicated, larger quantities of blood may be needed.

The quantity of the sample usually dictates the method of collec-tion or collection procedure. The overall goal is to get the required amount of blood with only one venipuncture. Multiple venipu-nctures are avoided if possible, even when gathering large amounts of blood. A single glass or disposable plastic needle and syringe may be used to obtain a small sample of 10-20 ml of whole blood. This amount is usually sufficient to

perform one or two tests. However, for a series of tests, more blood is needed.

In order to avoid multiple veni-punctures, it is usually best to use an evacuated blood tube system such as the "Vacutainer" or "Corvac" collection systems. These systems are very popular for drawing multiple samples of blood. They use blood tubes with a rubber stopper and a vacuum inside the tube. These tubes are manufactured in a variety of sizes and with a variety of additives in the evacuated tubes. Color-coded tubes indicate the different additives in the tube. The vacuum in the tube causes just the correct volume of blood to be drawn into the tube. The tubes are consecutively used to draw blood from one venipunc-ture site, thereby negating the use of multiple punctures. This, of course, is under ideal conditions. We assume that correct technique is being used. We also assume that the patient's vein will support multiple samples being drawn at one time from one location. These tubes hold 2-20ml of blood in each tube.

In infants and children, microanalysis techniques allow sampling of capillary blood through micropipettes or capillary tubes. This technique is used when the patient is an in-fant/child or has severe burns and/or has absolutely no useable veins to draw from. This technique is time-consuming and very expensive. Therefore, if possible, the multiple-sample technique is preferred. Micro-pipettes hold from 30 ul to 50 ul of serum or plasma.

Safeguards for venipuncture:

1. In case of syncope, be sure to place patient in a comfortable but "safe" position. The most common position is sitting or lying down.
2. If using a needle and syringe to draw blood, be sure not to inject air into the vein. Be sure to have the plunger completely depressed before you start the procedure.
3. Avoid drawing blood in an extremity used for infusing intravenous solutions. The solutions will dilute the blood directly proximal to the IV site. You may draw blood (below) distal to the IV site, being sure not to draw too close to the IV site. You are too close, if your venipuncture activities touch the IV site or interfere with the infusion of the IV in any way. Also be sure not to contaminate the IV site while drawing blood near the site.

Laboratory Requisitions:

The following items should be included on the lab requisition:

1. Full name: middle name should be included to avoid confusion in the event that there is another patient with the same first and last name.

2. Location: inpatient, room, unit, outpatient, address.

3. Patient's identification number: this identifica-tion can be very useful for instance in the blood bank

4. Patient age and sex: in evaluating laboratory results, the reference values may differ for age and sex; disease prevalence may be age- or sex-linked.

5. Name(s) of the physician(s): name all of the physicians on the case; "panic values" should be called to the attention of the physician ordering the test; a physician may have some specific test guidelines for his patients.

6. Name of the test and the source: reference values may be different for the different biologic specimens (e.g., serum and CSF glucose); in microbiology, it is essential to know the source of the swab.

7. Possible diagnosis: essential for evaluating laboratory results and selecting appropriate methodology; (media selection in microbiology).

8. The date and time the test is to be done: some tests must be scheduled by the laboratory; blood transfusions may require ample advance notice; patient preparation and diet regulations need to be considered.

9. Special notation: provide relevant information to assist the laboratory--e.g., medications taken; for hormone assay, the point in the menstrual cycle when the specimen was obtained; for microbiology, the patient's sensitivity to drugs.

Patient's Diagnosis and Patient's Condition:

It is very important to identify any patient condition or activity that might affect the lab test or diagnostic test being performed. Always be sure to identify anything that might be relevant to that particular test. Now, you might say that this is a very broad state-ment; and you are very correct. You as the nurse, however, should be alert to conditions that could possibly influence tests. For example, the patient's temperature can affect certain tests. Some patients are taking supplementary oxygen. Some patients might have just eaten a very large meal.

Of course, it is impossible to memorize every single lab test, along with every single factor that might affect these tests. There-fore, it is wise for every nurse to simply make note of any unusual conditions present during the test. For example, your patient has a 24-hour urine test ordered. When you begin the collection of the test, you will note the time in your nurse's notes. Therefore, when you mention that you have started the collection, also mention any other unusual conditions.

You might chart as follows:

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"24-hour urine started at 11:00 a.m. Patient emptied bladder at this time. Patient c/o mild abdominal pain, no abdominal distention noted. Patient is taking iron supplements and multivitamin supplements. Patient also has been on a high protein diet for 2 weeks ordered by Dr. Jones. Patient also has a history of CHF and renal stones. Pt. returned from physical therapy at 10:45 a.m. where he stated that he exercised very heavily."

The above is a detailed description of the patient's condition at the time the test was started. Perhaps later when the doctor sees the results of the test, he/she might look back and see that the patient was on a high protein diet. A high protein diet might affect the results of the 24-hour urine test. Or, perhaps the heavy

exercise might affect the results of a particular test. Therefore, I would say to nurses that you should be very aware and observant when any laboratory tests or diagnostic tests are ordered. Even if you are not familiar with ALL of the tests being done, you should at least be observant, and then chart your observations relating to the patient's condition at the time of the test.

Physical Activity is known to affect certain tests. After 20 minutes of strenuous exercise, serum potassium is decreased by about 8 percent; while SGPT (ALT) was raised by 41 percent. Heavy exercise will also increase the presence of other enzymes that are released into the bloodstream by the muscles under stress.

Patient Posture:

There is a little known fact that the patient's posture can affect lab values obtained from certain tests. There have been differences noted in lab values in patients who have been in a recumbent or supine position as opposed to those who have been standing or ambulatory for long periods of time. The difference in these lab values have been attributed to shifts in body fluids. Fluids tend to stay in the vascular compartment (bloodstream) when the patient is recumbent or supine. This tends to dilute the blood. There is a shift of fluids to the interstitial spaces upon standing or ambulation. The lab tests that are the most affected by this phenomenon are proteins (enzymes, albumin, globulins) and protein-bound substances such as triglycerides, choles-terol, calcium, and iron.

For example, ALT (alanine aminotransferase) has been known to increase up to 14% when the patient goes from supine to the erect position. Patients who are having any of these above tests performed, should be told to avoid prolonged standing prior to the venipuncture. It takes about 20 to 30 minutes to equalize fluid shifts due to changes in position.

Food Restrictions:

There is usually no special diet requirement for most "routine" lab tests or procedures. However, each nurse should be aware of tests that do require special food restrictions. Some tests require fasting prior to the test. Be sure you inform your patient verbally and in writing. Be sure that the staff is informed of any food restrictions. It is no secret that many tests and procedures had to be canceled at the last minute because the patient ate some food. Be sure to mark the patient's chart, diet list, and put signs in their room. Many hospitals have a specific procedure to follow for NPO. Be sure to follow this procedure and follow-up on keeping

them NPO, if required for testing or for the procedure. Also remember that some tests/pro-cedures might require that the patient consume a light meal, a liquid meal, or other special diet.

Drug Considerations:

Today, many pharmacologic agents are being used to treat disease conditions and for prophylaxis. The nurse must be aware and informed concerning interac-tions of these drugs and their effects on lab tests and diagnostic tests. For example, some oral contraceptives increase the values of iron, transferrin, triglycerides, and cerulo-plasm. Drugs toxic to the liver or kidney, could cause an increase in organ function tests (liver function tests, etc.) There are so many drugs in use today, you must have a reference available to use when your patient is going to be given a sensitive test or diagnostic procedure.

CHAPTER III

Hematology Blood Tests

HEMATOLOGY STUDIES

Test: Total Hemoglobin (Hgb or Hb)

A test used to determine the amount of hemoglobin in the blood. Hgb is the pigment part of the erythrocyte, and the oxygen-carrying part of the blood.

Normal Values: males: 12-17 grams-/100ml
females: 11-15 grams-/100ml

Clinical Implications:

A Low hemoglobin level indicates anemia. Estimates of Hgb in each RBC are moderately important when determining the total blood Hgb. However, hemoglobin findings are even more dependent upon the total number of RBC's. In other words, for the diagnosis of anemia, the number of RBC's is as important as the hemoglobin level.

Blood hemoglobin level has become a "routine" lab test for most patients admitted to hospitals to-day. Hgb is obviously important for the diagnosis of anemia and hemorrhage. It is equally important for diagnosing many lesser known dis-eases.

The test can be performed upon capillary blood, such as drawn from the finger stick. The test is often performed along with other tests, thereby requiring a larger specimen of blood, as from venipunc-ture. Hemoglobin in the body is dependent upon amounts of iron. A lack of available iron causes one type of ane-mia, due to the reduced produc-tion of hemoglobin. Remember that in the strictest sense, anemia is not in itself a diag-nosis, but rather a symptom that there is something else wrong in the body. For example, malnu-trition (low iron levels), would be the diagnosis of the patient, not just the anemia. The secondary diag-nosis would be anemia, but malnutri-tion must be treated in order to "cure" the anemia.

*Note--Fetal Hemoglobin:

Fetal Hb (Hb F), is a normal Hb product in the red blood cells of a fetus and in smaller amounts in infants. It constitutes 50% to 90% of Hb in a newborn; the remaining Hb consists of Hb A1 and Hb A2 the Hb in adults.

Under normal conditions, the body ceases to manufacture fetal Hb sometime during the first year of life, and from that point on manufactures adult Hb. If this changeover does not occur and fetal Hb continues to

constitute more than 5% of the Hb after age six months, an abnormality should be suspected, particularly thalassemia.

VARIATIONS OF HEMOGLOBIN TYPE AND DISTRIBUTION (in adults)

Hemoglobin	Percentage of total Hemoglobin	Clinical Implications
Hb A	95% to 100%	Normal
Hb A2	4% to 5.8%	- thalassemia minor
	1.5% to 3%	- thalassemia major
	Under 1.5%	- - thalassemia minor
Hb F	Under 2%	

	Normal
	2% to 5%
	- thalassemia minor
	10% to 90%
	- thalassemia major
	5% to 15%
	- - thalassemia minor
	5% to 35%
	Heterozygous hereditary
Persistence of fetal Hb	(HPFH)
	100%
	Homozygous HPFH
	15%
	Homozygous Hb S
	Homozygous Hb S

	70% to 98%
Sickle Cell disease	
Homozygous Hb C	90% to 98%
Hb C disease	
Heterozygous Hb C	24% to 44%
Hb C trait	

Test: Hemoglobin Electrophoresis

Hemoglobin electrophoresis is probably the most useful laboratory method for separating and measuring normal and some abnormal Hb. Through electrophoresis, different types of Hb are separated to form a series of distinctly pigmented bands in a medium (cellulose acetate or starch gel). Results are then compared with those of a normal sample.

Hb A (same as Hb A1), Hb A2, Hb S, Hb C, and Hb F are routinely checked, but the laboratory may change the medium or its pH to expand the range of the test. This test, by measuring the different types of Hb, is used to detect normal and abnormal types of hemoglobin, to aid in the diagnosis of thalassemia, and to aid in the diagnosis of sickle cell disease or trait.

**For normal or reference values, see the chart above.

Test: Hematocrit Hct

The hematocrit measures percentage by volume of packed red blood cells in a whole blood sample. For example, a HCT of 40% indicates that a 100-ml sample of blood contains 40 ml of blood cells. Packing is achieved by centrifuging anticoagulated whole blood in a capillary tube so that the cells are tightly packed without hemolysis.

Normal Values:

males:	40 to 50 percent
females:	37 to 47 percent

Clinical Implications:

Two small specimens of blood are obtained and compared. They are the same amount of blood exactly. One specimen is then centrifuged and subsequently compared to the first specimen. A percentage is then obtained from that comparison. This comparison is the hematocrit, Hct. The value of the hematocrit is dependent upon the number of RBC's. If the Hct is abnormal, then the RBC count is possibly abnormal. If the RBC count turns out to be normal, then the average size of the RBC is probably too small. Shock, hemorrhage, dehydration, or excessive IV fluid administration can reduce the Hct.

As you can see, there are many factors which can influence the results of the hematocrit test. However, this is still a good baseline lab test for the patient. It helps the physician to diagnose and to treat the patient with any disease which will lower or raise the Hct levels.

Test: Red Blood Cell Count RBC count

A count of actual (or estimated) number of RBC's per cubic mm of whole blood.

Normal Values:

males: 4.5 to 6.0 million/cu mm blood
females: 4.0 to 5.5 million/cu mm blood

Clinical Implications:

The RBC count is useful for determining such problems as anemia and hemorrhage. In combination with other hematology tests, it can be quite useful for diagnosis. This test can also give an indirect esti-mate of the hemoglobin levels in the blood. RBC's are actually "Red Blood Corpuscles," (non-nucleated cells). The term corpuscle indicates that it is a mature Red Blood Cell. Once the immature cell has matured, it is then, and only then, capable of carrying oxygen. It is then also not "technically" a cell anymore. Once it has matured, it loses its nucleus and can no longer be properly termed a cell. It would be called a corpuscle. However, everyone still refers to them as RBC's (cells). The source of the specimen is whole blood, capillary, or venous blood.

Test: Red Cell Indices (Wintrobe Indices)

A report of the individual characteristics of the RBC. The following are those character-istics which are used to indicate anemia. If abnormal findings are present,

the anemias can be defined as macrocytic, microcytic, hypochro-mic, others. When this is dis-covered, the exact cause of the anemia can be deter-mined more easily.
The following are all part of indices:

(1) MCV (2) MCH (3) MCHC

1. MCV---Mean Corpuscular Volume

-The volume of the average RBC

calculated by:

$$\frac{\text{Hct x 10}}{\text{\# of RBC's}} = \text{MCV}$$

Normal Value: 80-94 u3 (cubic microns)

Clinical Implications:

The MCV indicates the relative size of the RBC's. It does not indicate anything else about the cell. Several different types of anemias can be classified as micro- or macrocytic anemias. This test can direct the MD toward those types of anemias which alter the MCV results.

a. microcytic ane-mia.....decreased MCV (small cells)
b. macrocytic ane-mia.....increased MCV (large cells)

2. (MCH) Mean Corpuscular Hemoglobin: (Weight of hemoglo-bin in each cell)

calculated by:

$$\frac{\text{Hgb x 10}}{\text{\# of RBC's}} = \text{MCH}$$

Normal Value:

27-31 uuGrams (micro micro Grams)

-

3. MCHC--Mean Corpuscular Hemoglobin Concentration

Concentration of hemoglobin in the aver-age RBC

calculated by:

$$\frac{\text{Hgb x 10}}{\text{Hct}} = \text{MCHC}$$

Clinical Implications:

The MCHC is dependent upon the size of the RBC as well as the amount of hemoglo-bin in each cell. Certain diseases and anemias will alter the RBC count and/or the amount of hemoglobin in the cell. The MCHC is not as dependent upon the RBC count as the other tests in this

section. Therefore, the MCHC can be useful for the diagnosis of such conditions which are not dependent upon the number of RBC's.

The nursing implications for these tests are numerous. To the nurse, most cases of anemia are quite apparent. They are caused by hemorrhage, malnutrition, etc. However, the Indices can be used to help diagnose the less common types of anemias. Nursing care will then be determined according to the needs of that particular patient.

Test: Reticulocyte Count (Retic count)

This is a test for the estimation of the actual numbers of reticul-ocy-tes in the blood. Reticulocytes are the immature RBC's.

Normal Values:

approx 1% of normal RBC count (50,0-00); Results vary; range 0.5% to 1.5%

Clinical Implications:

The retic count is an indication of the production of RBC's by the bone marrow. An increase from the normal, usually indicates the body is responding to such pathologi-es as hemorrhage, anemia, hemolysis, or other such disease process. De-creased retic count may be indica-tive of aplastic anemia or any related disease.

The retic count is also examined for those persons working near any type of radioactive materials. The nurse should remember that the body tries to compensate for such conditions as the hemolytic and macrocytic conditions mentioned above. A large number of retics will be seen after the treatment has begun for pernicious anemia, in which large numbers will be produced as an attempt to bring to matur-ity, large numbers of RBC's.

Test: Sickle Cell Test

The sickle cell test, also known as the Hb S test, is used to detect sickle cells, which are severely deformed, rigid erythrocytes that may slow blood flow. Sickle cell trait (characterized by heterozygous Hb S) is found almost exclusively in people of African ancestry. It is present in nearly 8% of African Americans.

Although this test is useful as a rapid screening procedure, it may produce erroneous results. Hb electrophoresis should be performed to confirm the diagnosis if sickle cell disease is strongly suspected.

**See Hemoglobin electrophoresis test earlier in this chapter.

Test: Iron and Total Iron-binding Capacity

Iron is essential to the formation and function of hemoglobin, as well as many other heme and nonheme compounds. After iron is absorbed by the intestine, it is distributed to various body compartments for synthesis, storage, and transport. Serum iron concentration is normally highest in the morning and declines progressively during the day. Thus, the sample should be drawn in the morning.

An iron assay is used to measure the amount of iron bound to transferrin in blood plasma. Total iron-binding capacity (TIBC) measures the amount of iron that would appear in plasma if all the transferrin were saturated with iron.

Serum iron and TIBC are of greater diagnostic usefulness when performed with the serum ferritin assay, but together, these tests may not accurately reflect the state of other iron compartments, such as myoglobin iron and the labile iron pool. Bone marrow or liver biopsy, and iron absorption or excretion studies may yield more information.

Normal Values:

Serum Iron:

males: 50 to 150 u/g/dl
females: 35 to 145 ug/dl

TIBC, Total Iron-binding capacity:

males and females: 250 to 400 ug/dl

Saturation:

males and females: 14% to 50%

Test: <u>Ferritin</u>

Ferritin is a major iron-storing protein found in reticuloendothelial cells. It normally appears in small quantities in serum. In healthy adults, serum ferritin levels are directly related to the amount of available iron stored in the body and can be measured accurately by radio-immunoassay.

Normal Values:

Men: 20 to 300 NG/ml
Women: 20 to 120 NG/ml

6 mo to 15 yr 7 to 140 NG/ml
2 to 5 months 50 to 200 NG/ml

1 month old	200	to	600 NG/ml
Neonates	25	to	200 NG/ml

Normal serum Ferritin values will vary with age. Remember to check with your lab, as normal values may be different in different labs. The blood is collected via venipuncture in a standard 10-ml red-top tube. A random blood specimen is used. No special instructions need to be given to the patient except for explaining the procedure. Recent blood transfusions may elevate serum ferritin levels.

Increased Serum Ferritin Levels: may indicate acute or chronic hepatic disease, iron overload, leukemia, acute or chronic infection or inflammation, Hodgkin's Disease, or chronic hemolytic anemias.
Slight increase, or normal Ferritin Level: may indicate chronic renal disease

Decreased serum Ferritin Levels: may indicate chronic iron deficiency

Test: ESR--Erythrocyte Sedimentation Rate

The ESR measures the time required for erythrocytes from a whole blood sample to settle to the bottom of a vertical tube. Factors influencing the ESR include red cell volume, surface area, density, aggregation, and surface charge. The sample must be examined within 2 hours of collection and it must be handled gently, no clotting of sample must take place.

Normal values:

0-20 mm/hr (gradually increase with age)

The ESR is a sensitive, but nonspecific test that is frequently the earliest indicator of disease. It often rises significantly in widespread inflammatory disorders due to infection or autoimmune mechanisms. Such elevations may be prolonged in localized inflammation and malignancies.

Increased ESR: may indicate pregnancy, acute or chronic inflammation, tuberculosis, rheumatic fever, paraproteinemias, rheumatoid arthritis, some malignancies, or anemia.

Decreased ESR: may indicate polycythemia, sickle cell anemia, hyperv-iscosity, or low plasma protein.

Test: Osmotic Fragility

Osmotic fragility measures red blood cell (RBC) resistance to hemolysis when exposed to a series of increasingly dilute saline solutions. The sooner hemolysis occurs, the greater the osmotic fragility of the cells.

Purpose of test--The purpose of this test is to help diagnose hereditary spherocytosis and to supplement a stained cell examination to detect morphologic RBC abnormalities.

Normal results:

Osmotic fragility values (percentage of RBC's hemolyzed) are determined by the tonicity of the saline. Reference values for the different tonicities are as follows:

0.5 g/dl sodium chloride (NaCl) solution (unincubated)

males: 0.5% to 24.7% hemolysis
females: 0% to 23.1% hemolysis

0.6 g/dl sodium chloride solution (incubated)

males: 18% to 55.2% hemolysis
females: 2.2% to 59.3% hemolysis

0.65 g/dl sodium chloride solution (incubated)

males: 4% to 24.8% hemolysis
females: 0.5% to 28.9% hemolysis

0.75 g/dl sodium chloride solution (incubated)

males: 0.5% to 8.5% hemolysis
females: 0.1% to 9.3% hemolysis

Low osmotic fragility (increased resistance to hemolysis) is characteristic of thalassemia, iron deficiency anemia, and other red blood cell disorders in which codocytes (target cells) and leptocytes are found. Low osmotic fragility also occurs after splenectomy.

High osmotic fragility (increased tendency to hemolysis) occurs in hereditary spherocytosis, in spherocytosis associated with autoimmune hemolytic anemia, severe burns, chemical poisoning, or in hemolytic disease of the newborn (erythroblastosis fetalis).

Test: WBC count--White Blood Cell Count (Leukocyte count)

A laboratory test that counts the actual number of WBC's in the blood.
Normal Values: total WBC: 4,500 to 10,500

BASIC TYPES OF WBC'S:

-**neutrophils** (granulocyte)

lymphocytes (non-granulocyte)

monocytes (non-granulocyte)

eosinophils (granulocyte)

basophils (granulocyte)

Clinical Implications:

As we all know, WBC's are our body's first line of defense against invading bacteria and most other harmful organisms. This test (WBC), measures the total number of all types of WBC's. Further examination of the different types and numbers of cells present, could tell much about the state of the body's defense system. WBC count will normally vary as much as 2,000 on any given day.

Test: **Differential Cell Count** also known as "diff" or "differential"

Laboratory test that counts actual numbers of different types of WBC's.
Clinical Implications:

The following chart gives the normal values for each type of WBC. Interpretation of the results of the differential must always be done with the total number of WBC's in mind.

The **WBC differential** evaluates the **distribution and morphology** of white blood cells. Therefore, it provides more specific information about a patient's immune system than the WBC count alone. In the differential test, the lab classifies 100 or more white cells in a stained film of peripheral blood according to two major types of leukocytes. They are: **(1) Granuloc-ytes** (neutrophils, eosinophils, basophils); **(2) non-Granulocytes** (lymphocytes, mono-cytes). The percentage of each type is then determined.

The differential count is the **relative number of each type of** white cell in the blood. By **multiplying the percentage value of each type**, by the **total WBC count**, the lab obtains the **absolute number of each type of white cell**. Although little is known about the function of eosinophils in the blood, abnormally high levels of them are associated with various types of allergic disorders and reactions to parasites. In such cases, the eosinophil count is sometimes ordered as a follow-up to

the white cell differential. This test is also appropriate if the differential WBC count shows a depressed eosinophil level.

Interpre-ting the Differential:

In order to interpret the results of the WBC and the Differential, the nurse must consider both relative and absolute values of the differential. Considered alone, relative results may point to one disease while masking the true pathology that would be revealed by considering the results of the white cell count.

For example, consider a patient whose white blood cell (WBC) count is 6000/ul and whose differential shows 30% neutrophils and 70% lymphocytes. His relative lymphocyte count would seem to be quite high (lymphocytosis), but when this figure is multiplied by his white cell count (6000 x 70% = 4,200 lympho-cytes/ul), it is well within normal range.

The patient's neutrophil count, however, is low (30%), and when this is multiplied by the white cell count (6,000 x 30% = 1,800 neutrophils/ul), the result is a low absolute number. This low result indicates decreased neutrophil production, which may mean depressed bone marrow.

CELL TYPE	ADULT VALUE	ABSOLUTE VALUE	RELATIVE VALUE (6-18 years old) BOYS	GIRLS
Neutrophils	47.6% to 76.8%	1,950 to 8,400/ul	38.5% to 71.5%	41.9% to 76.5%
Lymphocytes	16.2% to 43%	660 to 4,600-/ul	19.4% to 51.4%	16.3% to 46.7%
Monocytes	0.6% to 9.6%	24 to 960/ul	1.1% to 11.6%	0.9% to 9.9%
Eosinophils	0.3% to 7%	12 to 760/ul	1% to 8.1%	0.8% to 8.3%
Basophils	0.3% to 2%	12 to 200/ul	0.25% to 1.3%	0.3% to 1.4%

(For interpretation, see next page)

NEUTROPHILS:

Increased by:

Infection; gonorrhea, osteomyelitis, otitis media, chickenpox, herpes, others
Ischemic necrosis due to MI, burns, carcinoma
Metabolic Disorders; diabetic acidosis, eclampsia, uremia, thyrotoxicosis
Stress Response; due to acute hemorrhage, surgery, emotional distress, others
Inflammatory disease; rheumatic fever, acute gout, vasculitis, myositis

Decreased by:

Bone marrow depression; due to radiation or cytotoxic drugs
Infections; such as typhoid, hepatitis, influenza, measles, mumps, rubella
hypersplenism; hepatic disease, storage disease
Collagen vascular disease; systemic lupus erythematosus
Deficiency of; folic acid or vitamin B12

EOSINOPHILS:

Increased by:

Allergic disorders; asthma, hay fever, food or drug sensitivity, others
Parasitic infections; trichinosis, hookworm, roundworm, amebiasis
Skin Diseases; eczema, psoriasis, dermatitis, herpes, pemphigus
Neoplastic diseases; Hodgkin's disease, chronic myelocytic leukemia
Miscellaneous; collagen vascular disease, ulcerative colitis, pernicious anemia, scarlet fever, excessive exercise, others

Decreased by:

Stress response; due to trauma, shock, burns, surgery, mental distress, **Cushing's Syndrome**

BASOPHILS:

Increased by:

Miscellaneous disorders; Chronic myelocytic leukemia, polycythemia vera, some chronic hemolytic anemias, Hodgkin's disease, myxedema, ulcerative colitis, chronic hypersensitivity states,

Decreased by:

Miscellaneous disorders; hyperthyroidism, ovulation, pregnancy, stress

LYMPHOCYTES:

Increased by:

Infections; pertussis, syphilis, tuberculosis, hepatitis, mumps, others
Others; thyrotoxicosis, hypoadrenalism, ulcerative colitis, immune diseases

Decreased by:

Severe debilitating illness; congestive heart failure, renal failure, advanced tuberculosis
Others; Defective lymphatic circulation, high levels of adrenal Corticosteriods, others

MONOCYTES:

Increased by:

Infections; subacute bacterial endocarditis, tuberculosis, hepatitis, malaria
Collagen vascular disease; systemic lupus erythematosis, rheumatoid arthritis
Carcinomas; monocytic leukemia, lymphomas

Decreased by: (unknown)

HEMATOLOGY.....In Summary

RBC lab values, along with the indices, are used to diagnose anemia and to define the type of anemia present. The lab values are calculated and compared for the individual characteristics of the blood cells.

When the individual charac-teris-tics of the cells are deter-mined, you can then decide if the con-dition is hem-orrhagic or another type of anemia.

One should ask the following questions in order to isolate the type of anemia:

1. Are the reticulocytes in-creased?

   possible hemorrhage

2. Is the hemoglobin abnormal?

   possible factor anemia

   possible hemorrhage

3. Is the RBC normal?

   possible metastatic problem

   possible hemorrhage

COAGULATION STUDIES

Nursing implications related to clotting studies are numerous. An increase in clotting of blood or a decrease in clotting ability will be considered the two main problems of coagulation of the blood.

Following is a summary of the overall phases of blood clotting. Circulating blood generally has two main inactive proteins relating to clotting. These are prothrombin and fibrinogen. It must also be remembered that platelets stimulate the clotting process.

Blood Clotting Process

PHASE I — Initiation Phase
plate-lets plus initiation factor

PHASE II — Thromboplastin Phase
* platelet factors plus Calcium
* plus factors 8, 9, 10, 11, 12

.....yields thromboplas-tin

PHASE III — Thrombin Phase
*prothrombin plus calcium
*plus thromboplastin
*plus accelerator factors 5, 7, 10

.....yields Thrombin

PHASE IV — Fibrin Phase
*fibrinogen plus factor 8
*plus Thrombin

.....yields

Fibrin **CLOT**

Test: Platelet Count

A test which is a direct count of platel-ets (thrombo-cytes) in whole blood.

Normal Values: 150,000 to 350,000 per mm3 (cubic mm)

Clinical Implications:

1. Platelets are the smallest formed elements in the blood. They are vital to the formation of the hemostatic plug in vascular injury. They promote coagulation by supplying phospholipids to the intrinsic thromboplastin pathway.

Thrombocytopenia--decreased platelet count, below approx 100,000
Spontaneous bleeding--if plate-lets decreased below approx 50,000
Fatal GI bleeding or CNS hemorrhage--if platelets below approx 5,000

2. When the platelet count is abnormal, diagnosis usually requires further studies, such as CBC, bone marrow biopsy, direct antiglobulin test (direct Coomb's test), and serum protein electrophoresis.

3. Use a 7-ml lavender-top tube for collection. A random specimen is used. Mix the blood GENTLY with the anticoagulant in the tube. Rough handling will interfere with the results.

4. Hemolysis due to rough handling or to excessive probing at the venipuncture site may alter test results.

5. Many medications will decrease platelet count; they include acetazolamide, acetohexamide, antimony, antineoplastic drugs, brompheniram-ine maleate, car-bamazepine, chloramphenicol, furosemide, gold salts, isoniazid, mephentoin, methyldopa, sulfon-amides, thiazide, and many others.

Platelets normally increase in persons living at high altitudes for extended periods of time. They also increase with persistent cold temperatures, and during strenuous exercise and excitement. The count decreases just prior to menstruation.

Test: Prothrombin Time PT or Pro Time

This test is a measure of phase III of the clotting process. The PT may give false read-ings due to some other clotting defects. However, it is usually indicative of a phase III problem.

Normal values: (child or adult): 11-15 seconds or 70%-100% (depends on method used)

Clinical Implications:

Prothrombin is also known as factor II of the coagulation factors. It is produced by the liver and requires vitamin K for its synthesis. In liver disease, PT is usually prolonged. The test requires 7 to 10 ml of blood with an anticoagulant in the blood tube. It can be collected in a black-top tube (sodium oxalate in the tube), or blue-top tube (sodium citrate in the

tube). The most common is the blue-top tube, the specimen must be tested within 4 hours of collection and is usually packed in ice and delive-red to the lab quickly. This is a very common lab test and is usually performed as a routine hospital admission screening test. A high-fat diet may cause decreased PT, and alcohol can cause an increased PT result.

Test: Partial Thromboplastin Time PTT

A test similar to the PT, the PTT is also used to detect clotting abnormalities. APTT, Activated PTT, similar to PTT but is more sensitive than PTT test; it will help to iden-tify the defective factor, if one is defec-tive.

Normal Values: PTT: 60-70 seconds
APTT: 30-45 seconds

*these results may vary due to test methods in different hospi-tals.

Clinical Implications:

The PTT is very similar to the PT. It is used to detect Phase II defects in the clotting process. It will usually detect deficiencies in all clotting factors except factors VII and XIII. It is usually performed for monitoring Heparin therapy. Heparin doses are usually adjusted according to the PTT test results. The PTT is usually more sensitive than the PT test.

Test: Bleeding Time

A raw measurement of the time needed for an artifi-cially produced skin puncture to stop bleeding.

Normal Values: Ivy method: 1-6 minutes
Duke method: 1-3 minutes

Clinical Implications:

Hodgkin's disease is suspected if there is decreased bleeding time. Prolonged rate may indicate: thrombo-cytopenic purpura, platelet abnor-mality, vascular abnor-mality, leukemia, severe liver disease, DIC dis-ease, aplastic anemia, factor deficie-ncies (V, VII, XI), Christmas disease, hemophilia. The following drugs can affect bleeding time: aspirin, dextran, mithramycin, coumadin, streptokinase-streptodornase (fibrin-olytic agent). Aspirin, alcohol, and also anticoagulants may increase bleeding time.

This test is usually inconclusive. It can however, be helpful for diagnosing capillary abnormalities and other disorders. For detecting other clotting problems,

this test will usually show a normal result. This test is usually just a general screening test.

Test: TGT, Thromboplastin Generation Time

A test for phase II clotting defects. It tests the ability of the patient to produce thromboplastin.

Clinical Implications:

This test is very complicated and only a few large laboratories will perform this test. The TGT has the ability to exactly pinpoint the defect in the clotting process. This fact can make the TGT a very valuable test under certain circumstan-ces.

Test: Plasma Fibrinogen

A test for the level of circulating plasma fibrino-gen.

Clinical Implications:

This test can be very valuable for helping diagnose disorders which can cause lowered levels of the fi-brin-ogen. It is also useful for detecting substances which destroy fibrinogen (fibr-in-olys-ins).

Discussion of Coagulation Tests:

The tests mentioned here are commonly used in hospitals today. There are many other coagulation tests available, most of which are compli-cated, expensive, and usually only per-formed at large medical centers. Many of those specialized tests are used only after simpler screen-ing tests are performed.

The nurse should always remember to obtain a very detailed history from the patient. The history can be most useful in helping the MD make an accurate diagnosis.

Many times the patient may not speak freely with the physician or may have forgotten some important detail or symptom. An observant nurse can possibly help with the medical diagnosis and possibly save the patient extra hospitalization and/or unnecessary testing.

As far as the mechanics of the tests are concerned, there is little for the nurse to do in order to prepare the patients. The nurse should always "warn" the patient

that the blood will be drawn, or that they will be injected with something, if it is part of the test. However, most coagulation studies are done with a specimen of blood drawn either randomly or at a special time of the day.

The specimen of blood will probably have an anticoagulant in it or in the collection tube and most specimens will either have to be iced or brought to the lab quickly for analysis.

CHAPTER IV

Special Serology and Blood Chemistry Tests

BLOOD CHEMISTRY TEST-ING

Blood chemistry testing is defined simply as identifying the numerous chemical substances found in the blood. The analysis of these substances will provide clues to the functioning of the major body systems. Most nurses are concerned with the fact that many blood chemistry tests are performed on the serum derived from whole blood. Serum, of course, is the liquid remaining after whole blood has clotted in the sample tube. Some blood chemistry tests are performed on other parts of blood as well.

Many laboratories now use automated electronic systems, such as the Sequential Multiple Analyzer (SMA) 12/60 and the Sequential Multiple Analyzer with Computer (SMAC). These machines are used for blood chemistry procedures, blood banking, serological procedures, and bacteriologic procedures. These systems perform blood studies rapidly, economically, and comprehen-sively. They can detect unsuspected abnormalities and indicate the need for additional tests.

The SMA 12/60 can make 12 determinations on 60 serum specimens in one hour. The SMAC can perform 20 to 40 biochemical determinations on 120 serum specimens in one hour. The SMAC can perform complete blood chemistry profiles in a short time and on very little blood.

Prior to taking the blood sample, the nurse should inform the patient about the test(s) to be performed and the preparation for the test. You should:

1. define and explain the test
2. state the specific purpose of the test
3. explain the procedure
4. discuss test preparation, procedure, and posttest care

Some of the more common tests require no special preparation. However, some blood chemistry tests will have specific requirements such as dietary restrictions

or medication restrictions. For some tests, such as hormones, stress should be avoided prior to the test. Be sure to inform the patient of any special preparation prior to the venipuncture and any posttest care needed.

CARDIAC ENZYMES and PROTEINS

Introduction:

Enzymes are proteins in the body and they act as catalysts. Catalysts are substances which change chemical reactions and rates of these reactions in the body. With their presence, reactions are either slowed or speeded.

Enzymes are found in all body cells and in other places in the body. When limiting our discussion to the cardiac enzymes, we are referring to the enzymes released into the bloodstream during myocardial damage. These enzymes can be used in the diagnosis of an MI. These blood tests are considered blood chemistry tests. However, we include them here as a separate chapter because they are so unique.

The term ***isoenzyme*** will also be used in this section. An isoenzyme (also known as ***Isozyme***) is an enzyme that may appear in multiple forms, with slightly different chemical or other characteristics, and be produced in different organs, although each enzyme performs essentially the same function. The various forms are distinguishable in analysis of blood samples, which aids in the diagnosis of disease. Isoenzymes that catalyze the same physiologic reaction may also appear in different forms in different animal species.

To summarize, **a protein enzyme is composed of (one or more) "isoenzyme."** These isoenzymes are very similar to each other in chemical composition, but have differences that can be measured by certain lab tests. For example, the CPK enzyme has three distinct isoenzymes. These isoenzymes are:

1. CK-BB (CK1) Isoenzyme #1
2. CK-MB (CK2) Isoenzyme #2
3. CK-MM (CK3) Isoenzyme #3

All three of these isoenzymes make up the main enzyme CPK (creatine phosphokinase) (also called CK--creatine kinase). However, as we will discuss later in this section, each isoenzyme can be isolated to different organs in the body and can help in diagnosing certain disorders.

Following are the main cardiac enzymes:

1. **SGOT** 2. **LDH** (also called **LD**) 3. CPK (also called **CK**)

1. Test: SGOT

Serum Glutamic Oxalo-acetic Transaminase, called: AST, (Aspartate Amino-transfer-ase) A blood chemistry test for the level of SGOT in blood (is released with tissue necrosis).

Normal Values: 5-40 U/ml (Frankel) 4-36 IU/L; or 16-60 (Karmen) U/ml U/L at 30 degrees C; or 8-33 (SI units) at 37 degrees C.

Clinical Implications:

This enzyme shows an elevation 8-12 hours after infarction. Peak levels are reached 24-48 hours after the MI. This enzyme is not particularly indicative of an MI. Other conditions can also cause a rise in the levels. High levels of SGOT may be obtained with trauma to the skeletal muscles, in liver disease, pancreatitis and others. SGOT is found in: heart muscle, liver, some also in skeletal muscle, kidneys and the pancreas. Demerol and morphine may elevate the levels tem-porarily. This en-zyme then, is used with other enzyme results to more definitely diagnose the MI. AST levels elevate in 6-10 hours following acute MI. They peak in 24 to 48 hours.

***Please note that** decreased levels of enzyme are found in pregnancy, diabet-ic ketoacidosi-s, beriberi. Elevations can be caused by hepatitis, trauma, musculoskelet-al disease, IM injection, pancreatitis, liver cancer, and strenuous exercise.

***Explain purpose of test to patient**
***do not give IM injections before the blood tests;** and if serial specimens are taken, still give no IM injec-tions, remember that very few meds can be given that do not affect the AST levels.

2. Test: LDH, Lactic Dehydrogenase (also called LD)

An intracellular enzyme present in nearly all metabolizing cells in the body. The highest concentration of enzyme is located in the heart, skeletal muscle, liver, kidney, brain, and erythrocytes. There are 5 isoenzymes of LDH. This is a blood chemistry test to measure the amount of enzyme in the blood.

LDH catalyzes the reversible conversion of muscle lactic acid into pyruvic acid, an essential step in the metabolic process that ultimately produce cellular energy. Because LDH is present in almost all body

tissues, cellular damage increases total serum LDH, limiting the diagnostic usefulness of this test.

Isoenzymes LD1 and LD2 appear primarily in the heart, red blood cells and kidneys. LD3 is primarily in the lungs. LD4 and LD5 are located in the liver, skin, and the skeletal muscles.

Normal Values:

Total LDH: 150-450 U/ml (Wroblewski-LaDue method), 60-120 U/ml (Wacker method) 70-200 IU/L--results are dif-ferent according to method used. Always check your own hospital for results used. These values have a wide range of normal and abnormal results.

Newborn: 300-1500IU/L Child: 50-150 IU/L

LD1---17.5% to 28.3% of total
LD2---30.4% to 36.4% of total
LD3---19.2% to 24.8% of total
LD4----9.6% to 15.6% of total
LD5----5.5% to 12.7% of total

Because many common diseases increase total LDH (LD) levels, isoenzyme electrophoresis is usually necessary for diagnosis. In some disorders, total LDH may be within normal limits, but abnormal proportions of each enzyme indicate specific organ tissue damage. For example, in acute MI, the LD1 and LD2 isoenzyme ratio is typically greater than 1 within 12 to 48 hours after onset of symptoms (known as flipped LD). Midzone fractions (LD2, LD3, LD4) can be increased in granulocytic leukemia, lymphomas, and platelet disorders.

Clinical Implications:

The total LDH may be influenced by other body tissues, other than the heart. Therefore, the LDH is split into its fractions, isoenzym-es, in order to isolate the particular one which is located almost solely in the myocar-dium. This isoenzyme is the number 1 isoenzyme. Although not foolproof, if this iso-enzyme is elevated, it is strongly indicative of an MI. LDH elevates in 24-48 hours and peaks in 48-72 hours after the episode.

Narcotic drugs and IM injections can elevate serum LDH levels. Hemolysis of the blood can cause an elevated LDH because LDH is plenti-ful in the erythrocytes.

Again, with this enzyme, it is important to gather a detailed patient history. Find out if there has been injury to any systems which might elevate the LDH levels. These include: trauma, cancers, leuk-emia, hepatitis, shock, heat stroke, sickle cell disease.

3. Test: CPK, Creatine Phosphokinase (CK) Creatine Kinase

This is a blood chemistry test to measure the amount of enzyme in the blood. The CPK enzyme is found in high concentration in heart and skeletal muscle; low concentration is brain tissue. CPK is an enzyme that catalyzes the creatine-creatinine metabolic pathway in muscle cells and brain tissue. Because of its intimate role in energy production, CPK reflects normal tissue catabolism; increased serum levels indicate trauma to cells.

Normal Values:

male:	5-35 ug/ml (mcg/-ml);
female:	5-25 ug/ml
newborn:	10-300 IU/L

Clinical Implications:

Serum CPK/CK will be elevated in skeletal muscle disease, in acute MI, in cerebral vascular disease, vig-orous exercise, IM injections, electrolyte imbalance, and hypo-kalemia. CPK has three isoenzymes as presented earlier. Fractionation and measurement of these three distinct CPK isoenzymes have replaced the use of total CK (or CPK) levels to accurately localize the site of increased tissue destruction. CK-BB is most often found in brain tissue. CK-MM and CK-MB are found primarily in skeletal and heart muscle. In addition, subunits of CK-MB and CK-MM, called isoforms or isoenzymes, can be assayed to increase the test's sensitivity.
These isoenzymes are:

1. CK-BB (CK1) Isoenzyme #1
2. CK-MB (CK2) Isoenzyme #2
3. CK-MM (CK3) Isoenzyme #3

When the isoenzyme CPK-MB is elevated, greater than 5%, it could strongly indicate damage to the myo-cardial cells. The CPK-MB elevates within 4-6 hours after an acute MI; peaks in 18-24 hours; it then returns to normal within 3-4 days. It is best to avoid IM injections, even though the injec-tions will usually not cause elevation of the CPK-MB. This is because other enzymes can be affected by the injecti-ons, and other enzyme studies are performed in conjunc-tion with the CPK studies. Trauma and surgery will elevate the CPK levels.

Precautions:

Draw the sample before giving or one hour after giving I.M. injections. I.M. injections will increase the total CK level. However, in most clinical situations today, this is not a problem. Most persons admitted with a possible MI will almost

always have an intravenous line started and all medications will be given intravenously, not I.M. Be sure to obtain the blood samples on schedule. Always note on the laboratory slip, the time the sample was drawn and the hours elapsed since onset of chest pain. Be sure to draw blood samples in a 7-ml red top tube.
Be sure to handle the sample gently to prevent hemolysis. Always have the sample transported to the lab promptly because CK activity diminishes significantly after 2 hours at room temperature.

DISCUSSION OF CARDIAC ENZYMES:

The diagnosis of MI is the main reason for the study of these enzymes. However, from the discussion of each enzyme, you can see that the diagnosis cannot be made quickly. The fact that the enzymes are not exclusively in the cardiac muscle, make the diagnosis very unsure. In the clinical setting, one of the most common reasons for enzyme elevation, is the IM injection. The injection will injure the muscle. The ingestion of alcohol, and trauma could also cause elevations which could cloud the diagnosis.

Isoenzyme assay techniques have become very refined in the recent years. The new techniques of measure-ment and reporting of the results have made the physician more sure about the diagnosis. The MD must also rely on other data in making the diagnosis. Within 12-24 hours of acute MI episode, a poly-morpho-nuclear leukocyto-sis develops. Also seen in these cases, is a slight increase in body temperature and a slight increase in the sed rate of the blood. When all of the above data are compiled, an MI may be suspected.

The observant nurse can make very important discoveries about the patient. Be familiar with the test method(s) used at your facility to measure enzymes and isoenzymes. Some labs now report the results on a very sophisticated lab sheet on a graph which will graphi-c-ally depict normal and abnormal results and will practically diagnose the condition for you.

Test: Myoglobin

This is a blood chemistry test used to measure the amount of this enzyme in the blood. This enzyme is ***not considered one of the cardiac enzymes***. However, myoglobin is often used to help confirm the results of the cardiac enzymes and to help confirm damage to the myocardium.

Normal Values: 30 to 90 NG/ml

Clinical Implications:

This test measures serum levels of myoglobin, an oxygen-binding muscle protein, similar to hemoglobin. Myoglobin is normally found in skeletal muscle and

cardiac muscle, and is released into the bloodstream after muscle injury. Thus, serum myoglobin levels help to estimate the amount of muscle damage. However, because myoglobin does not indicate the site of the damage, this test is used only to CONFIRM other tests such as CPK, CPK-MB, and others. Test results must also be correlated with the patient's signs and symptoms.

Do not collect the blood specimen from a patient who recently had an angina attack or undergone cardi-oversion. Cardioversion or angina attacks may increase myoglobin levels. Performing this test immediately after an MI produces misleading results, since myoglobin levels do not peak for 4 to 8 hours. A radioactive scan performed within one week before the test may affect the results. Myoglobin levels are also increased with skeletal muscle injury, polymyositis, dermatomyositis, systemic lupus erythematosis, shock, and in severe renal failure.

SERUM ELECTROLYTES

Introduction:

Serum electrolytes are mineral salts dissolved in water (the blood). The electrolytes are found throu-ghout the entire body. These salt solutions have special properties in our bodies. They play an important part in the maintenance of all body functions. From a nursing point of view, it is imperative that we know the impact of these electrolytes on the human body.

Electrolyte determination can be a very important part of the management of the patient with dehydration and many other related disorders. To review the nursing respon-sibilities: **(1) be sure the blood specimen is not drawn from an arm which has an IV running, (2) note if the patient has had a large meal high in sodium, (3) note if they are on a special diet restricting sodium or other nutrients, (4) any other condition such as diabetes which might influence the test results, (5) watch carefully for signs of fluid or e-lectroly-te imbalance.** Be sure to perform a complete head-to-toe assessment paying particular attention to cardiac assessment and vital signs.

Test: Sodium, (Na Serum)

This is a lab test which measures the level of serum sodium. Sodium is the major cation in the ex-tracellular fluid; and it is noted for its water-retaining property.

Normal Values:

adult: 135-145 mEq/L (same for child)
infants: 134-150 mEq/L

Clinical Implications:

There is no special patient preparation. However, if the patient has eaten a meal with a very high sodium content in the past 24 hours, this should be noted because it may affect the test. A serum sodium test is rarely ordered alone. This test is usually a part of a panel of electrolyte tests ordered at the same time. The same is true for the other electrolytes mentioned in this section.

This electrolyte has many functions in the body, including: conduction of neuromuscular impulses via sodium pump, (sodium shifts into cells as the potas-sium shifts out for cellular activity); enzyme activ-ity, osmolality of intravas-cular fluid; the regulation of acid-base balance, and others.

Decreased levels (hyponatremia) may be caused by: vomiting, diarrhea, gastric suction, excessive perspiration, continuous IV 5% Dextrose/water; low-sodium diet, burns, inflam-matory reactions, tissue injury, others.

Increased sodium can mean: dehydration, severe vomiting & diar-rhea, CHF, Cushing's disease, hep-atic failure, high-sodium diet, and others.

Test: Potassium, (K+)

Definition: Serum electrolyte

Normal Values: 3.5-5.0 mEq/L

Clinical Implications:

Potassium is another of the important electrolytes in the body. Our body is quite sensitive to abnormal levels of potassium. Cardiac arrhythmias and neurologi-cal disturbances are seen with high or low levels of this electrolyte. Hypokalemia can be caused by decreased intake, protracted vomiting, renal loss, cirrhosis and others. Hyper-kalemia can be caused by renal failure and other causes. The nurse must carefully check vital signs of any patients in the above risk groups, especially the cardiac stat-us and mental status.

Test: Chloride, (Cl)

Definition: Serum electrolyte

Normal Values: 95-105 mEq/L
Clinical Implications:

Chloride anion is found mainly in our extracellular fluid. Chloride plays an important role in fluid balance just as sodium does. Chloride also plays an impor-tant role in acid-base balance as well. However, many times the chloride test is ignored; in most cases when the sodium value is normal the chlo-r-ide value will be normal. So in some hospitals, testing for chloride is not performed very often. Most of the chloride ingested is combined with sodium (sodium chloride-table salt). The normal daily intake of chloride is about 2 g.

Test: Serum Osmolality,

Total amount of active electrolyte particles in solution in the blood.

Normal Values: Adult: 280-300 Osm/kg/H-2O.

Clinical Implications:

Serum osmolality measures the number of all dissolved particles in the serum (electrolytes, urea, sugar). It can be helpful in diagnosing fluid and electrolyte imbalances. Sodium will contribute about 90% of the serum osmolality due to its abundance in the body.

There are usually no restrictions for collecting the blood. A random sample is taken for testing. Hyper-glycemia will increase the serum osmolality. Decreased osmolality is associated with serum dilution due to overhydration and excessive fluid intake. Increased osmolality is associated with a fluid volume defi-cit, hypovolemia, dehydration, sodium overload, or hyperglycemia. With increased osmolality, there is thirst, dry mucous membrane, poor skin turgor, and shock-like symptoms.

Test: Acid Phosphatase

Test used to detect prostatic cancer and to monitor response to therapy for prostatic cancer.

Normal Value:

0 to 1.1 Bodanzky units-/ml;
1 to 4 King-Armstrong units/ml;
0.13 to 0.63 BLB units-/ml.

Clinical Implications:

Acid phosphatase, a group of phosphatase enzymes, appears primarily in the prostate gland and semen. It is also found in other organs, but in very small amounts. Prostatic and erythrocytic enzymes are the two major isoenzymes. They can be separated in the lab. The prostatic isoenzyme is more specific for prostatic

cancer. The more widespread the tumor, the more likely it is to produce high serum acid phosphatase levels.

Marked increased acid phosphatase levels:
A tumor that has spread beyond the prostatic capsule

Moderately increased acid phosphatase levels: Prostatic infarction, Paget's disease, Gaucher's disease, multiple myeloma

Declining high acid phosphatase levels: Successful treatment of prostatic cancer

Fluorides and phosphates can cause false-negative results. Clofibrate can cause false-positive results. Prostate massage, catheterization, or rectal examination within 48 hours of the test, may interfere with results. Hemolysis due to rough handling of sample or improper storage may interfere with test results. **Acid phosphatase levels drop by 50% within one hour if the sample stays at room temperature without the addition of a preservative or if it is not packed in ice.**

Test: Ammonia Measures plasma levels of ammonia

Normal value: is less than 50 mcg/dl

Clinical Implications:

This test measures plasma levels of ammonia, a nonprotein nitrogen compound that helps maintain acid-base balance. Most ammonia is absorbed from the GI tract, where it is produced by bacterial action on protein. A smaller amount of ammonia is produced in the kidneys. Normally, the body uses the nitrogen fraction of ammonia to rebuild amino acids. The liver then converts ammonia to urea, for excretion by the kidneys.

In diseases such as cirrhosis of the liver, however, the ammonia can bypass the liver and accumulates in the blood. Therefore, plasma ammonia levels may help indicate the severity of hepatocellular damage.

Precautions:

1. **These may cause increased levels of ammonia:** acetazolamide, thiazid-es, ammonium salts, furosemide, hyperali-mentation, portacaval shunt

2. **These may depress levels of ammonia:** lactulose, neomycin, kanamycin

3. **Hemolysis of blood sample** caused by rough handling may alter the ammonia test results.

4. **Before removing pressure from the venipuncture site,** make certain bleeding has stopped. Hepatic disease may prolong bleeding time.

5. **Fasting specimen** is usually required for this test; random samples may also be used (indicate if fasting or random)

Increased plasma ammonia levels:

Seen in hepatic coma, Reye's syndrome, severe congestive heart failure, gastrointestinal hemorrhage, erythroblastosis fetalis

Test: Creatinine

A test for creatinine levels in blood. Creatinine is a nonprotein end product of creatine metabolism. Creatine is an end product of protein metabolism, formed in the liver, kidneys, intestine, pancreas. Test used to assess renal glomerular filtration and screen for renal damage.

Normal Value: males: 0.8 - 1.2 mg/dl females: 0.6 - 0.9 mg/dl

Clinical Implications:

This test provides a sensitive measure of renal damage, because renal impairment is virtually the only cause of creatinine elevation. Creatinine is similar to creatine which appears in serum amounts proportional to the body's muscle mass. Unlike creatine, creatinine is easily excreted by the kidneys, with minimal or no absorption by the tubules. Creatinine levels, therefore, are directly related to the glomerular filtration rate. Since creatinine levels normally remain constant, elevated levels usually indicate diminished renal function. Elevated serum creatinine levels are most often seen in patients with renal disease that has seriously damaged 50% or more of the nephrons of the kidneys.

The sample is collected in a standard 10 ml or 15 ml red-top tube. It is ideal to restrict foods and fluids for 8 hours prior to the venipuncture to collect the specimen. Ascorbic acid, barbiturates, and diuretics may raise serum creatinine levels. Patients with

exceptionally large muscle masses, such as athletes, may have above-average creatinine levels, even in the presence of normal renal function. Elevated creatinine levels are also seen in persons with Gigantism and Acromegaly.

*Sulfobromophthalein or phenolsulfonphthalein given within the previous 24 hours can elevate serum creatinine levels if the test is based upon the Jaffe reaction.

BLOOD GROUPS AND TRANSFUSIONS

All nurses are certainly aware of the ABO blood grouping system. The ABO system is used clinically to type blood for transfusion, in order to assure compatibili-ty. This following section, will deal with the nursing considerations associated with typing of blood and blood products, and the step-by-step process of preparing blood for use by the patient.

Test: Blood Typing

Determination of major blood group a person belongs to. (ABO system)

This test is rapid and simple. It determines the "main" blood type of the person to be transfused. Of course a transfusion is not the only reason a person may be typed. Major blood types are: A, B, AB, and O.

Blood typing in the ABO system, and others, involves the iden-tification of specific proteins that are contained in the blood. Red Blood Cells have either antigen (protein) A, B, or AB or none, on the surface of the cells. These antigens, (proteins) make the blood of each person unique and separate from one an-other. Blood typing then, categorizes blood in individuals according to these proteins (ABO).

Test: Rh Determination

Definition: test for the Rh factor protein on the RBC, Red Blood Cell.

Normal Values: Most adults (85%) have the Rh factor in their blood, (Rh positive). Only a very small number of persons (15%) do not have the Rh factor (called: Rh negative)

The Rh factor (Rh antigen) was discovered in 1941 by Landsteiner and Weiner using Rhesus monkeys in their research. Since most persons carry the antigen, there are rarely any problems with compatibility of blood. However, most nurses are very aware of the problem seen in the case of erythroblastosis fetalis. In this disorder of the second newborn, the Rh negative mother becomes sensitized to the Rh antigen. If the conditions are right, the infant can be in great trouble.

Test: Crossmatch

Comparison test performed on whole blood in order to ensure compatibili-ty of transfused blood.

Clinical Implications:

Since there are many known and unknown antibodies in our blood, cross-matching is done as a final step before transfusing blood. Simply stated, a crossmatch involves the actual mixing of a sample of the donor's blood with that of the recipient's blood. The mixed samples of blood are then observed for any aggl-utination which might occur. The process takes 45 minutes to one hour to watch for a reaction.

Some of the above unknown antibodies may cause a reaction in the patient even though the blood has been shown to be compati-ble in the ABO and Rh systems. Therefore, the two blood specimens are mixed (cross-matched), and if a re-action occurs, there must be some other antigen on the RBC's which is incom-patible.------

CHAPTER V

Body Fluid Lab Tests

URINALYSIS

The urinalysis is another common test routinely taken in almost all acute hospitals as an admission lab screening test. It can easily reveal renal and systemic pathologies. Everyone should be reminded of the importance of this test. It has become such a routine patient test, that often, care is not taken when col-lecting and handling specim-ens. This improper handling can affect the results of the test, since contam-ination can occur at any point in the handling.

Even the routine urinalysis should be a midstream specimen after cleansing the meatus. This does not require any special equipment or expense to the patient. Some hospitals will require that even the rout-ine urinalysis be collected under sterile conditions just as a culture specimen would be collected. The container for this routine specimen should be clean; again, in some cases, the hospital requires a sterile container for all specimens. Remember that it will always save time in the long run to take care not to contaminate any type urine specimen.

The following tests are most common components of the urinalysis:

Test: Urinalysis: Appearance

Clinical Implications:

Turbidity and other terms are used to characterize the appearance of a urine specimen. Urine may contain red or white blood cells, bacteria, fat, or chyle and may reflect renal or urinary tract infection.

Some drugs can change the color of the urine. Normal urine color is a light yellow to a dark amber color. Inflamma-tion may also cloud the urine as well as other pathological conditions can. Dorban can color the urine red; phenolphthalein can color it red; pyridium can color the urine dark orange. Of course, the patient should be "warned" of these changes. Hospitalization is stressful enough without the added shock of unexpected orange urine.

The odor of a urine specimen is also noted. In diabetes mellitus, starvation, and dehydration, a fruity odor accompanies formation of ketone bodies. In urinary tract infections, a fetid odor commonly is associated with E. coli. Maple syrup urine disease and phenylketonuria (PKU) also cause distinctive odors. Certain foods may also give urine certain color and odor. A patient diet history is important if the urine has an odor.

Test: Urinalysis: pH

Clinical Implications:

Urine is normally slightly acid (4.5 - 7.2 normal range). If alkaline, it can be indicative of infection. However, the urine pH does change during the day due to dietary influences and water intake. A 24-hour specimen would reveal an optimum pH of about 6.0.

Test: Specific Gravity

Specific gravity is the weight of the urine as compared to water.

Normal Values: 1.005 to 1.025

Clinical implications:

Specific Gravity will increase with the amount of dissolved particles (concentrated) in it. Specific gravity will decrease when the water content is high and the dissolved particles are low (less concen-trated). Low specific gravity (<1.005) is characteristic of diabetes insipidus, nephrogenic diabetes insipidus, acute tubular necrosis, or pyelonephritis. Fixed specific gravity, in which values remain 1.010 regardless of fluid intake, occurs in chronic glomerulonephritis with severe renal damage. High specific gravity(>1.035) occurs in nephrotic syndrome, dehydration, acute glomerulonephritis, heart failure, liver failure, or shock.

Test: Urinalysis: Protein

Clinical Implications:

Only a very small amount of protein should be excreted into the urine in a 24-hour period (normal is 0-trace). Albumin is usually the first protein to be excreted in disease conditions. Some non-disease conditions such as extreme muscle exertion and pregnancy may cause proteinuria. Some of the disease conditions which can cause proteinuria are renal disease, fever, CHF, hypertension, tumors, and others.

Test: Urinalysis: Glucose and ketones

Clinical Implications:

The how and why glucose gets into the urine is dependent upon several factors. Without disease, it is possible to "spill" glucose after eating a large meal. Once serum glucose reaches 180 mg/100ml and above, it is possible to spill small amounts of glucose into the urine. This is a normal condition. However, some people have a higher or lower threshold for spilling glucose

into the urine. A normal urine glu-cose is 0 to trace amounts.

Serum glucose levels are obviously important in diabete-s, and so is the spilling of glucose into the urine. Glucose levels may also be raised or lowered in several other disease con-di-tions as well as in diabetes.

Ketonuria occurs in diabetes mellitus when cellular energy needs exceed available cellular glucose. In the absence of glucose, cells metabolize fat for energy. Ketone bodies--the end products of incomplete fat metabolism--accumulate in plasma and are excreted in the urine. Ketonuria may also occur in starvation states and following diarrhea or vomiting.

Urinalysis: Microscopic exam of the urine

A microscopic examination of the urine may reveal many different disease conditions. The following tests are the usual components of the exam:

Test: Microscopic Urine Exam: RBC's

Clinical Implications:

This will detect the presence of RBC's in the urine. Normal is 0-3 RBC's. Gross bleeding into the urine is usually obvious. On lab exam of the urine, numerou-s, many, and gross are terms used to describe the amount of blood in gross bleeding. However, all bleeding is not that obvious. In order to detect slower bleeding and inflam-mation in the urinary tract, the microscopic exam is needed. In some normal condi-tions, a very few RBC's may get into the urine. When a level of more than 3 RBC's are found, a disease condition is often present. One of the most common causes of RBC's in the urine, is infec-tion or inflamma-tion of the urinary tract itself (i.e., cystitis). Trauma and several other conditions may also cause bleeding into the urine. Of course, the nurse will carefully observe the patient with gross bleeding. However, do not forget the patient with only very slight bleeding as well. This patient can just as easily develop a severe hemor-rhage from only a "min-or" condition.

Test: Microscopic exam of urine: WBC's

Clinical Implications:

WBC's are most often present in the urine due to direct infec-tion/inflammation of the renal system. An infection in the urinary tract or in the kidney itself is usually the most common reason for this inflammation. However, there are also obstructive disorders which can cause WBC's to be in the urine. With obstructive

disorders, however, there are usually other, more definitive symptoms present than only the WBC's present in the urine. The WBC count in the urine then, is not relied upon heavily to diagnose these obstructive disorders.

Test: Microscopic exam of urine: Casts

Clinical Implications:

Casts are solid, formed elements which appear in the urine, secondary to some other type of cell des-truction. They can also be formed from other waste material as well as from dead cells. There are several different types of casts, named usually by the formation of their shape, or from their composition. Casts can be formed in the renal tubules and actually take the shape of the lumen of the tubules. They can also take other shapes and are named accordingly. The sig-nificance of casts in the urine is quite ques-tionable. Casts formed from WBC's are noted more when infections are present. Likewise, certain diseases tend to form characteristic-type casts. However, diagnosis cannot be made definite from the pres-ence of casts alone. This is true, because casts are influenced by the urine pH, by dehydra-tion, inflam-mation and other such conditions.

Test: Microscopic exam of urine: Crystals and other components

Some crystals normally appear in urine, but numerous calcium oxalate crystals suggest hypercalcemia or ethylene glycol ingestion. Cystine crystals (cystinuria) reflect an inborn error of metabolism.

Bacteria, yeast cells, and parasites in urine sediment reflect genitourinary tract infection or contamination of external genitalia. Yeast cells, which may be mistaken for red blood cells, are identified by their ovoid shape, lack of color, variable size, and frequently, signs of budding. The most common parasite in sediment is Trichomonas vaginalis, which causes vaginitis, urethritis, and prostatovesiculitis.

Summary: Urinalysis

Some of the most common tests included in the urinalysis have been presented here. There are many other tests that can also be performed on urine, but most are not "routine" tests. Remember that routine tests will vary greatly in hospi-tals. What is routine in one hospital may not be routine in another. These may include the presence of crystals, bile, yeasts, acetone, and others.

When you are faced with one of these infrequent tests, it is best to ask the lab in your hospital for the correct procedure for collec-tion of the specimens and transporting to the lab. Most nursing units also have lab manuals for that same purpose.

In all cases, the nurse should use care in the collecting and handling of the specimens. The re-sults of the routine urinalysis can be used to help diagnose everything from dehydration to the rare metabolic disorders. The specimens themsel-ves can be either random spot specime-ns or timed; depending u-pon the particular test. The urinalysis is almost always a random specimen, being refrigerated until delivered to the lab.

Test: Urinary Calculi

Urinary calculi (stones) are insoluble substances most commonly formed of the mineral salts--calcium oxalate, calcium phosphate, magnesium ammonium phosphate, urate, or cystine. They may appear anywhere in the urinary tract and range in size from microscopic to several centimeters.

Formation of calculi can result from reduced urinary volume, increased excretion of mineral salts, urinary stasis, pH changes, and decreased protective substances. Calculi commonly form in the kidney, pass into the ureter, and are excreted in the urine. Because not all calculi pass spontaneously, they may require surgical extraction. Calculi do not always cause symptoms, but when they do, hematuria is most common. If calculi obstruct the ureter, they may cause severe flank pain, dysuria, urinary retention, frequency, and urgency.

The procedure for this test is quite simple. The nurse will simply strain all the patient's urine and observe the strainer for any signs of calculi. Be sure to teach the patient to save all his urine. Many alert patients will be able to save and strain their own urine. Be sure to place a “SAVE URINE” sign at the bedside and in the patient's bathroom so that other health care workers will not discard any urine.

The nurse will send any stones, “gravel,” or sediments strained to the lab according to hospital procedure. Also note any hematuria, flank pain, and any other symptoms. Many patients with renal calculi may be in severe pain and also might be groggy due to analgesics. Be sure to observe the proper nursing measure for these conditions.

Test: Concentration and Dilution Tests

The kidneys normally concentrate or dilute urine according to fluid intake. When such intake is excessive, the kidneys excrete more water in the urine. When intake is limited, they excrete less. This test evaluates renal capacity to concentrate urine in response to fluid deprivation, or to dilute it in response to fluid overload.

Preparation and procedure:

Explain the test to the patient. Explain that there will be certain food and fluid restrictions and requirements during the test period.

Concentration test:

Provide a high-protein meal and only 200 ml of fluid the night before the test.
Instruct the patient to restrict food and fluids for at least 14 hours before the test. (Some concentration tests require that water be withheld for 24 hours but permit a relatively normal food intake.)
Limit salt intake at the evening meal to prevent excessive thirst.
Emphasize to the patient that his cooperation is necessary to obtain accurate results.
Collect urine specimens at 6:00 a.m., 8:00 a.m., and 10:00 a.m.

Dilution Test:

Generally, this test directly follows the concentration test and necessitates no additional patient preparation. If it's performed alone, simply withhold breakfast.
Instruct the patient to void and discard the urine.
Give him 1,500 ml of water to drink within 30 minutes.
Collect urine specimens every half hour for 4 hours thereafter.

Normal Concentration results:
specific gravity:
1.025 to 1.032
Osmolality:
>800

mOsm/kg

Normal Dilution Test results:

specific gravity:

<1.0003

Osmolality:

<100 mOsm/kg

Decreased renal capacity to concentrate or dilute urine may indicate tubular epithelial damage, decreased renal blood flow, loss of functional nephrons, or pituitary or cardiac dysfunction.

CEREBROSPINAL FLUID

Cerebrospinal fluid, CSF, is collected via the (LP) lumbar puncture. The nursing considerations include assisting with the LP and proper handling of the specimen-s. The actual procedure for the LP will vary at different hospitals, so the nurse should become thoroughly familiar with the procedure at each indi-vidual hospital. Most commonly today, specimen tubes are marked very clearly for the tests to be per-formed on that numbered specimen. The sterility of the specimen must also be main-tained.

Test: cerebrospinal fluid examination, Pressure

Clinical Implications:

The cerebrospinal fluid pressure is measured during the extraction of the fluid at the LP site, by the physician. This is not a lab test, but it is important for the nurse to know its value.

Normal pressure is: 100 to 200 mm H2O

The most common cause of increased pressure of the fluid is increased intracra-nial pressure. There are also other conditions which can cause this, but they are quite rare.

Test: cerebrospinal fluid examination: Appearance

Clinical Implications:

CSF will change color according to the abnormal constituent:

1. increased RBC's red color
2. increased WBC's cloudy
3. increased protein cloudy
4. severe jaundice sligh-tly yellow
5. old blood sligh-tly yellow

The above abnormalities are easily detected, usually. The RBC's and WBC's may both be present in many in-flamm-atory condi-tions and will be discussed later. Appearance then, can be a good indicator of the type of problem pres-ent and can lay suspect certain pathological conditions.

Test: Cerebrospinal fluid examination: Glucose

Clinical Implications:

CSF glucose levels are usually 1/2 of the serum glucose values (approx. 50-100 mg). The main path-ologies occur when the CSF glucose is lower than normal. Decreas-ed levels (45 mg and lower), are seen in meningitis, meningealcarcinoma and sometimes in intracranial hemor-rhage.

Test: Cerebrospinal fluid examination: Protein

Clinical Implications:

Normal levels of protein are 15-40 mg. Some disorders which can cause an increase in protein, can also cause an increase in the WBC count as well. The following list of disorders can cause increased protein in the CSF, some also cause a corresponding elevation in WBC's:

1. brain tumors
2. some diabetics
3. multiple sclerosis
4. guil-lian-Barre syndrome
5. syphilis

Test: Cerebrospinal Fluid Examination: Cell Count

Clinical Implications:

As discussed earlier, many disorders can cause increased cell counts in the spinal fluid. The first two specimen containers obtained will be contaminated with blood cells due to the trauma of the Lumbar Puncture it-self.

Therefore, the cell count is usually performed on the last of the specimens tak-en. This is one of the reasons for correctly marking the specimen tubes as they are ob-tained. Most of the new disposable Lumbar Puncture trays today have conve-niently pre-marked specimen con-tainers for each successive specimen. This reduces the risk of mis-marking the containers.

In most hospitals, a cell count is usually performed in order to detect the presence of infection. Upon examin-ation, the lymph-ocytes are examined and their presence under 500mm3 may indicate a viral in-fection, or over 500mm3 may indicate purulent infections (incr-eas-ed granulocytes). In addition, a WBC different-ial count may be ordered so that the individual types of WBC's can be identified.

adult	0-8 leukocytes per cubic mm (mm3)
child	0-8 leukocytes per cu mm
newborn	0-15 leukocytes per cu mm
premature infant	0-20 leukocytes per cu mm

Test: Cerebrospinal fluid examination: Culture

Clinical Implications:

This test usually is performed when meningitis or other infection is suspec-ted. In many hospitals a culture of the CSF is a routine procedure on all specimens col-lected.

Test: Cerebrospinal fluid examination: Serology

Definition: test for syphilis

Clinical Implications:

This test for CSF serology can have great clinical significance. Many times when the blood serology test is negative, the CSF test is positive. An example of this is: tertiary syphilis; where the serum test turns negative with time. There are also other times when the CSF test will be negative and the serum test will be positive. Each case must be evaluated individually. If syphilis is suspected, a CSF serology may be done in the presence of negative blood serology report from the lab.

Test: Cerebrospinal fluid examination:

Soluble Amyloid Beta Protein Precursor

The presence of the amyloid beta protein in the senile plaques of the brain is a hallmark of Alzheimer's Disease, leading researchers to believe that this protein may be responsible for the disease's neurotoxic effects. Although amyloid is found in the CSF of healthy people, it is found in smaller amounts in some patients with dementia, making it a useful diagnostic tool.

Preparation and procedure:

Explain the test to the patient. The specimen is obtained through a lumbar puncture, so be sure to review your facility's guidelines for this procedure as well. There is usually no restriction of food or fluid, except some facilities prohibit a heavy meal right before the procedure.

The lumbar puncture is performed by the physician. Review the nursing implications of assisting with the LP and post-LP nursing care.

During the procedure, the physician will usually take routine measurements of the CFS such as pressure readings and CSF samples. Be sure you know ahead of time what samples are to be obtained. Some physicians prefer to take the one sample and "get out."

After the procedure, be sure to observe the patient for post-LP complications.

Mark the lab slip appropriately with the correct patient data, time of specimen collection, and the type of specimen (CSF).

Findings:

Soluble amyloid beta protein precursor is found in the CSF of healthy people. Normal amyloid beta protein levels in CSF are greater than 450 units/L, based on age-matched controls using the ELISA test.

Low CSF levels suggest an alteration in the amyloid beta protein precursor processing and amyloid beta protein formation. Low soluble amyloid beta protein precursor levels correlate with clinically diagnosed and autopsy-confirmed Alzheimer's disease.

Summary: <u>Body Fluid Lab Tests</u>

The tests presented here are the most commonly used tests in most hospitals today. There are other special tests which can be performed on these fluids, urine and spinal fluid, but usually just for rare conditions. There are also many other body fluids which may be tested. These include, but are not limited to:

synovial fluid, Pericardial fluid, pleural fluid, sweat, urogenital secretions, sputum, gastric acid, peritoneal fluid, fecal lipids, bile, semen, amniotic fluid, and many others

As we stated earlier, the nurse can be instrumen-tal in the success of treatment of the patient, if those sugges-tions are followed. These diseases are serious ones which need the cooperation of the entire health care team.

Those suggestions are:

proper assistance during the lumbar puncture, urine collection, gastric aspiration, amniocentesis, etc.

Be sure to completely explain the test to the patient.

Be sure to obtain the proper consent forms (when required).

careful handling and transporting of the specimens

accurate recording and reporting of the patient symptoms

Be sure to perform after-care on special procedure such as LP, amniocentesis, etc.

possible isolation precautions for the pati-ent

The need for isolation may be great, so be careful to follow hospital guide-lines for han-dling suspected contagious fluids, such as meningitis patients, hepatitis patients, (and other infections).

CHAPTER VI

Select Organ Function Blood Tests

LIVER FUNCTION TESTS (L.F.T.)

The following set of tests is commonly used to diagnose liver disease. Almost all types of liver disease can be isolated by the use of these following tests. Liver disease is fairly common today, so these

tests are of particular significance in the diagnosing of these related diseases.

Test: BSP, Bromsulpha-lein Test

This is a liver function test used to diagnose general liver disfunction-, including ob-structive liver disease.

Clinical Implications:

This test uses an injected dye, BSP, for diagnosis of liver disease. After the injection, several blood samples are taken to determine the blood level of the dye. These levels will indicate the liver's ability to excrete the dye and thus the general functioning of the liver. This test is very diagnostic of inactive cirrhosis of the liver.

Test: Serum Bilirubin

This test is a measure of the bilirubin in the blood.

Normal Value:
total bilirubin = less than 1.5 mg/100ml

Clinical Implications:

Bilirubin is present in blood at all times due to the break-down of hemoglob-in which occurs all the time. Normally, bilirubin is removed from the blood by the liver. Increased serum bilirubin levels indicate obstructive disease of the liver, hemolysis or actual liver cell damage.

direct bilirubin--quick, one-minute test for bilirubin (usually not accurate)
indirect bilirubin--30 minute test (more accurate)

Test: Alkaline Phosphatase

This is a liver enzyme test. Alkaline phosphatase (ALP) is produc-ed in the liver and bone, it is also derived from the kidney, intes-tine, and placenta. In obstruc-tive biliary disease, there is elevated serum ALP.

Normal Values:

20-90 U/L at 30 degrees C. adult
40-300 U/L child

Clinical Implications:

This test is very useful for diagnosing biliary obstruction. Even in mild cases of obstructive disease, this enzyme is elevated. It is not very useful for diagnos-ing cirrhosis. If a patient has bone disease, this test may be highly inaccurate, as ALP is also found in bone tissue.

Test: SGOT, SGPT, LDH

Definition:

These enzymes are used to help diagnose liver disease (also MI, refer to previous chapter).

Clinical Implications:

These enzymes can be indicative of liver disease. However, as stated earlier in this text, these enzymes are also found in other body tissues such as bone, heart, kidney, etc. Isoenzyme tests usually must be performed in order to isolate the isoenzyme that is elevated and if the source is the liver.

SGPT--Serum Glutamic Pyruvic Transaminase
normal: 5-35 U/ml (highest levels seen in liver disease)
SGOT--Serum Glutamic Oxaloacetic Transaminase
normal: 5-40 U/ml

Test: Blood Ammonia level of ammonia in the plasma

Normal Values: 3.2 - 4.5 g/dl (depends upon the method used)

Clinical Implications:

Ammonia is formed due to bacterial action in the intestines and by normal metabolism in all body tis-sues. Most of this ammonia is then absorbed by the intestines and goes into the portal circulation, where normally the liver converts it to urea and it is excreted by the kidneys. This test then, is most useful in diagnosing hepatic failure, although plasma ammonia levels are not elevated in all cases. Reduced portal circulation (through the liver) can also result in very high ammonia levels. CHF and/or acid-osis may also cause a temporary rise in plasma ammonia.

Arterial or venous blood may be used for the specimen in most hospitals; some also recommend putting the specimen on ice and transpo-rt to the lab. A green-top tube (heparinized) is usually used. NPO, except for water, 8 hours prior to the test is usually recommended.

High or low protein diets may also affect the lab test results. Exercise and certain antibiotics (neomycin and tetracycline) will usually affect the test results.

THYROID FUNCTION TESTS

Introduction:

As most nurses know, the thyroid affects the following in our bodies:

1. body metabolism and the amount of oxygen consumed
2. speed of chemical reactions in the body
3. amount of heat produced in the body

The two main hormones the thyroid secretes are responsible for the stimulation effects throughout the body. They are:

a. Triiodothyronine(T3) (T3 has 3 atoms of iodine)
b. Levo-thyroxine (T4) (T4 has 4 atoms of iodine)

T3 is the stronger of the two hormones. It has a stronger and more rapid metabolic action that T4. Most of the T3 is made of T4 which has been broken down at a cellular level. Some T3 is actually made in the thyroid gland, but most is from the degradation of T4 in the cells.

The following tests are the most common ones performed today in most hospitals. Always remember that each hospital is different and the procedure from one place to another will vary. Always consult the lab manual or procedure manual at your facility to be sure that the nursing responsibilities have been carried out properly.

Test: BMR, Basal Metabolism Rate

Normal Values:

+ 5% probably means slightly overactive thyroid

- 5% probably means undera-ctive thyroid

Clinical Implications:

This test is rapidly being replaced today by more sophisticated tests of thyroid function. The test is indirect, meaning that it actually measures oxygen consumption in the body. This oxygen con-sumption could be directly related to metabol-ism, as the thyroid hormones affect the metabolic rate.

As you see, this test is unreliable, but it is still used oc-casionally as a general indicator of thyroid function.

The patient should be prepared for this. Inform them that they will be asked to breathe oxygen through a set of tubes for a few minutes. The patient should be as "stable" as possible, meaning that he should be free from stress and have no excessive physical activity for 6-8 hours before the test. If it is an outpatient, he should be instructed to sleep at least 8 hours the night before the test and will be asked to lie down for 30 minutes immediately before the test.

In the lab where the testing is conducted, room air pressure and temperature are measured. Patient data are collected; height, weight, age and normal sleeping and eating habits must be recorded, as any of these can affect the test. The patient is kept NPO before the test, no smoking is allowed, NPO at home after 9:00 p.m. the night before. The results of the test are recorded as a "plus" or "minus" from the normal, in a percentage.

Test: PBI, Protein Bound Iodine Measures the amount of iodine in serum

Normal Values: 5-8 ug (micro grams) /100 ml serum

Clinical Implications:

In the blood, iodine is not a free molecule, but rather it is bound to protein. Since iodine is stored in the thyroid and used to syn-thesize thyroxine, the amount of iodine in the serum can give a good indication of thyroid function.

Since there is a direct relationship between PBI concentration and the activity of the thyroid, this test is valuable for testing general activity of the thyroid. A low concentration of PBI in blood, indicates hypothyroidism; and a high concentration will usually indicate hyperthyroidism.

Test: Radioactive Iodine Uptake (RAI) (RAIU) (uses I131)

Clinical Implications:

This is a test of thyroid function. The patient is given a dose of iodine (radioactive iodine), and after a certain length of time, the amounts of the material absorbed are measured. The iodine causes no discom-fort for the patient, it is certainly not dangerous to the staff, and the patient can eat soon after the ma-terial is ingested.

Basic procedure at most facilities is:

1. NPO for 6-8 hours

2. Capsule or liquid is administered with the radioactive iodine (50-100 uC [micro Curie])

3. Save urine, most hospitals will discard after 24-48 hours

4. Patient usually eats 1 hour after administering the dose

5. Blood tests are done at intervals; (check your hospital lab for times and be sure samples are taken)

Levels of radioactive iodine are usually checked, in the blood, in the urine, and in the thy-roid itself. As the thyroid gland takes up the iodine, some iodine will be con-centrated in the thyroid itself and in the blood. It is the blood concentrations that are measured. It is an indirect measure of how much the thyroid has ab-sorbed.

Test: Thyroidal Iodide Clearance

This test measures the amount of iodine cleared by the blood in a period of time.

Normal Values: 25 ml/min (25 ml plasma is cleared of iodine per minute)

hyperthyroid-ism....250 ml/min
hypothyroid-ism.....1.6 ml/min

Clinical Implications:

The patient is given an intravenous injection of radioactive iodine. Blood samples are then taken fre-quently for 1 to 2 hours after the injection. Amounts of iodine are measured and compared to normal.

Test: Radioactive Iodine Excretion

Definition:

Similar to above test, this procedure measures the amount of radioactive iodine excreted in the urine after a test dose is administe-red.

Normal Values:

40-80% of dose is excreted in 24 hours

hyperthyroid-ism....less than 40% excreted
hypothyroid-ism.....more than 80% excreted

Test: Thyroid Scan

This test is an organ scan of the thyroid (scintillation scanner).

Normal Values: normal concentration of radioactive iodine in thyroid

Clinical Implications:

Radioactive iodine is injected intravenously. The patient is then scanned by the scintillation camera. The thyroid, of course, absorbs the iodine and the scanner picks it up. If the concentration in the gland is normal, the test is normal. If there are spots on the scan, it may mean tumor growths. The images are recorded on video tape and/or photographs.

Test: Triiodothyronine levels (T3 level)

amount of hormone in blood plasma

Normal Values: 11-19% men 11-17% women
Clinical Implications:

This hormone is one of the thyroid substances. In the blood, it is found in the plasma and in RBC-'s. It is strongly attracted to the plasma, therefore, saturat-ing it first. It then goes to the RBC's. Knowing this, the test for this hormone is performed in the lab by adding a measured amount of radio-active T3 to the patient's blood sample.

If the normal amount of T3 is present naturally, in the blood, the specimen will only uptake a small amount of the radioactive hormone added to the blood. When they measure the amount of the radioactive hormone in the blood, they can deduce that either a normal amount was present in the blood, or that there was too little, or too much.

If the thyroid is underactive and not producing sufficient T3, then it follows that when the radio-active T3 is added to the patient's blood, it will have room to absorb a greater amount.

hypothyroidism....less than 11% results (or low T3 results)
hyperthyroidism...greater than 19% results (or high T3 results)

**note that hyper- and hypothyroidism will be measured by different criteria (test results); by dif-ferent experts; always consult your hospital lab for what they consider high and low results.

This test is very good for patient safety. No radioactive materi-al is given to the patient, it is added to the blood sample later. No other special prepara-tion is needed, and iodine supplements usually do not affect the results. False high results seen in:

a. in abnormal liver conditions (blood plasma proteins are altered)
b. nephrosis
c. hypoproteinemia
d. in patients on anticoagulant therapy

*False lows seen in pregnancy
*Results can be affected by estrogens, androgens, Dilantin, and Aspirin
*T3 also known as T3 Resin Update and T3 Uptake
*Normal results can be as high as 25% to 30% depending upon method

Test: T3 Suppression Test

This test is not used very often today, it measures the amount of T3 uptake before and then after patient is given large doses of T3 by mouth. Consult lab for exact procedure on rare occasions this test is ordered.

Test: Serum Thyroxine test (T4 level)

This test measures the amounts of thyroxine in the blood. Like Triiodothyronine, (T3), thyroxine (T4), is bound to the protein molecules in the blood, and can be influenced by the same things.

Pancreatic Enzymes:

Test: Pancreatic Enzymes: Amylase

Amylase is an enzyme that is synthesized primarily in the pancreas and salivary glands. Amylase (alpha-amylase or AML) helps to digest starch and glycogen in the mouth, stomach, and intestine. In cases of suspected acute pancreatic disease, measurement of serum or urine AML is the most important laboratory test.

Normal serum amylase results: 25 to 160 U/L

**Please note:

There are more than 20 different lab methods for determining the results of this test. Be sure to use the normal values at your facility. Be sure to withhold drugs that elevate AML levels such as aspirin, asparaginase, azathioprine, corticosteroids, cyprohepadine, narcotic analgesics, oral contraceptives, rifampin, sulfasalazine, and thiazide or loop diuretics. If they cannot be withheld, note them on the lab slip.

After the onset of acute pancreatitis, AML levels begin to rise within 2 hours, peak within 12 to 48 hours, and return to normal within 3 to 4 days. Determination of urine levels should follow normal serum AML results to rule out pancreatitis. Moderate serum elevations may accompany obstruction of the common bile duct, pancreatic duct, ampulla of Vater, pancreatic injury from a perforated peptic ulcer, pancreatic cancer, or acute salivary gland disease. Impaired kidney function may increase serum levels.

Test: Pancreatic Enzyme: Lipase

Lipase is produced by the pancreas and secreted into the duodenum, where it converts triglycerides and other fats into fatty acids and glycerol. The destruction of pancreatic cells, which occurs in acute pancreatitis, causes large amounts of lipase to be released into the blood. This test is used to measure serum lipase levels. It is most useful when performed with a serum or urine amylase test.

Normal value: 56 to 239 U/L (depending on method)

Prior to the test, withhold cholinergics, codeine, meperidine, and morphine. If these drugs cannot be withheld, note their use on the lab slip when the specimen is sent to the lab.

High lipase levels suggest acute pancreatitis or pancreatic duct obstruction. After an acute attack, levels remain elevated for up to 14 days. Lipase levels may also increase in other pancreatic injuries, such as perforated peptic ulcer with chemical pancreatitis due to gastric juices, and in patients with high intestinal obstruction, pancreatic cancer, or renal disease with impaired excretion.

CHAPTER VII

STD and HIV Blood Tests

STD and HIV Laboratory Tests

Additional Serology Tests:

Introduction:

Serology is the study of immune bodies in human blood. These immune bodies are the product of the defe-nse mechanisms against dis-ease-causing organisms in the body. The principle involved with serology is the antibody-antigen response. The antigen actually comes first, in that the antigen is the substance which "provokes" the body to produce antibodie-s. As we all know, the antibody is the substance which fights the invading organism. Antibodies take many forms because there are many forms of antigens which can invade the body.

Some an-tibodies are:

a. agglutinins
b. compliment-fixing
c. hemag-glutinins
d. opsonins
e. precipitins
f. hemagglutinin inhibitors
g. cytolysi-ns
h. hemolysins

We will discuss in this section, only the most common tests in the study of serology. As we examine these tests and their results, you will see that many of the tests rely heavily on the fact that the body pro-duces certain specific antibodies in response to specific invading organisms, viruses, proteins, and any other foreign substances which at-tack our bodies.

Test: Syphilis

Clinical Implications:

There are several tests for syphilis. Most can be performed in the standard hospital lab-oratory with minimum of equip-ment. However, some tests will require special equipment. Most standard tests depend upon the syphilis antibody, Reagin, in order to test for positive results. When syphilis is present, the body produces Reagin.

There are other disorders which can also pro-duce Reagin. Therefore, when the person has a positive test for Reagin, further testing is needed to determine if the person has syphilis or some other disorder such as leprosy, tuberculosis, malaria, mononuc-leosis, col-lagen disease, and a few types of viruses. Most standard screening tests for syphilis seek Reagin. It would be very costly to test for the actual infectious organism in syphilis, called treponema pallidum. But keep in mind that there could be a false positive result with this Reagin test.

Tests for syphilis:

1. Flocculation test

[also called: **The Kline Test** or **The Kahn Test** or **VDRL** (**V**enereal **D**isease **R**esearch **L**ab)]

These can be performed rapidly and with minimum amount of equip-ment. They are only screening tests, and any positive results must be retested by a more specific procedure.

if positive (reactive): needs further analysis
if negative (non-reactive): syphilis absent; unless exposed very recently

2. Compliment Fixation Tests, Wassermann or Kolmer

These tests are slightly more specific. They use an antigen in the testing procedure which gives more reliability. However, even these tests are not 100% accurate or specific for syphilis. Therefore, if positive, the results must be checked with a more accurate test.

3. Treponema Pallidum Immobilization, TPI (or TPCF)

This is the most specific test for syphilis. The serum of the person is mixed with a sample of live syphilis organisms. The mixture is then observed for a very specific type of reaction. This reaction will indicate the pres-ence in the body of antibodies for syphilis.

This test is often performed in conjunction with tests similar to those above, in order to determine quantita-tive results in the reac-tion. It is also called the T. Pallidum compliment-fixation test (TPCF).

4. Fluorescent Antibody Test

This is another good test for syphilis. It requires extensive amounts of equipment and time for the test. It is not quite as sensi-tive as the above test, so it will not be useful for detecting cases of late syphilis. The principle of this test causes the antibodies to be labeled with fluorescent dye so as to detect syphilis.

The Serological Tests:

Serological examination is important for the diagnosis of other types of disorders as well as for syph-ilis. Bacterial infections, viral infections, and others can be diagnosed by the use of serological studies. Listed here are some of the most common conditions in which the diagnosis can be aided by serology studies.

a. Bacterial Infections:

Antigens can readily be prepared for serological study from cultures of bac-terial organisms. The most frequently used test is the agglutination test. This test takes the patient's serum with its anti-bodies and mixes it with a lab prepared solution of that killed disease organism.

The mixture will then ag-glutinat-e, or clump togethe-r, because of the antigen-antibody reaction. The degree to which they clump will not only confirm the original diagnosis, but will tell to what degree of, or concentration of, the antibodies are present. This test is used for all types of dysentery, tularemia, and brucellosis.

b. Virus Infections:

The presence of viral infection can be determined by certain serology tests. It is similar to the bacterial tests above, but two different samples of blood are needed, and from two different points in the illness of the patient. When a rise in the titer of antibodies is noted, a virus can be determined as the cause of the infection. The tests used, as we mentioned, are the compliment-fixation, the hemagglut-ination, and others.

c. Others:

There are also several other disorders which can be diagnosed by serological examination. These follow-ing disorders use very specific types of tests. They are uncommon disorders and the M.D. will use the re-sults of these tests along with other test results in order to make the diag-nosis.

1. Primary Atypical Pneumonia

The cold hemagglutination test, and the an-tistrep-tococcus MG tests, are used to diagnose this condition. Neither test is conclusive, and other tests are necessary to confirm. Again, these tests require nothing of the patient except the random venous blood sample (serum).

2. Rickettsial Infections

The compliment-fixation tests are used as well as other tests. The MD will need to see a significant rise in titer of antibodies in order to confirm this diag-nosis.

3. Infectious Mononucleosis

The heterophile agglutination test, uses RBC's from sheep which normally do not react with human antibodies, when they do, and there is high titer indi-cated, mono-nucleosis is diagnosed.

4. Mycotic Infections

These fungal infections in the deep tissues (lungs, for example), can be diagnosed by the same compliment-fixation test.

5. Inflammatory conditions

The C-Reactive Protein Test, (CRPA), is a serologi-cal test for certain inflammatory diseases. C-protein is released when there is tissue inflammation or necrosis. When this C-protein and a certain an-tiserum are mixed, a reaction occurs leading to a posit-ive result. The result is then graded from Plus 1 (1+) to plus 4 (4+), depending- -on degree of reac-tion.
Diseases such as these can give positive results:

a. rheumatoid arthritis
b. myocardial infarct
c. certain malignant diseases

6. Rheumatoid Arthritis

The Latex Agglutination test, or called: the rheumato-i-d arthritis test, makes use of a form of polystyrene latex and human gamma globulin. When this mixture is mixed with the serum from a victim of rheumat-oid arthritis, the entire mixture will agglutina-te, clump, and positively diagnose the disease.

Summary:

This concludes the serological studies.

Nursing responsibilities for these tests are few. Prepare the patient for the blood withdrawal. There may be fasting before some of the tests. You may need to explain the results of the test to the patient. An accurate and detailed history is important. If it is not on the chart, the nurse should be sure there has been a history completed. Information from the history may significantly affect the results of some tests. Also, report any such significant findings to the MD; such as ingestion of drugs which may affect the test results.

LABORATORY TESTING FOR HIV

Starting in 1996/1997 testing for HIV has become more complex and yet more accessible to everyone. The FDA has approved several new test options for detecting HIV. (Neergaard 1996 by AP) Amid sweeping changes in the U.S. health care system, Americans are growing more

aggressive about making their own medical decisions. They spent more than $1 billion on home tests in 1996. The FDA regulates the effectiveness of home tests and makes sure laymen can use them and understand the results. Some decisions about some tests are straightforward, like pregnancy tests where chemically treated strips simply change color in urine samples. Others pose more complicated challenges. The FDA wrangled for almost six years over whether Americans should be allowed to mail their blood samples to a laboratory and learn over the telephone if they had the AIDS virus. The FDA approved a home test this year only after phone counseling was added.

Even after that experience, the FDA failed to set a policy on how to balance rapidly evolving tests with the social concerns of how and when to sell them directly to laymen. Will patients be hurt if tests are wrong? When do they see a doctor? Could they force a test on a family member? More basic. Are there some tests -- like those that detect genetic flaws that might cause incurable diseases -- that laymen should never use?

Following are the latest methods of laboratory testing for exposure to the HIV and other tests related to HIV. However, the nurse should remember that there are certain obligations prior to conducting the HIV testing sequence. ***Informed consent*** for the HIV blood test is re-quired in most situations. Prior informed consent is usually not needed for military personnel, persons in penal institutions, and usually not required prior to anonymous HIV testing (where only numbers are used for identification). The patient will be required to sign a special consent form before the blood is withdrawn. In addition, most official test sites will arrange for counseling in regards to taking the test and about the outcome of the test.

Counseling is important before a person takes the HIV test. Just deciding to take the test is very stressful for most people. If a person has decided to be tested for HIV, then they "probably" strongly suspect they might be infected. Therefore, the person's stress level is very high even before they take the actual test. Now with the advent of home test kits, this pretest counseling is even more important and least addressed.

Next, of course, the person should be counseled on what are their options, should the test be **positive**. In fact, they will still need to be counseled even if the test result is **negative**.

Later, we will present guidelines for counseling persons for the HIV screening test. However, the remainder of this chapter will discuss actual lab tests and procedures for testing for the presence of the HIV virus.

At this time, the screening test still most widely used to detect the HIV antibodies in the blood is the ELISA test. In March 1985, the FDA approved the ELISA test, (En-zyme-Lin-ked Immunoso-rbent Assay). This test may soon be replaced by one of the newer home test and/or

the new rapid tests. These options will be discussed later in this text.

The development of detectable antibodies to HIV (sero-conversion) usually occurs within three to six months of infection with HIV. Antibody testing usually consists of the ELISA (mentioned below) and then the Western Blot test is performed. It is a highly specific test, performed for confirmation.

The ELISA test deter-mines whether or not the person's blood contains the antibodies to the HIV virus. At this time, it is the best meth-od for screening for AIDS. As with most tests of this type, it is not 100% effective. In fact, it is only about 97% to 98% effective.

The ELISA test does not diagnose the disease. It merely indicates whether or not the person has been exposed to (infected with) the HIV virus. If the first ELISA screening test is positive, the person will usually be given a second ELISA test in order to confirm the results.

Some testing sites give the person a repeat ELISA test (as mentioned), or they may be given the Western Blot Assay test instead of a second ELISA test (below). If the second test is positive (either ELISA or Western Blot), then the chances are virtually 100% that they have been infected.

Testing protocols are different in various facilities. Most facilities use the ELISA test first. It is a fairly good, reliable test and relatively inexpensive, about $10 to $35 per test. Some public health clinics give free tests, but the actual cost is around $10 to $35 per ELISA test.

Some facilities use a more specific test such as the Western Blot Assay (discussed below) as the second confirming test. The Western Blot Assay test usually takes longer to complete than the ELISA. It is much more expensive that the ELISA. Therefore, it is usually not used as the first test, or screening test for HIV virus exposure.

On January 3, 1997, the FDA approved the licensure of a test for the HIV virus types 1 and 2 (HIV-1, 2). The test, manufactured by United Biomedical Inc., Hauppauge, NY, is based on synthetic peptides and detects antibodies to the viruses. It is suitable for diagnostic laboratories and blood donor screening. This is the quickest test yet available for blood screening, requiring at least ½ to 1-1/2 hours less than the procedures currently licensed. United Biomedical is a privately held international diagnostic and

biopharmaceutical company. It is recognized as a leader in the design and manufacture of synthetic peptide-based blood test for antibodies to HIV-1 approved by the FDA.

Probably the most exciting new test option introduced in 1996/1997 is the OraSure Oral HIV-1 antibody Testing System. OraSure technology is unique in that it does not test saliva, but rather an oral sample called oral mucosal transudate (OMT), which contains high concentrations of antibodies and is free of most of the contaminants found in saliva. That is the key to the technology and to its high level of accuracy. Collecting samples with OraSure, compared with taking blood, is painless and easy to perform (according to those using the system). A specially treated pad attached to a handle is placed between the person's lower cheek and gum for two minutes. The pad is then placed in a vial with preservative and sent to a laboratory for testing, the same way blood samples have been tested.

Finally, a company called Saliva Diagnostic Systems Inc. (SDS), has begun a campaign for approval in the U.S. of its rapid, non-laboratory, HIV test kit. SDS is submitting to the FDA a proposal for approval of this test which is already being used in other countries. This saliva-based test will be able to rapidly produce results and does not require a lab to process the specimen. At this time the company hopes to develop an HIV test similar to other home test kits now being used. Of course, the political ramifications of this type of test are immense. How would counseling be administered if a person performs their test at home? SDS should be through with the approval process by this writing, as they work out all the final bugs on the test itself and work through the approval process.

All of the above tests for HIV are now administered by health care professionals. These tests are performed in the lab and the results given in person to the individual. There is now an alternative to this type of testing. There is now an approved **home HIV test**. An individual may send the test to the lab and receive the results over the phone. In fact, soon there will be several companies who offer over-the-phone results. As we stated earlier, counseling should also be made available for those who receive their results over the phone.

Viral Load Test:

The viral load test measures the amount of HIV virus in the blood. There are different techniques for doing this:

The PCR (polymerase chain reaction) test uses an enzyme to multiply the HIV in the blood sample, then

uses a chemical reaction to mark the virus. The markers are measured and used to calculate the amount of virus. Roche produces this test.
The bDNA (branched DNA) test combines a material that gives off light with the sample. This material connects with the HIV particles. The amount of light is measured and converted to a viral count. Chiron produces this test.
The PCR test results are usually at least double the bDNA results for the same sample. Because the tests are different, you should stick with the same kind of test (PCR or bDNA) to measure your viral load over time.

Viral loads are usually reported as copies of HIV in one milliliter of blood. The tests count up to about 1.5 million copies, and are always being improved to be more sensitive. The first bDNA test measured down to 10,000 copies. The second generation could count 500 copies; the third goes down to 25 copies.

The best viral load test result is "undetectable." This does not mean that there is no virus in the blood; it just means that there is not enough for the test to find and count. With the first generation test, "undetectable" could mean 9,999 copies. With the newest test, it means no more than 24 copies. So what "undetectable" means keeps changing as the tests get more sensitive.

The viral load test is helpful in several areas:

In basic science, the test has been used to prove that HIV is never "latent" but is always multiplying. We know this because many people who had no symptoms of AIDS and high T-cell counts also had high viral loads. If the virus was latent, the test wouldn't have found any HIV in the blood.

The test can be used for diagnosis, because it will come back as "detectable" any time after HIV infection. This is better than the standard HIV (antibody) test, which can come back "negative" during the period after HIV infection and before the development of antibodies.

For prognosis, viral load can help predict disease progression: how long someone will stay healthy. Several research studies show that the higher the viral load, the faster HIV progresses. These studies also show that viral load is better than T-cell (CD4+) count for predicting disease progression.

Finally, the viral load test is valuable for managing therapy, to

measure the impact of antiviral drugs. Current guidelines suggest measuring baseline (pre-treatment) viral load. A drug is having some effect if it lowers viral load to less than 1/3 of baseline level. If viral load climbs back to within 1/3 of baseline, that would be a sign to switch drugs.

Repeat tests of the same blood give results that vary by about a factor of 3. This means that a meaningful change would be a drop to less than 1/3 or an increase to more than three times the previous test result. For example, a change from 200,000 to 600,000 is within the normal variability of the test. A drop from 50,000 to 10,000 would be significant. The most important change is to reach an undetectable viral load.

Viral load changes are often described as "log" changes. This refers to scientific notation, which uses powers of 10. For example, a 2-log drop is a drop of 102 or 100 times. A drop from 60,000 to 600 would be a 2-log drop.

There are no "magic" numbers for viral loads. If the patient's viral load is 75,000, it is not known how long they will stay healthy. It is not known if 150,000 is twice as bad as 75,000. All that is known so far is that lower is better and seems to mean a longer, healthier life for the patient.

An international panel of doctors suggested that anyone with a viral load over 5,000 or 10,000 should be treated with antiviral drugs. Some people may think that if their viral load is undetectable, they can't pass the HIV virus to another person. THIS IS NOT TRUE. Although research shows that people with higher viral loads are more infectious, there is no "safe" level of viral load. Even if viral load is undetectable, it is possible to pass HIV to another person.

There are some concerns with the viral load test. Some scientists think that as little as 2% of the HIV in your body is in the blood. The viral load test does not measure how much HIV is in body tissues like the lymph nodes, spleen, or brain. New research shows that HIV levels in lymph tissue goes down when blood levels go down, but not at the same time or the same rate. And viral levels in semen seem to be unrelated to blood levels.

The viral load test results can be thrown off if the person is fighting an infection, or if they have just received an immunization (like a flu shot). They should not have blood taken for a viral load test within four weeks of any infection or immunization.

Immunological and Virological Markers of HIV Disease Progression

From an article by Zeller, J., McCain, N., Swanson, B. JANAC, 1996.

Immunological and virological markers are indicators of the progression of HIV disease in humans. Infection with the human immunodeficiency virus (HIV) results in progressive immunosuppression associated with increasing susceptibility to opportunistic infections and malignancies. The primary target for the HIV infection is the CD4 positive helper lymphocyte, a cell that is profoundly depleted over the course of the illness. Since CD4 positive T lymphocytes play a key role in initiating and amplifying both humoral and cell-mediated immune mechanisms, virtually all components of the immune system are at least indirectly influenced by HIV infection.

The rate at which clinical disease progresses in HIV-infected persons is highly variable, although it is estimated that all seropositive persons will develop AIDS within 10-15 years after the initial infection. In an attempt to aid clinicians in predicting the course of HIV illness in individual patients and to assist in evaluating responses to therapeutic modalities, researchers have proposed a number of parameters as prognostic indicators.

Markers are either:

1. Cellular Immune Markers, or
2. Virological markers.

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1. Cellular Immune Markers:

a. T-cell Tests

T-cells are a type of lymphocyte (white blood cell). They are an important part of the immune system. There are two main types of T-cells. T-4 cells, also called CD4+, are "helper" cells. They lead the attack against infections. T-8 cells, (CD8+), are "suppressor" cells that end the immune response. CD8+ cells can also be "killer" cells that kill cancer cells and cells infected with a virus. Researchers can tell the T-cells apart by specific proteins on the surface of the cells. These proteins are also called "receptor sites" because they can lock onto certain molecules. So a T-4 cell is a T-cell with a CD4 receptor on its surface. This type of T-cell is also called "CD4 positive," or CD4+.

When HIV infects humans, the cells it infects most often are CD4+ cells. The virus becomes part of the cells, and when they multiply to fight an infection, they also make more copies of HIV. When someone is infected with HIV for a long time, their number of CD4+ cells

(their T-cell count) goes down. This is a sign that the immune system is being weakened. The lower the T-cell count, the more likely the person will get sick. There are millions of different families of T-cells. Each family is designed to fight a specific type of infection. When HIV reduces the number of T-cells, some of these families can be totally wiped out. When this happens, they lose the ability to fight off particular infections those families were designed for. When this happens, opportunistic infections might develop.

HOW ARE THE TEST RESULTS REPORTED?

T-cell tests are normally reported as the number of cells in a milliliter of blood. There is some disagreement about the normal range for T-cell counts, but CD4+ counts are between 500 and 1600, and CD8+ counts are between 375 and 1100. CD4+ counts drop dramatically in people with HIV, in some cases down to zero. The ratio of CD4+ cells to CD8+ cells is often reported. This is calculated by dividing the CD4+ value by the CD8+ value. In healthy people, this ratio is between 0.9 and 1.9, meaning that there are about 1 to 2 CD4+ cells for every CD8+ cell. In people with HIV infection, this ratio drops dramatically, meaning that there are many times more CD8+ cells than CD4+ cells.

The T-cell value bounces around a lot. Time of day, fatigue, and stress can affect the test results. It's best to have blood drawn at the same time of day for each T-cell test, and to use the same laboratory. Infections can have a large impact on T-cell counts. When your body fights an infection, the number of white blood cells (lymphocytes) goes up. CD4+ and CD8+ counts go up, too.

Because the T-cell counts are so variable, some doctors prefer to look at the T-cell percentages. These percentages refer to total lymphocytes. So if your test reports CD4+% = 34%, that means that 34% of your lymphocytes were CD4+ cells. This percentage is more stable than the number of T cells. The normal range is between 20% and 40%.

The meaning of CD8+ cell counts is not clear, but it is being studied.

Most researchers believe that the CD4+ cell count is a good measure of the health of the immune system. The lower the count, the greater damage HIV has done. But some people with almost no CD4+ cells have stayed healthy for a long time. CD4+ counts were used to estimate how long someone would stay healthy. However, a viral load test is better for this purpose. CD4+ counts are now used to indicate when to start certain types of drug therapy.

When the CD4+ count goes below 500, most doctors begin antiviral drugs such as AZT, ddI, or 3TC. Also, some doctors use the CD4+% going below 15% as a sign to start aggressive

antiviral therapy, even if the CD4+ count is high. However, the viral load test has become at least as important as the CD4+ count in deciding when to start antiviral drugs.

2. Virological Markers:

The measurement of virological markers, such as serum core antigen levels, plasma viral load, and cell-associated virus, can be used to estimate the amount of virus present in the host. Since higher viral loads are associated with HIV-related symptoms, virology markers are potentially useful measures of disease progression.

a. Viral Core Antigen Levels (p24):

Serum levels of the viral core antigen, p24, have been routinely used by clinicians to monitor disease progression. However, the usefulness of serum p24 as a marker of disease progression is limited by the fact that antigen cannot be detected in the serum of most asymptomatic individuals and, in the later stages of infection, antigen levels are highly variable and not consistently correlated with the stage of the disease.

In the asymptomatic stage, the inability to detect serum p24 may be related to the relatively high levels of anti-p24 antibody that are present in serum. The technique of acid dissociation was recently developed to reduce the interference of antibody in the p24 detection assay. Acid dissociation treatment of asymptomatic individuals' serum or plasma has been shown to increase significantly the amount of detectable p24, thereby increasing the sensitivity of p24 as a measure of viral load.

Although acid-dissociated p24 level may be a sensitive measure of disease progression, it is only an indirect measure of infectious viral load. Direct measures of infectious viral load, such as plasma viral load and viral load in peripheral blood mononuclear cells (PBMC), have been developed and are being tested for their utility as measures of disease progression.

b. Plasma Viral Load:

Levels of infectious virus in plasma can be quantified by culturing donor cells from seronegative individuals with increasing dilutions of plasma from HIV-infected individuals. The highest dilution of plasma required to produce a positive culture is used to calculate the total number of infectious virus particles, or titer. Although in some studies viral titers have been shown to increase across progressive stages of HIV infection, plasma viremia has not been shown to be a consistent marker of disease progression. Another

limitation of this method is that it is dependent upon the ability of the viral isolates to infect donor cells in vitro.

Conversely, measuring plasma viral RNA levels, using the amplification technique known as reverse-transcription polymerase chain reaction (PCR), does not require infection of donor cells in vitro and has been shown to correlate with stage of disease and CD4 counts. Although plasma RNA levels are indicators of viral load in the plasma, they do not necessarily reflect the viral load in peripheral blood mononuclear cells (PBMC) and lymphoid tissue. Additionally, PCR quantification of plasma viral RNA does not indicate whether the RNA is from actively replicating virus or replication-defective virus.

c. Virus in PBMC:

Viral load in PBMC can be measured. Although it may have potential utility as a marker of disease progression, it is an indirect measure of viral replication, since only a small number of cells with provirus actively replicate HIV. A more direct index of viral replication in PBMC may be the amount of viral messenger RNA (mRNA), since cells that express viral mRNA are permissive for HIV replication. Increasing viral mRNA levels in PBMC have been shown to correlate with declines in CD4 cells and disease progression. Additionally, viral mRNA levels in PBMC are more sensitive to the effects of antiretroviral therapy than is proviral burden.

d. HIV in Other Tissues:

Recent studies have demonstrated that in both early and advanced stages of disease, viral load may be substantially higher in mononuclear cells isolated from lymphoid tissue than in circulating PBMC. Therefore, measurement of the viral load in circulating cells may result in an underestimate of the body's total viral load. However, the measurement of tissue viral load has not been feasible for most researchers, since most lymphoid tissue specimens are not typically obtained in the routine clinical management of HIV-infected persons.

CHAPTER VIII

Arterial Blood Gas Interpretation

Arterial Blood Gas Interpretation

(ABG) Arterial Blood Gas Analysis is used to measure the partial pressures of oxygen (PaO2), carbon dioxide (PaCO2), and the pH of an arterial blood sample. Oxygen content (O2CT), oxygen saturation (SaO2), and bicarbonate (HCO3-) values are also measured. A blood sample for ABG analysis may be drawn by percutaneous arterial puncture from an arterial line.

The ABG analysis is mainly used to evaluate gas exchange in the lungs. It is also used to assess integrity of the ventilatory control system and to determine the acid-bas level of the blood. The ABG analysis is also used for monitoring respiratory therapy (again by evaluating the gas exchange in the lungs).

Nursing considerations:

Your first look at an ABG result might prove to be confusing. Any pati-ent who is critically ill might be given this test at regular intervals. Arter-ial blood gas determinations will indicate two basic bodily functions:

1. acid-base balance of the blood
2. oxygenation status of the blood

ABG's will also indicate other important facts about a patient's status. However, the two functions above are the most important.

In a clinical situation, most nurses need only to understand these two basic concepts. When the results of an ABG are abnormal, most hospitals today will have a lab procedure for notification of the MD or to the ICU staff. But if you should be one of those "lucky" nurses who is floated to a critical care area or a respirat-ory care area, you may have to interpret the results by yourself. If you are able to do this, and fast, it may mean that the patient will get help fast.

Hypoxemia, acidemia, and alkalemia are important concepts which should be under-stood before beginning.

Hypoxemia is a term which refers to a lowered blood oxygen content. This term and the term hypoxia are probably quite familiar to most nurses. They both will be used as meaning exactly the same. Hypoxia is the basis of one part of inter-pretation process. From above, we know that oxygena-tion status of the patient can be critical during certain disease states.

Acidemia or acidosis is a term which refers to excessive amounts of acid in the blood. Acids are produced naturally in the body as a product of metabolism and other specific body processes. If our blood acid levels rise too high, it will interfere with the health of the individual. This will be in addition to the disease which is already present causing the acidosis.

Alkalosis, or alkalemia is the term which refers to the condition of exces-sive bicarbonate ions (bases) in the blood. As we mentioned above, this im-balance in the blood pH will then cause further problems as the normal body recovery mechanism may also be interrupted.

On the next pages you will find an explanation of what the ABG test is all about. We will also present the nursing considerations surround-ing their interpretation. Read each section of the following text in order. The text builds up from the simpler concepts to the more complex concepts so each nurse will be able to easily follow the in-terpretation process. When you fully understand one section, then go on to the next section until you fin-ally are able to interpret the ABG with the fullest understanding.

Since this course is very clinically oriented, we will concentrate on the as-pects of ABG interpretation that apply to direct patient care. The clinical uses of ABG studies will be listed on the following pages. ABG studies may be helpful to diagnose and treat the following: (Brunner 1994)

1. unexplained tachypnea, dyspnea (esp. in patients with cardio-pulmonary disease)
2. unexplained restlessness and anxiety in bed patients
3. drowsiness and confusion in patients receiving oxygen therapy
4. assessment of surgical risk
5. before and during prolonged oxygen therapy and during ventilator support of patients
6. progression of cardiopulmonary disease

Collecting the ABG specimen

The ABG is performed on a sample of arterial blood. The specimen is then ob-tained in a syringe prepared with heparin so as to prevent coagulation from occurring. The sample is then placed in crushed ice and rushed to the lab for analys-is. Each insti-tution will have a slight variation in the method of the col-lection and in which department the sample will be handled. The reason for rushing the specimen and for using the ice is to prevent coagulation of the specimen, and spec-ifi-cally, ice slows the clotting of the blood. Be sure you are familiar with that pro-cedure in your facility.

Terms used in connection with ABG's:

a. Acid-Base Balance

a homeostatic mechanism in the human body that strives to maintain the optimal pH, so that body process may function optimally (normal pH of arterial blood = 7.35-7.45)

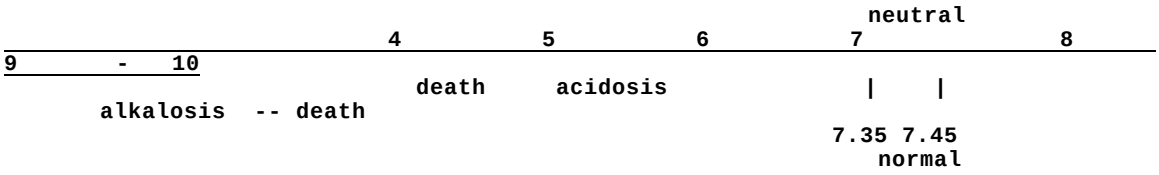
b. **Buffer System:** combination of body systems that work to keep optimal acid-base balance

c. **Partial Pressure:** the amount of pressure exerted by each gas in a mixture of gases
d. PO_2 partial pressure of oxygen
e. PCO_2 partial pressure of carbon dioxide
f. PAO_2 partial pressure of alveolar oxygen
g. PaO_2 partial pressure of arterial oxygen
h. $PACO_2$ partial pressure of alveolar carbon dioxide
i. $PaCO_2$ partial pressure of arterial carbon dioxide
j. PvO_2 partial pressure of venous oxygen
k. $PvCO_2$ partial pressure of venous carbon dioxide
l. P50 oxygen tension at 50% hemog-lobin saturation
m. Respiratory Acidosis--condition of lowered pH (acidosis) due to decreased respiratory rate (hypo-ventil-ation)
n. Respiratory Alkalosis--condition of increased pH (alkalosis) due to increased respiratory rate (hyperve-ntilation

ACID/BASE BALANCE

pH is the measurement used to determine acidity or alkalinity of arterial blood. pH is a measure of an acid or base solution and the relative strength of that solution.

Below is the pH scale, 7 being the arbitrary center point indicting a neutral solution. An example of an acid is carbonic acid. Carbonic Acid is formed when carbon dioxide (CO_2) chemically com-bines with water (H_2O) to form carbonic acid (H_2CO_3). The "H" at the begin-ning of a chemical formula usually designates and acid.



The further away from 7 in either direction indicates the strength of the acid or base. An acid can donate the hydrogen ion (H^+) and the base is a sub-stance which can accept the ion. The pH then is the concentration of the ion in solution. Normal blood pH ranges from 7.35 to 7.45 this is slightly to the alkaline side of the scale. If the pH is at the low end of the scale or if it is actually below 7.35, the condition is acidemia. Thus if it above 7.45 it is described as alkale-mia.

The body is in a state of constant change. Thus, the pH is constantly chan-ging within this range of values. This of course is called the homeostatic

process. Body waste products are constantly being produced, and affecting the pH of the blood. As food is metabo-lized, these wastes are dumped into the blood and affect the pH. There are also concurrent processes which act to balance these actions. They are known as buffers. If the body pH should start to became too acid, the buffers work to neutralize them and balance the pH at normal levels. The exact opposite occurs in an alkaline pH situation. This buffer pair of acid--base work to maintain pH at an optimum 7.40. Carbonic acid and the ion bicar-bo-nate is the buffer pair we refer to.

The buffer systems

The lungs, kidneys, and the buffer system are the primary consider-ations in the homeostatic proc-ess. The lungs can control certain small amounts of carbon diox-ide in the blood.

Carbon diox-ide in the blood chemically produces carbonic acid. Thus, in cases where the lungs do not function properly, CO_2 builds up, causing increased carbonic acid. This increase in acid can affect the blood pH, leading to acid-osis. The main function of kidneys is retaining or excret-ing of the bicar-bonate ion (HCO_3). This is the ion which neutr-alizes the excess acid in the blo-od. If both organs are working properly, the natural build--up of acids can be neutral-ized effec-tively by the buffer system.

The buffer system in the body is able to work very quickly to maintain proper pH of the blood and body tissues. The prime buffer system is the system of carbonic acid and bicarbonate. Bicarbonate will neutralize the correct numbers of carbonic acid molecules to maintain the correct ratio of 20:1 acid molecules. This 20:1 ratio will preserve the blood pH at the normal range of 7.35 to 7.45. Bicarbonate ions and carbonic acid are constantly being produced and combined in order to keep the optimal pH.

The respiratory system also works to maintain the proper blood pH. When the bicarbonate/carbonic acid buffer system cannot work fast enough to compen-sate for pH disturbances, the respiratory system has a mechanism for buffering the blood. Hyperventilation and hypoventilation can be used by the body to control the amount of carbonic acid in the blood.

The respiratory center in the brain responds to changing levels of carbonic acid in the blood. When the acid level of blood increases, **and is not controlled** by the first buffer system, the respiratory system responds.

Hyperventilation causes the body to exhale and "get rid of" CO_2 from the blood, through the lungs. This reduction of CO_2 causes the blood pH to become less acid. Reduce the CO_2 and the acid level of the blood is reduced. This is how the body responds to excess acid in the blood.

The opposite mechanism occurs with hypoventilation. Hypoventila-tion will cau-se the retention of CO_2 in the

blood. As we discussed earlier, this CO2 be-comes carbonic acid when it remains in the blood and mixes with water. If you retain CO2, the acid level of the blood will go up. This increased acid could "buffer" any excess base that is present in the blood. If the blood becomes alkaline, then hypo-ventila-tion may be another way to neutralize it and get the blood pH back to normal. These respiratory conditions will be discussed in more detail later in this text.

In the lab, pH is measured directly using an electrode placed in the blood sample. The "p" of pH is actu-ally defined as "percent Hydri-on" or called the nega-tive logarithm of the hydrog-en conce-ntra-t-ion. The conc-ent-ra-tions can be ex-pressed as 10-7, for example; this means: 0.0000001. This negative logarithm can also be expressed as the inverse ratio (Cooper 1987). The more hydrogen ions there are, the lower the pH, or acid. On the other hand, as the hydrogen ion concentra-tion decreases in the blood, the pH increases (alkalinity).

A third buffer system exists that will react if the first two methods fail to correct an abnormal blood pH. This third and powerful buffer system is the kidney. The kidneys will react to sustained and/or high levels of acid and/or alkalinity. The kidney buffer system responds to these dangerous levels, called- "metabolic" conditions. These conditions are metabolic acidosis and alkalosis, and will be discussed later.

$CO_2 + H_2O$ <--- H_2CO_3 ---> $HCO_3^- + H^+$

(Normal HCO_3^- is: 24 to 28 mEq/L)

NORMAL vs. ABNORMAL ABG VALUES

To continue the discussion from the previous section, we must now look at the value of the carbon dioxide in the blood. CO2 levels are reported on the ABG test as the partial pressure of carbon dioxide. PCO2 levels will directly af-fect the levels of acid in the blood.

PCO2 normal-- 35 to 45 mm Hg

Increases above the levels indicated, could possibly mean that the CO2 is buil-ding due to hypoventil-ation or respiratory failure of some kind. Decreased levels of CO2 can indicate the opposite type of problem, hyperventila-tion, as dis-cussed earlier.

Analysis of respiratory status

First: examine pH value; if HIGH (above 7.45), ALKAL-OSIS is present
THEN: examine CO2 LEVELS, If below 35 mmHg, RESPI-RATORY ALKALOSIS present

IF: pH was low (below 7.35) and CO_2 levels are High (above 45 mm Hg),
RESPIRAT-ORY ACIDOSIS is present

As you see, the conditions of respiratory acidosis or respiratory alka-losis can be determined by examining just the pH and the carbon dioxide levels in the blood. In fact, there are two ways that the pH values can be affected. Ear-lier we demonstrated that the respiratory system will increase or decrease breathing when the acid levels are too high or too low. The reverse condition can also occur.

If some other factor(s) directly causes either hyperventilation or hypo-ventila-tion, then the acid content of the blood will be forced to go up or down. Ex-amples of these conditions are described below. So remember that respira-tions can be con-sidered a buffer to help the body; or, if there is a primary respir-at-ory probl-em, it can adversely affect the blood pH.

In most cases, the respir-atory conditions of acidosis or alkalosis can be cor-rected quite simply, by merely improving the pa-tient's respiratory status. Respirat-ory alkalosis can be reversed in most cases by merely stopping the hyper-ven-tilati-on.

Nursing Considerations:

As we look at the medical conditions which can produce pH imbalanc-es, we will first concentrate on respirations. Any diagnosis which has decreased brea-thing as a symptom, can lead to either prev-iously mentioned condi-tion.

Respiratory Acid-Base Disorders

Respiratory Acidosis

Findings:

- excess CO_2 retention
- pH<7.35
- HCO_3^- > 28 mEq/L (if compensating)
- $PaCO_2$ > 45 mm Hg

Possible Causes:

- CNS depression from drugs, injury, or disease
- asphyxia
- hypoventilation due to pulmonary, cardiac, musculoskeletal, or neuromuscular disease

Signs and Symptoms:

- diaphoresis
- headache
- tachycardia
- confusion
- restlessness
- apprehension

Respiratory Alkalosis

Findings:

excess CO2 excretion
pH > 7.45
HCO3- < 24 mEq/L (if compensating)
PaCO2 < 35 mm Hg

Possible Causes:

hyperventilation due to anxiety, pain, or improper ventilator settings
respiratory stimulation caused by drugs, disease, hypoxia, fever, or high room temperature
gram-negative bacteremia

Signs and symptoms:

rapid, deep breathing
parasthesia
light-headedness
twitching
anxiety
fear

Recognition of these conditions can be the key to prevention. When ad-minister-ing pain meds, remem-ber possible respiratory problems which can occur. With fever, remember hyperventilation can hap-pen, quite subtly.

METABOLIC CONDITIONS:

Now we will dis-cuss metabolic situations. Metabolic acid-osis and met-abolic alkalosis conditions are determined by the levels of bicar-bonate ion in blood. The kidneys excrete these ions into the urine and out of the body when not needed. As the body demands the bicar-bonates to neutralize acids, the kidneys conserve bicarb ions to keep the body in balance. Bicarb ions, are also met-abolic by-pr-oducts (normal by-products of metabolism).

To detect metabolic conditions:

FIRST: examine pH values------High pH (above 7.45)

SECOND: examine CO2 levels (assumed to be normal)

THIRD: examine bicarb levels-----high bicarbonate (above 22 to 26 mEq/L)

Condition: METABOLIC ALKALOSIS

***opposite conditions indicate METABOLIC ACIDOSIS**

FIRST:	**Low pH (below 7.35)**
SECOND:	**Normal CO2 levels**
THIRD:	**Low Bicarb levels**

Nursing Considerations in Metabolic Conditions:

Metabolic Acidosis can be caused by many conditions:

renal failure, shock, severe diarrhea, dehydr-ation , diabetic acidosis, salicylate poisoning, para-ldehyde

The above conditions can all lead to metabolic acidosis. Patients who have had pancreatic drainage and have had a ureterosigmoidostomy are also prone to develop a metabolic acidosis. The nurse should observe for any of the signs or symptoms of dehydration, shock or diabetic acidosis. Mental confusion, dis-orienta-tion, and other neurological signs should not be overlooked, especi-al-ly if the patient is an unst-able dia-betic. Remember, the kidneys will work to relieve the acidosis, but it may not be enough to fully com-pensate such as in the case of aspirin overdose.

With salicylate poisoning, initially there is a respira-tory alkalosis due to the stimulant effect of aspirin on the respirat-ory system. However, later ABG's will show the true danger of salicylate pois-oning, in the fact that metabolic acidosis will shortly follow.

Metabolic Alkalosis can be caused by many disease conditions as well as by iatrogenic causes.

The fol-low-ing are the most fre-quently seen causes of metabolic alkalosis:

severe and/or prolonged vomiting, Cushing's disease, administra-tion of large amounts of sod-ium bicarbonate, diuretic therapy (long-term), steroid therapy (long-term), prolonged GI (gastrointestinal) suction-ing

Every nurse should be aware of the great imbalances which might be brought on by suction-ing of any kind. Espec-ially long-term naso-gastric suctioning can induce fluid and electrolyte imbalances and can lead to alkalosis.

A common cause of alka-losis is hyperventilation. This respiratory condi-tion can lead to metabolic alkal-os-is espec-ially if another of the above disor-ders is present. One of the first symptoms seen in these cases is dizzi-ness. Other symptoms of increased alkalemia include numbness and tingling in extr-em-i-ties, wea-kness, twitching of the muscles, and some arrhythmias may be seen.

Metabolic Acid-Base Disorders

Metabolic Acidosis:

Findings:

HCO3- loss (acid retention)
pH < 7.35
HCO3- < 24 mEq/L
PaCO2 > 35 mm Hg (if compensating)

Possible Causes:

HCO3- depletion due to renal disease, diarrhea, or small-bowel fistulas

excessive production of organic acids due to hepatic disease
endocrine disorders including diabetes mellitus, hypoxia, shock, and drug intoxication

Signs and Symptoms

rapid, deep breathing

fatigue
fruity breath

headache
drowsiness

lethargy
nausea

vomiting
coma (if severe)

Metabolic Alkalosis

Findings:

HCO3- retention (acid loss)
pH > 7.45
HCO3- > 28 mEq/L
PaCO2 > 45 mm Hg

Possible Causes:

Inadequate excretion of acids due to renal disease
Loss of hydrochloric acid from prolonged vomiting or gastric suctioning
Loss of potassium due to increased renal excretion (as in diuretic therapy) or steroid overdose
excessive alkali ingestion

Signs and Symptoms:

slow, shallow breathing

confusion
hypertonic muscles

twitching
restlessness

apathy
irritability

tetany
coma (if severe)

seizures

Oxygenation status

In the previous section, acid--base balance concepts were presented. Those simple respiratory and met-abolic disease conditions can be determined by analysis of the results of the ABG. We also discussed the many clinical applications of this knowledge. Next, we will present the oxygena-tion concepts involved with interpretation of the ABG.

Oxygen as a gas in our atmos-phere is in the concentration of about 21%. It is important to know that the pati-ent was breathing room air when the ABG sample was ob-tained. As with all gases, oxygen is also meas-ured in its partial pressure. Partial pressure of a gas refers to the pressure a gas exerts as a result of its molecular activity in a mixture of gases. The lab results of the ABG`s are reported as per-centa-ges and partial pressures of these gases. For our purposes as nurses, these percentages and partial pressures should only be used as a com-parison figure to the norm when interpreting the results. As an example, the normal PO2 (partial pres-sure of oxygen) is 80-100 mmhg.

All this should really mean to us is that in arterial blood, 80 to 100 mmHg represents the "amount" of oxygen that is dissolved in each 100 ml of the ar-terial blood. If a patient's PO2 results are 70, then we know there is an insuf-fi-cient amount of dis-sol-ved oxy-gen present. Clinically, there can be many dif-ferent reasons for this. The patient may be anemic, or may have decr-eas-ed respira-tions, or may have pneum-onia. All or any of these conditions may lead to low PO2.

Oxygen Content of the Blood:

Another term with which nurses should be familiar is FIO2. This term refers to fractional inspired oxygen (FIO2). If a patient is breathing other than 21% room air, the FIO2 is said to be higher or at a greater per-centage.

In some cases, ABG's are analyzed simply for the results of the oxygen content. Perhaps it might al-ready be known that the patient does not have an acid-base imbalance, but the physician is more interested in the amount of oxygen in the blood. Remember that many COPD patients will almost always have a slig-ht im-balan-ce in the pH of the blood due to a chronically high CO2 level. In these cases the PO2 is critically important for diagnosis.

Oxygen Saturation of the Blood:

Next we will present saturation of hemoglobin in determining ABG results. The SO2 value is defined as the extent to which oxygen saturates the hemoglobin mole-cules in the RBC's. It is expressed in a percent-age, compared to the full potential of the blood to be saturated. Therefore, at full saturation the nor-mal SO2 is 95% to 100%. As you can then see, the SO2 and PO2 are directly related to each other. As one increa-ses, so does the other, usually. This holds true in the upper level numbers.

However, when the relat-ion-ship be-tween these two numbers changes, it also indi-cates that saturation is affected by other factors not just the a-mount of oxy-gen present. Remember that oxygen is present in the blood in two forms. Oxy-gen is dissolved in the blood and oxygen is combined with hemoglobin. The solubility of oxygen depends upon the pressure of oxygen and its solubility as a gas. Oxygen dissolved in the blood represents only a very small part of the total oxygen in the blood. Most oxygen is carried on the hemoglobin.

Arterial oxygen pressure valu-es (PaO2) are used to calculate the hemo-globin saturation. These values are also used to es-timate the availability of oxygen for the vital organs of the body. The PaO2 is also used with the PaCO2, arter-ial carbon dioxide pressure, can be used to estimate the alveolar-arterial oxygen gradient (Aagradient). Cal-cula-tion of the Aagradient serves as an index of lung effective-ness in gas ex-change. The wider the difference, the greater the severity of the lung dys-function.

As an example, even if the PO2 reaches as low as 50 to 60 mmHg, the oxygen saturation can remain at 85% - 90%. That is an indication that even though the oxygen levels are quite low, the saturation will be nearly normal. Clinic-ally, this means that the patient has very little oxygen in

reserve. The pati-ent may seem quite normal while at rest, but even a slight exert-ion will be too much to handle and will probably cause a crisis. Again, this is due to the ability of the hemoglobin to remain saturated at relatively high levels, even though there is actu-ally a reduced amount of oxygen in the blood. (For instance, in anemia, where there is a reduced number of cells and hemo-globin, but the cells that are present, are fully saturated)

By this time, the clinical ramifications should be much clearer. A person who has a respirat-ory disease has the double danger of low oxygen levels, but also high CO2 levels. Now we see how these two problems can lead not only to an oxygen problem, but also an acid-base problem. We will discuss this further in the next section.

Pick an ABG result which indicates hypoxia:

Patient A	Patient B	Patient C
pH 7.32	pH 7.34	pH 7.35
PCO2 48	PCO2 46	PCO2 45

Compensation

We have seen how imbalance in the levels of CO2 and HCO3 can disturb the blood pH. However, the body has mechanisms to counteract these imbalances. Compensation is the process of the body's response to these imbalances, and tries to bring the pH back to normal.

If there is hypo- or hyperventilation causing a rise or fall in the CO2 levels, the pH will also ch-ange. The response of the kidneys would be to con-serve or excrete bicarbonate, in order to get the pH back to normal.

As an example: a patient is hyperventilating, CO2 is "blown off" thus causing lowe-red acid levels, and alkalosis. The kidneys respond by excreting HCO3, to try to restore the normal pH.

The ABG's might be: pH 7.45 CO2--36 HCO3--22

As you see, the pH is high normal, indicating that the patient is border-line alkalotic. The low normal is trying to compensate. Another ABG will be needed soon to see if the patient has stabi-li-zed or if they are now in full blown alkalosis. If it was recognized that the patient was in compensation, the pati-ent would be watched very carefully and probably have frequent ABG determina-tions to see if they were able to handle the mild hyperventila-tion which lead to the alkalosis.

As another example, if we are dealing with a serious metabolic problem, the condi-tion can be much more unstable. For example, with renal failure, the kid-neys will not be able to excrete even normal amounts of HCO3. This renal fail-ure will cause alkalosis as bicarbonate builds up in the blood. The body's initial re-sponse will be hypoventil-ation, in an effort to build up CO2 and thus neutral-ize the bicarb with acid.

The ABG's might be: pH--7.45 CO2--45 HCO3--25

You can see that the patient is in compensation now, but if the kidneys continue to fail, the sit-uation will

become worse, rapidly. Compensation is a delicate situation. The patient can easily go into acidosis or alkalosis with little or no reserve power to fight the situation. Also, compensatory situat-ions can last for only a short time.

When the lungs or the kidneys respond to a pH change, they have limits to what they can do to correct the situation. If the person is already sick, and then they also develop a pH disturbance, they are probably in serious trouble. The lungs and the kidneys will only be able to compensate for a short time, due to low body reserves.

In completing our discussion on compensation, we also have to remember the patient. He/she will need to be treated as soon as possible. Since the body's own defense mechanism will last just a short time, the nurse must look for and accurate-ly report symptoms. The susceptible patient must be identified and observed for life-threatening complications in the acid-base balance. However, do not forget the patient's oxygenation status. Up to this point, we have primarily been concerned with pH of the blo-od. We should also remember that changes in the acid-base balance may also effect the <u>oxygen content</u>.

In cases of compensation, the patient's respiratory status may be severely compromised. For example, if the patient begins to hypoventil-ate, it may be due to the primary cause of reduced CO2 in the blood. However, hypoventil-ation may still occur in a person who is going into metabolic alkalosis. In that case, the patient may be severely hypoxic and needs to <u>hyperventilate</u>, but the overpowering effect of alkalosis still causes the patient to slow respirations instead of increase them. Therefore, the pa-tient may show signs of hypoxia (cyanosis, lethargy, etc.), but they may still be unable to breathe on their own due to the pH problem which effects the respiratory center in the brain.

Clinically, the patient looks terrible, and cannot breathe well. In
fact, the breathing may beco-me erratic. First there may be hyperv-enti-lation which changes rapidly to hypoventilation, the patient may experience long peri-ods of eupnea, even though they may actually be hypoxic and in alkalosis. This is why nurses must also be aware of the delicate situation the compensation creat-es.

The nurse should.....

1. Be aware of sudden changes in pH (especially if borderline resul-ts)
2. Be aware of hypoxia (may develop suddenly)
3. Be aware of clinical signs/sympt-oms of both of the above:

confusion, lethargy, tremors, cyanosis, hypoventilation, hyperventila-tion, in-creased depth of respirations, decreased urinary output, change in vital signs, sweating, nausea, vomiting, asymmetrical breathing pattern

Analyzing the ABG

This section is a guide to analysis of the ABG. Follow the steps as indi-cated in order to best interpret the results.

step 1 examine pH

if low, indicates acidosis --
if high, indicates alkalosis --
if normal, check to see if borderline (may be compensation)

step 2 examine CO_2

if high, indicates respiratory acido-sis (with low pH)
if low, indicates respiratory alkalo-sis (with high pH)
if normal, check for compensatory problem

step 3 examine HCO_3

if high, indicates metabolic alkalosis (with high pH)
if low, indicates metabolic acidosis (with low pH)
if normal, check for compensatory condition

step 4 check PO_2 levels

if low, indicates an interference with ventilation process (should evaluate the patient)

if normal, indicates patient is gett-ing enough oxygen

step 5 check signs/sym-ptoms of patient

This analysis is for the patient whose respiratory status is fairly stable clinically, but acid/b-ase balance is questionable. Following is a step-by-step account of how to analyze ABG if the prime concern is oxygena-tion.
Patient 1

pH 7.45 CO_2 32 HCO_3 23

identify:

a. (condition) _____

b. compensation YES or NO

c. name the possible diagnosis:

(answers: a. resp alkalosis b. yes because HCO3 is less than 24
c. possible hyperventilation)

Possible causes: hyperventilation, respiratory stimulation, gram-negative bacteremia.
Signs & symptoms: rapid, deep breathing, twitching, anxiety, fear

Part B

Use this guide to analyze ABG's if the patient's primary diagnosis is hypoxia or any con-dition where O2 may be compromised.

step 1 Examine PO2

if normal, go to step 2
if high, go to step 2 (patient may be over venti-lated)
if low, indicates poor oxygenation

*may require immediate intervention, as in obstructed airway, COPD, or if on a ven-tilator.

step 2 Examine pH

if normal, patient is either in no acute distress or is compensa-ting
if low, (and O2 is sufficient) go to step 2 prev page
if high, (with normal O2) go to step 2 prev page

step 3 Examine patient symptoms:

If you have checked all of the above steps and they are within normal limits, then your patient is either in compensation or is adequately venti-lated. If ABG's are normal, but the patient still has symptoms of hypox-ia, then repeat ABG's in a short time. Then the problem should be ap-parent.

CHAPTER IX

Select Diagnostic Tests

HISTOLOGY, CYTOLOGY, AND CYTOGENIC TESTING

Improved technology in histologic, cytologic, and cytogenic testing has greatly aided identification of abnormal cells. This has special significance in the detection of malignancy and genetic abnormalities.

A HISTOLOGY:

Histology is the study of the microscopic structure of tissues and cells. Histology is vital to confirm malignant disease and has made biopsy--extraction of a living tissue specimen--a common procedure. New tissue preparation techniques and needle designs allow rapid specimen removal from even deep tissue without surgery.

Biopsies:

Biopsies may be incisional or excisional. In incisional biopsy, a scalpel, cutting or aspiration needle, or punch is used to remove a portion of tissue from large, multiple, hidden lesions. Fine needle aspiration differs slightly from traditional needle biopsy. Although the procedure is the same, it provides a smaller specimen, requires cytologic (not histologic) studies, and is usually performed on outpatients for breast biopsies. Incision of a hidden lesion is called a closed, or blind, biopsy.

In excisional biopsy, a scalpel is used to remove abnormal tissue from the skin or subcutaneous tissue. When such tissue can be easily and completely removed, excisional biopsy is preferred, because it combines diagnosis and treatment. Biopsies commonly take place in the hospital, but they may also take place in clinics and physicians' offices. Open biopsy, performed in the operating room, usually requires general anesthesia. Open biopsy is required when the results of a closed biopsy or other diagnostic tests (i.e., CT scan) suggest the need for complete excision of a tissue mass.

Tissue preparation and Tissue Classification:

Tissue preparation involves several time-consuming steps in the fixation of specimens on slides for examination by pathologist. Even a stat tissue preparation can take 24 hours. The exception to this normal method of fixation of slides is a ***frozen section***. Frozen sections may provide results in 10-15 minutes in emergency situations. However, frozen section results are not reliable and will usually be confirmed by the standard process.

After standard analysis, tissue classification takes place. The pathologist's report provides both gross and microscopic descriptions, which result in histopathological classification of the tumor. Typical-ly, results of this analysis are expressed on a scale of four grades: G1--well differentiated; G2--moderately well differentiated; G3--poorly differentiated; G4--anaplastic. A staging system is then used to direct the treatment and predict the prognosis when biopsy results confirm malignancy.

B CYTOLOGY

Cytology is the study of cells, including their formation, origin, structure, function, biochemical activities, and pathology. Cytologic tests are generally inexpensive, useful screening tests that help detect suspected malignant or premalignant conditions and assess the effective-ness of therapy. However, they fail to determine the location and size of a malignancy and may require further histologic confirmation.

Tissue scraping is a type of cytologic test. One of the most common tissue scrapings is the Papanico-laou (PAP) test, in which cervical scrapings are evaluated.

Cytologic specimens may also be obtained by aspiration or by cell washing. **Fine-needle (19G to 23G) aspiration** of body fluids permits evaluation of a palpable mass, a lymph node, or a lesion that has been localized by x-rays. **Cell washing** is performed by instilling a solution into the bronchial tree, esophagus, stomach, or uterine cavity and subsequently aspirating it out. This procedure loosens exfoliated cells from crevices and suspends them in the solution, thereby increasing the number of cells collected for cytologic examination. The procedure also increases the probability of finding recently exfoliated cells.

C CYTOGENICS

Cytogenics is the branch of genetics that studies cellular components concerned with heredity; primarily the structure, function, and origin of the chromosomes. Cytogenic tests identify abnormal genetic factors or patterns seen in conditions such as Down's syndrome and Turner's syndrome.

COMMON CYTOLOGIC SPECIMENS:

sputum, bronchial washings, lung aspirate, breast mass aspirate, bone marrow aspirate, cul-de-sac of Douglas aspirate, solid tumor aspirate, pleural fluid, ascitic fluid, spinal fluid, bladder urine, vaginal pool scrapings, cervical scrapings, endometrial scrapings

Nursing Implications:

1. Explain the purpose of the test. Each cytologic test will have different implications for each patient.

2. Explain the procedure. Explain where the test will be performed and who will be performing it. Tell the patient how the specimen will be obtained.

3. Describe what discomfort, if any, to expect during the procedure.

4. If a local anesthesia is used, explain that it may alleviate some discomfort, but that the patient will remain alert. If a general anesthesia is used, explain that the patient will not be conscious for the procedure, and that foods and fluids are not permitted after midnight before the test.
5. Explain any other special care, positioning, or restrictions that will follow the procedure and explain why they are necessary.

6. provide the outpatient with written instructions, and, if sedation will be used, advise him to have someone accompany him for transporta-tion.

7. Inform the patient when the test results will be available, since this patient may be especially anxious.

Some Common Biopsy/Cytology Tests and Nursing Implications

Test: Breast Biopsy

The breast biopsy is performed to confirm or rule out breast cancer after clinical examination, mammography, or thermography has identified a mass. Fine-needle aspiration is usually done on a mass that has been identified by ultrasonography as being fluid-filled. Solid masses are assessed by one of four methods: Ultrasound-guided core biopsy; needle or wire localization biopsy; or excisional biopsy. An incisional biopsy is seldom performed. Stereotactic breast biopsy immobilizes the breast and allows the computer to calculate the exact location of the mass, based on x-rays from two angles. Needle or wire localization biopsy is used to localize a nonpalpable lesion for excisional biopsy.

All four techniques require only local anesthesia, although an excisional biopsy may be done under general anesthesia. If sufficient tissue is obtained and the mass is found to be a malignant tumor, specimens are sent for estrogen and progesterone receptor assays to assist

in determining future therapy and the prognosis. Because breast cancer remains the most prevalent cancer in women, genetic researchers are continually working to identify women at risk.

Procedure and Preparation:

The nurse should be sure that the procedure has been explained to the patient and all questions answered. Explain any food, fluid, or medication restrictions (usually few restrictions if local anesthesia is used). Offer emotional support if the patient appears anxious or expresses concerns.

Ultrasound-guided core biopsy:

The gowned patient will lie on her back on the ultrasound table. The patient will then be repositioned according to the location of the mass.
Ultrasonography is performed, the mass is localized, and its position is marked on the skin.
The area is cleaned and local anesthetic is injected.
The biopsy needle is inserted at the marked spot and a tissue specimen is obtained.
When the needle is withdrawn, apply pressure for 10 minutes and then apply a dressing and an ice bag.

Stereotactic breast biopsy:

The gowned patient is instructed to lie face down on a special breast biopsy table; position breast through the round opening in the table. Mammography equipment located under the table is used for the procedure.
The breast is compressed by a paddle, as with a regular mammogram, and remains compressed throughout the procedure. Films are then taken from two angles and visualized on the computer.
The computer calculates the exact position of the mass and the insertion site for the needle.
Next, the skin is cleaned and the local anesthesia is injected.
The biopsy probe is inserted, and x-ray images are taken to confirm proper placement.
Tissue specimen obtained using punch biopsy needle or Mammotome probe.
After the probe is removed, apply pressure for 10 minutes, dress the site, and apply ice.

Needle or Wire Localization Biopsy:

The suspicious area is identified, using craniocaudal and medolateral x-ray views of the breast.
The area is anesthetized and a double-lumen needle is inserted.

X-rays are obtained to ensure proper needle placement, and areas may be marked with blue dye or a radiopaque contrast medium.
The outer needle is then removed, leaving in place a small hooked wire. The wire is taped to the patient's skin to identify the excisional biopsy site.

Excisional biopsy:

After the patient receives an anesthetic, her skin is prepared and draped.
A curvilinear incision is made over the palpable mass or the area identified by the localization wire.
The mass as well as a margin of normal tissue around it are removed, and the skin is sutured.
A dressing is applied, and the patient is observed for at least one hour before discharge.

All procedures:

Tissue specimens are placed in 10% formaldehyde solution and sent for frozen-section and receptor assays.
Check vital signs, and provide analgesia if needed.
If the patient has received general anesthesia, check vital signs every 30 minutes for the first 4 hrs, every hour for the next four hours, and then every 4 hours.
Observe for and report bleeding, tenderness, redness at the biopsy site.
Provide emotional support to the patient who is awaiting diagnosis.

Normal breast tissue consists of cellular and noncellular connective tissue, fat lobules, and various lactiferous ducts. It's pink, more fatty than fibrous, and shows no abnormal development of cells or tissue elements. Abnormal breast tissue may exhibit a wide range of malignant or benign pathology. Breast tumors are common in women and account for 32% of female cancers; such tumors are rare in men. Benign tumors include fibrocystic disease, adenofibroma, intraductal papilloma, mammary fat necrosis, and plasma cell mastitis (mammary duct ectasia). Malignant tumors include adenocarcinoma, cystosarcoma, intraductal carcinoma, infiltrating carcinoma, inflammatory carcinoma, medullary or circumscribed carcinoma, colloid carcinoma, lobular carcinoma, sarcoma, and Paget's disease.

Test: Lung Biopsy

The purpose of a lung biopsy is usually to confirm the diagnosis of diffuse parenchymal pulmonary disease and pulmonary lesions. Usually, a biopsy of the lung is

recommended after chest x-rays, computed tomography scan, and bronchoscopy have failed to identify the cause of any diffuse parenchymal pulmonary disease or a pulmonary lesion. Closed Technique or ***Open Technique*** may be used for lung biopsy.

Closed technique is performed under local anesthesia and includes both needle biopsy and transbronchial biopsy. Needle biopsy is appropriate for lesions that are readily accessible, originates in the lung parenchyma and is confined to it, or is affixed to the chest wall. Needle biopsy provides a much smaller specimen that the open technique. Transbronchial biopsy is used for the removal of multiple tissue specimens through a bronchoscope. This technique may be used for patients with diffuse infiltrative pulmonary disease or tumors or when severe debilitation contraindicates open biopsy.

Open technique is performed under general anesthesia and includes both limited and standard thoracotomies. Open biopsy is appropriate for the study of a well-circumscribed lesion that may require resection.

In addition to the general nursing considerations above, sedatives may be administered and blood studies may also be performed. The nurse should check vital signs every 15 minutes for 1 hour, then every hour for four hours. Assess for any bleeding, dyspnea, elevated pulse rate, diminished breath sounds on the biopsy side, and eventually, cyanosis. Also, remember to keep the patient calm and quiet. Coughing and movement during biopsy may cause tearing of the lung by the biopsy needle.

Findings:

Normal lung biopsy tissue results show uniform texture of the alveolar ducts, alveolar walls, bronchioles, and small vessels. Histological examination of a pulmonary tissue specimen can reveal squamous cell or oat cell carcinoma and adenocarcinoma. These findings supplement the results of microbiological cultures, deep-cough sputum specimens, chest X-rays, and bronchoscopy and the patient’s physical exam history in confirming cancer or parenchymal pulmonary disease.

The nurse should remember that several factors may influence these above findings. The nurse should always be sure to obtain a careful history from the patient. The patient’s medical history, medication history, and family history may influence these findings. The nurse must also remember to collect and store the tissue specimens according to procedure. Failure to handle and deliver specimens correctly may lead to inaccurate results. In addition to these potential problems, the specimen may also be flawed by failure to obtain a representative tissue specimen.

Test: Lymph Node Biopsy

Lymph node biopsy is the surgical excision of an active lymph node or the needle aspiration of a nodal specimen for histological examination. Lymph node biopsy is performed to determine the cause of lymph node enlargement, to distinguish between benign and malignant lymph node process, and to stage certain cancers or metastatic carcinoma.

Both techniques usually use a local anesthetic and sample the superficial nodes in the cervical, supraclavicular, axillary, or inguinal region. Excision is preferred because it yields a larger specimen.

Although lymph nodes swell during infection, biopsy is indicated when nodal enlargement is prolonged and accompanied by backache, leg edema, breathing and swallowing difficulties and, later, weight loss, weakness, severe itching, fever, night sweats, cough, hemoptysis, and hoarseness. Generalized or localized lymph node enlargement is typical of such diseases as chronic lymphatic leukemia, Hodgkin's disease, infectious mononucleosis, and rheumatoid arthritis. Complete blood count, liver function tests, liver and spleen scans, and x-rays should precede this test.

Procedure and Preparation:

As with all procedures, be sure to fully explain the procedure and answer any question regarding the test. Of course, the physician has probably already explained the procedure. However, the nurse cannot assume this. Be sure that a complete history and physical exam has been done, noted, and available on the patient's chart. Be sure that the consent form has been fully explained and legally signed. Also, be sure to explain any food restrictions and any other preparation. Usually no prep is required for the needle biopsy. However, there may be a complete surgical-type prep for the excisional biopsy. The prep depends upon many factors such as the patient's history and the location of the node to be biopsied.

Excisional Biopsy

After the skin over the biopsy site is prepared and draped, the anesthetic is administered.
The examiner makes an incision, removes an entire node, and places it in a properly labeled bottle containing normal saline solution.
The wound is sutured and dressed.

Needle Biopsy

After preparing the biopsy site and administering a local anesthetic, the examiner grasps the node between his thumb and forefinger, inserts the needle directly into the node, and obtains a small core specimen.

The needle is removed, and the specimen is placed in a properly labeled bottle containing normal saline solution.
Pressure is exerted at the biopsy site to control bleeding, and an adhesive bandage is applied.

Both Procedures

Check vital signs as ordered and watch for bleeding, tenderness, and redness.
Inform the patient that he may resume his usual diet.

The results of a normal lymph node biopsy show a normal lymph node encapsulat-ed by collagenous connective tissue and divided into smaller lobes by tissue strands called trabeculae. It has an outer cortex, composed of lymphoid cells and nodules or follicles containing lymphocytes, and an inner medulla, composed of reticular phagocytic cells that collect and drain fluid.

Histological examination of the tissue specimen distinguishes between malignant and nonmalignant causes of lymph node enlargement. Lymphatic cancer accounts for up to 5% of all cancers and is slightly more prevalent in males than in females. Hodgkin's disease, a lymphoma affecting the entire lymph system, is the leading cancer affecting adolescents and young adults. Lymph node cancer may also result from metastasizing carcinoma.

When histological results are not clear or nodular material is not involved, mediastinoscopy or laparotomy can provide another nodal specimen. Occasionally, lymphangiography can furnish additional diagnostic information.

Test: PAPANICOLAOU SMEAR
(Pap Smear--cytology test for cervical cancer)

The Pap Smear became nationally known and used in the 1950's for detecting cervical cancer and precancerous tissues. Dr. George Papanicolaou developed the cytology test in 1928 after spending 18 years in research. Today, he is referred to as the father of modern cytology. As the result of his work, there are many cytology studies done on body tissues and secretions.

Since malignant tissue changes usually take many years, yearly examination of the exfoliative cervical cells (cells that have sloughed off) allows detection of early precancerous conditions. It is suggested that women from age 18 to 40 have yearly Pap smears and that women over age 40, have twice a year, or yearly Pap smears. How often the Pap smear test should be performed is determined by the woman's physician.

Pap Smear (cytology) results are reported on a 5-point scale:

Grade (Class)	I	Absence of atypical or abnormal cells
Grade (Class)	II	Atypical cells, but no evidence of malignancy
Grade (Class)	III	Suggestive of but not conclusive of malignancy
Grade (Class)	IV	Strongly suggestive of malignancy
Grade (Class)	V	Conclusive for malignancy

For suggestive or positive Pap Smears, colposcopy and/or cervical biopsy are frequently ordered to confirm the smear results. Atypical cells may occur due to cervicitis and excessive or prolonged use of hormones.

Nursing Implications:

1. Explain the purpose of the test. Be sure to explain the test even if the patient has had the test in the past. Explain how often and why the test is being performed.
2. Explain the procedure to the patient. Be sure to inform the patient not to douche, have intercourse, or insert vaginal suppositories for 24-48 hours prior to the test. Be sure to inform her that usually a complete examination will be performed along with the Pap Smear. This means that a bimanual examination of the vagina will be performed. Also, an examination of the lower abdominal area and rectal exam may be performed.
3. Usually there are no restrictions on food or fluids before the test.
4. Obtain a patient history regarding any problems with menstruation such as the last menstrual period, bleeding flow, vaginal discharge, itching, whether or not she is taking any medications, especially hormones or oral contraceptives.
5. label the specimen slide with the patient's name, the date, the time, the patient's age, and the specimen site. (other requirements may be needed in different facilities, be sure you are informed as to the correct procedure before you assist with the test)
6. Inform the patient that test results will take about two to three days. Each physician has a different reporting system. Some physicians call the patient personally; others will send a card with the results. A follow-up visit may be necessary, especially if results are abnormal.

Nuclear Medicine Procedures

Nuclear medicine refers to the medical discipline that uses radioactive isotopes to aid in the diagnosis and treatment of certain disease conditions. The major fields of nuclear medicine are physiologic function studies, radionuclide imaging, and therapeutic techniques. In this text we have already presented several procedures that often use radioactive isotopes such as the MRI and certain organ scans. There will be

overlap with some of these procedures. Nuclear medicine is used quite often and is an important tool for diagnosis of many conditions and is even used in the treatment of many medical conditions.

Be sure you are aware of your facility's "Radiation Precautions" procedure. Each facility has its own way of handling radioactive materials. In most cases, nurses will not have to be concerned with radioactive substances.

Most radioactive substances on the nursing unit are harmless and no precautions are needed. However, occasionally, the nurse will have patients who are receiving higher doses of radiation. Be sure to follow precautions set by the nuclear medicine department. These precautions may include, but are not limited to: isolation of the patient, wearing lead aprons, collecting all body fluids, and other precautions.

Test: Radioactive Iodine Uptake Test (RAIU)

The radioactive iodine uptake test evaluates thyroid function by measuring the amount of orally ingested iodine 123 (123I) or iodine 131 (131I) that accumulates in the thyroid gland after 6 and 24 hours. An external single counting probe measures the radioactivity in the thyroid as a percentage of the original dose, thus indicating its ability to trap and retain iodine. The RAIU test accurately diagnoses hyperthyroidism but is less accurate for hypothyroidism. Indications for this test include abnormal results of chemical tests used to evaluate thyroid function (thyroid function tests, T3, T4, etc.).

Following is the BASIC preparation and procedure for the RAIU test. However, the nurse should remember that each facility has its own procedures. Some facilities will scan the patient at different intervals (2-hours, 6-hours, 24-hours). Some facilities may perform another test at the same time, for example, a thyroid scan. The ***Thyroid Scan*** test also uses 131I. Frequently, a ***thyroid scan*** may be performed along with the RAIU. The ***thyroid scan*** involves the oral or intravenous administration of radioactive iodine (131I) and then a scan at 30 minutes and at 60 minutes. Therefore, be aware that the nursing implications may change according to hospital and/or laboratory procedures. Also keep in mind that outpatient procedures may be different as well. The best "policy" is to carefully follow your facility's procedures and to be aware that this procedure below may be quite different at your facility.

Preparation and Procedure:

Explain the test and the purpose of the test to the patient. He will need to begin fasting at midnight the night before the test. Explain that he will receive the

radioactive iodine in capsule or liquid form and then be scanned at the 6-hour interval and again at a 24-hour interval. If the patient is an inpatient, the nurse or a technician will administer the dose to him right on the nursing unit at the specified time. Be sure to note the exact time the dose is administered. If he is an outpatient, the patient will usually be given the capsule to take at home at a certain time. Be sure you instruct the patient to take the dose at the specified time. If he misses the exact time, be sure to have the patient write down the exact time he did take the dose. Be sure to explain that the test is painless. Be sure to explain that the radioactive material is very small and will not harm him.

Check the patient's history for IODINE EXPOSURE, which may interfere with the test results. Note any prior radiological tests using contrast media, nuclear medicine procedures, or current use of iodine preparations or thyroid medications on the film request form. Substances containing iodine, such as dyes used for the intravenous pyelogram (IVP), gallbladder series, or bronchograms ***may*** cause incorrect test results. Iodine hypersensitivity (allergy) is not considered a contraindication for this test because the amount of iodine used is similar to the amount consumed in a normal diet.

Radioactive iodine uptake testing is contraindicated during pregnancy and lactation because of possible teratogenic effects.

> After ingesting an oral dose of radioactive iodine, the patient's thyroid is scanned at 6 hours and at 24 hours by placing the anterior portion of his neck in front of an external single counting probe. Instruct the patient to resume a light diet 2 hours after taking the oral dose of radioactive iodine. When the study is complete, the patient may resume a normal diet.

At 6 hours, 5% to 20% of the radioactive iodine should accumulate in the thyroid. At 24 hours, accumulation should be 15% to 40%. The balance of the radioactive iodine is excreted in the urine. Local variations in the normal range of iodine uptake may occur due to regional differences in dietary iodine intake and procedural differences among laboratories.

Below-normal iodine uptake may indicate hypothyroidism, subacute thyroiditis, or iodine overload. Above-normal iodine uptake may indicate hyper-thyroidism, early Hashimoto's thyroiditis, hypoalbuminemia, lithium ingestion, or iodine-deficient goiter. However, in hyperthyroidism, the rate of turnover may be so rapid that a false normal measurement occurs at 24 hours.

<u>The following factors may decrease iodine uptake</u>:

renal failure; diuresis; severe diarrhea; x-ray contrast media studies; ingestion of iodine preparations including iodized salt, cough syrups, and some multivitamins; thyroid hormones; thyroid hormone antagonists; salicylates; penicillins; antihistamines; anticoagulants; corticosteroids

The following factors may increase iodine uptake:

phenothiazines, iodine-deficient diet

Test: Bone Scan

A bone scan involves imaging the skeleton by a scanning camera after an intravenous injection of a radioactive tracer compound. The tracer of choice, radioactive technetium diphosphonate, collects in bone tissue in increased concentrations at sites of abnormal metabolism. When scanned, these sites appear as "hot spots" that are often detectable months before an x-ray can reveal any lesion. To promote early detection of lesions, this test may be performed with a gallium scan.

Preparation and Procedure:

Explain the procedure to the patient and reassure him that it will be painless and the radioactive substance involved is not dangerous. There will be no food or fluid restrictions prior to the test. However, most facilities will have the patient withhold fluids two hours prior to the test, simply because the patient will be required to drink (as part of the test) four to six glasses of water or tea during the test. Before the procedure, some patients may be administered a sedative or analgesic, not due to the procedure itself, but to anxiety.

Approximately two hours before the procedure, the patient is given the intravenous injection of the tracer and imaging agent. This occurs either on the nursing unit or in the procedure room (or lab). After the injection, the patient is encouraged to drink four to six glasses of water or other clear fluids during the next 1 to 3 hours in order to facilitate renal clearance of the circulating free tracer.

Transport the patient to procedure room and instruct the patient to void. Then position him on the scanner table.

As the scanner head moves back and forth over the patient's body, it detects low-level radiation emitted by the skeleton and translates this into a film or paper chart, or both, to produce two-dimensional pictures of the area scanned.

The scanner takes as many views as needed to cover the specified area. The patient may have to be repositioned several times during the test in order to obtain adequate views.
At the end of the procedure the patient can be returned to the nursing unit immediately. Check the injection site and monitor the patient for 24 hours for any delayed reactions to the tracer. Be sure not to schedule any other radionuclide tests for 24 to 48 hours.

Although a bone scan demonstrates hot spots that identify sites of bone formation, it doesn't distinguish between normal and abnormal bone formation. But scan results can identify all types of bone malignancy, infection, fracture, and other disorders, if viewed in light of the patient's medical and surgical history, x-rays, and other laboratory tests.

Test: Liver-Spleen Scanning

In liver-spleen scanning, a gamma camera records the distribution of radioactivity within the liver and spleen after intravenous injection of a radioactive colloid.

The colloid most commonly used, technetium sulfide-99m (99mTc), concentrates in the reticuloendothelial cells through phagocytosis. About 80% to 90% of the injected colloid is taken up by Kupffer's cells in the liver, 5% to 10% by the spleen, and 3% to 5% by bone marrow. The gamma camera images either organ instantaneously without moving.

Although the indications for this test include the detection of focal disease, such as tumors, cysts, and abscesses, liver-spleen scanning demonstrates focal disease nonspecifically as a cold spot (a defect that fails to take up the colloid) and may fail to detect focal lesions smaller than 3/4 inch (2 cm) in diameter. Although clinical signs and symptoms may aid diagnosis, liver-spleen scanning frequently requires confirmation by ultrasonography, computed tomography, gallium scanning, or biopsy.

Test: Gallium Scanning

The gallium scan is a total-body scan used to assess certain neoplasms and inflammatory lesions that attract gallium. It is usually performed 24 to 48 hours after the intravenous injection of radioactive gallium (67Ga) citrate. Occasionally, it is performed 72 hours after the injection or, in acute inflammatory disease, after four to six hours.

Because gallium has an affinity for both benign and malignant neoplasms and inflammatory lesions, exact diagnosis requires an additional confirming test, such as ultrasonography or computerized tomography scanning. Also be aware that many neoplasms and a few inflammatory

lesions may fail to demonstrate abnormal gallium activity.

Preparation and Procedure:

Explain the procedure to the patient and inform him that there will be no food or fluid restrictions before the test. Also reassure him that there will be no pain during the test and the radioactive material is very low-dose and is of no danger to him. The intravenous injection will be administered 24 to 48 hours prior to the actual scan (in most cases). There may be some transient pain or discomfort at the injection site.

The patient may be positioned erect or recumbent or in an appropriate combination of these positions, depending upon his physical condition.
Scans or scintigraphs of the patient are taken 24 to 48 hours after the gallium injection, from anterior and posterior views and occasionally, lateral views.
If the initial gallium scan suggests bowel disease and additional scans are necessary, give the patient a cleansing enema before continuing the test.

Gallium scanning may reveal inflammatory lesions, discrete abscesses or diffuse infiltration. In pancreatic or perinephric abscess, gallium activity is relatively localized. In bacterial peritonitis, gallium activity is spread diffusely within the abdomen.

Abnormally high gallium accumulation is characteristic in inflammatory bowel disease, such as ulcerative colitis, regional ileitis (Crohn's disease), and in carcinoma of the colon. However, because gallium normally accumulates in the colon, the detection of inflammatory and neoplastic diseases is sometimes difficult.

Abnormal gallium activity may be present in various sarcomas, Wilm's tumor, aneuroblastomas; carcinoma of the kidney, uterus, vagina, and stomach; and testicular tumors, such as seminoma, embryonal carcinoma, choriocarcin-oma, and teratocarcinoma, which often metastasize via the lymphatic system. In Hodgkin's disease and malignant lymphoma, gallium scanning can demonstrate abnormal activity in one or more lymph nodes or in extranodal locations. However, gallium scanning supported by results of lymphangiography can gauge the extent of metastases more accurately than either test alone because neither test consistently identifies all neoplastic nodes.

After chemotherapy or radiation therapy, gallium scanning may be used to detect new or recurrent tumors. However, these forms of therapy tend to diminish tumor affinity for gallium without necessarily eliminating the tumor.

In the differential diagnosis of focal hepatic defects, abnormal gallium activity may help narrow the diagnostic possibilities. Gallium localizes in hepatomas, but not in pseudotumors; in abscesses, but not in pleural effusions; and in tumors, but not in cysts or hepatomas.

In examining patients with suspected bronchogenic carcinoma, abnormal activity confirms the presence of a tumor. However, because gallium also localizes in inflammatory pulmonary diseases, such as pneumonia and sarcoidosis, a chest x-ray should be performed to distinguish a tumor from an inflammatory lesion.

Special Diagnostic Procedures

Test: ANGIOGRAPHY (angiogram)

Angiography simply means the examination of blood vessels. Angiography and arteriography (examination of the arteries) are often used interchangeably. Angiography is performed through the use of an injected contrast dye which outlines the lumen of the vessels.

Under surgical asepsis, a long catheter is inserted into the femoral, brachial, or carotid artery. The catheter is positioned under fluoroscopy and the contrast dye is injected. Angiography is useful for evaluating the patency of blood vessels and for identifying abnormal vascularization resulting from neoplasms (tumors).

The most common forms of angiography are:

(1) cerebral angiography--The dye is used to outline the carotid artery, vertebral artery, large vessels of the circle of Willis, and small cerebral arterial branches.

(2) pulmonary angiography--The brachial artery or the femoral artery is most often used for this procedure. The catheter is then threaded into the pulmonary artery. The dye is used to visualize the various pulmonary vessels. Cardiac arrhythmia is a possible complication of this procedure.

(3) renal angiography--The catheter is usually inserted in the femoral artery. It is then passed through the iliac artery and the aorta to the renal artery. The dye visualizes the renal vessels and parenchyma. An aortagram is usually made during this procedure because the catheter conveniently passes through the aorta on its way to the renal artery. Some very interesting information may be obtained by visualizing the aorta as well as the renal arteries.

Nursing Implications:

The nursing implications may be similar to those of the general surgery patient. Angiography is an invasive procedure and carries risks similar to those of the surgical patient. There are pretest prepara-tions and posttest considerations; in addition to the nursing care given during the test.

Preparation:

1. a consent form must be signed
2. patient must be NPO 12 hours prior to the procedure
3. anticoagulants (especially heparin) are usually suspended prior to the procedure (sometimes 24 hours before procedure)
4. vital signs monitored and recorded prior to procedure
5. rings and other such metallic objects removed prior to procedure
6. dentures removed prior to procedure
7. catheter insertion site is prepped (shaved)
8. sedatives and premedications are usually administered prior to procedure
9. an IV line and/or IV fluids may be started prior to procedure
10. pre-medications may include the prophylactic administration of antihistamines if the patient has a history of allergic reactions to medications or foods in the past
11. a laxative or enema may be ordered prior to procedure for those having a renal angiogram
12. Cardiac monitoring chest leads may be placed on the patient's chest if he is having a pulmonary angiogram in order to monitor for any arrhythmias
13. have patient void before procedure
14. patient teaching includes informing about procedure and especially let patient know that he will have strange sensations while dye is being injected; Many patients experience a warm, flushed sensation when dye is injected.

During the procedure the nurse will assist. The patient is usually in the supine position. A local anesthetic is usually administered to the catheter insertion site. Try to keep the patient warm while on the X-ray table. Try to keep the patient still while the X-rays are being taken or distortions may occur. Monitor EKG, if indicated; monitor vital signs; monitor IV fluids.

After the angiogram:

Many "routine" post-op observations apply to the angiogram patient. The nurse will monitor vital signs, temperature, bedrest, IV fluids, the EKG if indicated, the incision dressing (usually a pressure dressing), and monitor the level of consciousness.

In addition, the following care should be given after the procedure:

1. Manual pressure is usually applied to the incision site for 5 to 15 minutes; then a "pressure dressing" is usually applied. Monitor the dressing site very carefully for bleeding. Excessive blood loss may occur into the tissues of the patient, especially at the femoral site. Monitor the size and coloration of the patient's upper leg for signs of concealed bleeding and monitor peripheral pulses. Apply ice (cold compress) to site if ordered.

2. Observe for delayed allergic reactions to the dye.
3. Observe for any signs of TIA (transient ischemic attack).

The angiogram today has become a "routine" procedure. However, it does carry a certain amount of risk. The nurse must still carefully observe the insertion site and observe for any adverse signs or symptoms of complications. In many cases the patients have no ill effects and the angiogram can be a very important diagnostic tool.

Test: Cardiac Catheterization

(Cardiac Angiography, Angiocardiography, Coronary Arteriography)

Cardiac catheterization is a procedure used for visualizing the heart structures and/or coronary arteries. A long catheter is inserted into a vein or artery of the arm or leg, guided under fluoroscopy. Contrast dye is then injected into the catheter. During the injection of the dye, cineangiography is used for filming the heart activity.

The terms ***Angiocardiography*** and ***Coronary Arteriography*** are usually used interchangeably with Cardiac Catheterization. However, with Coronary Arteriography, dye is injected directly into the coronary arteries. With Angiocardiography, the dye is injected into the heart, coronary, and/or pulmonary vessels.

There is also a distinction between right cardiac catheterization and left cardiac catheterization. With right cardiac catheterization, the catheter is inserted into the femoral vein or an antecubital vein and threaded through the inferior vena cava into the right atrium to the pulmonary artery. Pressures in the right atrium, right ventricle, and pulmonary artery are measured. Samples of blood from the right side of the heart can be taken. As the dye is injected, the functions of the tricuspid and pulmonary valves can be observed as they operate. Some of the problems that can be detected with this procedure are: tricuspid stenosis, pulmonary stenosis, pulmonary hypertension, and septal defect.

With left cardiac catheterization, the catheter is inserted into the brachial or femoral artery and is advanced retrograde through the aorta to the coronary arteries and/or left ventricle. As dye is injected, the patency of the coronary arteries can be observed. The function of the aortic and mitral valves and the left ventricle can also be observed. Some of the problems that can be detected with this procedure are: coronary artery disease, partial or complete coronary occlusion, valvular heart disease--mitral stenosis, mitral regurgita-tion, aortic regurgitation, left ventricle hypertrophy; aneurysm--ventricle.

There still today remain some rare complications with cardiac catheteriza-tion. However, the rate of complications is less than 2 percent. Some of the serious complications are: cardiac arrhythmias, myocardial infarction, cardiac tamponade, pulmonary embolism, and cerebral embolism.

Nursing Implications:

a. Explain the test; explain the purpose of the test and the implica-tions of the test. Be sure the patient's doctor has discussed the risks involved with the procedure. Answer any questions the patient may have regarding the risks/benefits of the test. Cardiac catheterization is performed to check the coronary arteries for blockage or to check for defects in heart valves. Cardiac catheteriza-tion is almost always performed prior to most types of heart surgery.

b. Explain prep for the test; Food and fluids will be restricted 6-10 hours prior to test. Obtain patient history, such as allergies to foods and/or dyes; record baseline vital signs, and have patient void before the procedure. Be sure the consent form is signed and attached to the patient's chart.

b. Explain the details of the procedure; Explain the details of the procedure that the patient will experience. He will be taken to a special room. He will have an IV started, if not already done. He will have ECG leads attached to his chest. Explain how the catheter is inserted and other details such as having his vital signs monitored very frequently. Instruct him to report any chest pain of difficulty breathing during the procedure.

c. Administer premedications; Administer premedications if ordered. Inform the patient that the procedure will take approximately two to three hours. Allow the patient to express anxieties and reassure him and the family.

d. After the procedure:

*monitor vital signs, every 15 min. first hour, then
*every 30 minutes for two hours, then every hour until stable

*observe catheter insertion site for bleeding and/or hematoma
*check peripheral pulses below insertion site with vital signs
*assess patient's skin color and temperature
*bedrest for at least 12 hours
*analgesics as ordered if vital signs stable
*encourage fluid intake unless contraindicated

Test: ELECTROENCEPHALOGRAPHY, Electroencephalogram--EEG

The EEG test measures the electrical impulses produced by the brain. Sensitive electrodes are attached to the surface of the scalp at predetermined locations in order to pick up those minute electrical impulses ("brain waves"). These recorded impulses (EEG tracings) show patterns of "normal" activity or abnormal activity which indicates that disease may be present in certain parts of the brain.

Abnormal EEG tracings may indicate the presence of pathology such as: epilepsy or seizure disorders, brain tumors, brain abscesses, head (brain) injury, intracranial hemorrhage, encephalitis, unconsciousness, coma.

Nursing Implications:

a. Explain the purpose of the test and explain that there will be no pain from the test.

b. Explain the procedure of the test. The test may be performed when the patient is fully awake, drowsy, undergoing stimuli, asleep, during sleep deprivation, under sedation, or other situations.

c. Prepare the patient: The hair is usually washed thoroughly the night before the test. Use no oils or sprays on the hair. Restrict only sedatives and/or stimulants such as caffeine, alcohol, etc. prior to the test. Many times the patient will be encouraged to eat a meal before the test as hypoglycemia may affect the results of the test.

d. Patient Teaching: Be sure to include family in the teaching process. The machine may look frightening to the patient. Reassure the patient that he will not get a shock from the machine, especially if this is the first time this patient will have this test. Patients have other misconceptions and fears about the test. The machine cannot read his mind, nor does it test intelligence.

e. Report to the physician if the patient is taking any medications. Some drugs (legal or otherwise) may affect the results of the test. Report if the patient is unusually anxious or upset before the test.
f. The patient will be carefully observed during the test. Ask the patient to relax and lay still during the test. Note any activity and especial-ly any seizure activity during the test. During the test, note carefully the time, duration, and symptoms during any seizure activity.
g. Usually, normal activity may resume after the test. Be sure to clean hair after the test, as some paste may still be in the hair and scalp.

GASTRIC ACID SECRETION
(Gastric Acid stimulation, Gastric acid Analysis)

The Gastric Acid Analysis test examines the acidity of the gastric secretions. An increased acidity level (Hydrochloric acid) could mean that ulceration of the gastric lining is present, especially with clinical symptoms present. A lowered or absence of acid could indicate gastric atrophy or pernicious anemia.

Gastric analysis is accomplished by a nasogastric tube inserted into the stomach. The following gastric analysis are the most common:

Test: Basal gastric acid analysis

Gastric secretions are aspirated through the nasogastric (NG) tube after a period of fasting. Specimens are obtained of the gastric secretions to evaluate the acidity of those secretions. This is a "baseline" or Basal analysis.

Test: Stimulation gastric acid analysis

The stimulation test is a continuation of the Basal test and is usually performed after the Basal test is performed. After obtaining the basal sample, sometimes immediately after, a gastric stimulant is administered. The stimulant is usually histalog or pentagastrin. Gastric samples are aspirated every 15 to 20 minutes until three or four specimens are obtained. (This may vary from place to place). The samples are then analyzed for the response of gastric acid secretion to the stimulant.

Test: Tubeless Gastric analysis

This test is for screening purposes only for the presence of hydrochloric acid in the stomach. This test will not be specific enough to give the amount of free acid in the stomach. The test is performed by

administering a gastric stimulant such as caffeine or histalog. An hour later a resin dye such as Azuresin, Diagnex Blue is taken orally by the patient. Free hydrochloric acid in the stomach will cause the release of the dye from the resin base. The dye is then absorbed by the gastrointestinal tract and is excreted in the urine. If there is no dye in the urine after two hours, it is indicative of no gastric acid in the stomach. This general screening test is not very accurate, but it might save the patient from the discomfort of the NG tube insertion.

Test: Hollander Test

This test is rarely performed today due to the patient risks involved. Intravenous injections of insulin are administered to the patient. IV insulin causes hypoglycemia, which increases vagal stimula-tion and acid secretion. This test may be performed after a Vagotomy in order to test the effect of the surgery. Again, it is very dangerous to the patient and rarely performed any more.

Nursing considerations for all Gastric Analysis Tests:

a. Explain the purpose of the test.

b. Explain the procedure to the patient. Explain the various parts of the test. First, explain the NG tube insertion part of the test. Next explain about how the samples will be obtained. You should also explain when the tube will be removed. In some cases the NG tube may be left in place for a while. If this is an outpatient situation, the tube may be removed immediately. Be sure you know when to remove the tube. Be sure you have a physician's order to insert the tube and to remove the tube.

c. Be sure to note if the patient has been recently taking any medica-tions. Certain medications may interfere with the gastric analysis tests. These are: antacids, antispasmodics, anticholinergics, adrener-gic blockers, choliner-gics, steroids.

d. Monitor vital signs. Observe for any adverse reactions to the NG insertion (aspiration, etc.). Observe for any adverse reactions to the gastric stimulants (if administered); such as dizziness, flushing, headache, tachycardia, hypotension.

PULMONARY FUNCTION TESTS PFT's

Pulmonary function tests may be divided into two groups of tests; the ventilatory function tests for differentiating between obstructive and restrictive lung diseases and the arterial blood gas (ABG) tests for

evaluating the distribution and diffusion of gases across the alveolar capillary membrane. The ABG test is not always a part of pulmonary function tests. The ABG test was already presented in this text in greater detail. Ventilatory function tests that are performed with a spirometer and a recording device will be discussed in this section.

Pulmonary function tests are ordered for a variety of different reasons. They may be ordered as baseline screening tests to compare with future pulmonary tests; to evaluate pulmonary disability (for insurance purposes); to evaluate pulmonary status prior to surgery; to determine the severity of lung disease (either obstructive or restric-tive); to follow the course of pulmonary disease and treatment; or to detect early respiratory failure. They cannot identify the type of lung tumor or give its location. With the use of spirometry, a patient's pulmonary volumes, capaci-ties, and flow rates can be measured.

The spirometer measures and records tidal volume (Vt or TV), vital capacity (VC), forced expiratory volume (FEV), forced inspiratory volume (FIV), and many other ventilatory parameters. Some of the important measures for detecting disease entities are as follows:

Tidal volume (TV, Vt): Normal breathing with approximately 500 ml of inspired and expired gas

Vital capacity (VC): The VC is the maximal amount of air exhaled after a maximal inspiration. A forced vital capacity (FVC), is the greatest amount of air exhaled quickly and forcefully after a deep inspiration. With obstructive lung disease, the FVC and FEV1 are decreased, and with restrictive lung disease, they could be normal or decreased.

Forced expiratory volume (FEV): This test is part of the forced vital capacity test, giving the total volume of exhaled air in one second (FEV1), two seconds (FEV2), three seconds (FEV3), and four seconds (FEV4).

Expiratory reserve volume (ERV): This is the maximal amount of air that can be exhaled after normal breathing.

Inspiratory capacity (IC): This is the greatest amount of air inhaled after exhaling in normal breathing.

Forced inspiratory volume (FIV): This is the greatest amount of air inhaled after a maximal expiration form a forced vital capacity (FVC).

Residual Volume (RV): After a maximal expiration, the amount of air left in the lungs is referred to as the RV. Chronic air trapping from COLD (Chronic Obstructive Lung Disease) will cause an increased RV. In restrictive lung disease, the residual volume may be decreased.

Functional residual capacity (FRC): This gives the amount of air left in the lungs after normal expiration. It is calculated by adding expiratory reserve volume and residual volume (ERV + RV = FRC). With obstructive lung disease, FRC is increased due to hyperinflation of the lungs through air trapping. The FRC can be normal or decreased in restrictive lung disease.

Maximal voluntary ventilation (MVV): This is the maximal rate and depth of respiration after breathing fast and deep for 10-15 seconds. It tests the air flow and airway resistance. Decreased MVV can indicate obstructive lung disease and normal or decreased MVV can suggest restrictive lung disease.

Total Lung Capacity (TLC): This is the total amount of air in the lungs at the end of a maximal inspiration. The total lung capacity, TLC, can be measured by adding the vital capacity and the residual volume (VC + RC = TLC) or by adding the inspiratory capacity, tidal volume, expirato-ry reserve volume, and residual volume (IC + Vt + ERV + RV = TLC).

Flow volume loop (F-V Loop): The F-V Loop is a forced expiratory volume and followed by a forced inspiratory volume (FEV + FIV = F-V Loop). This test is useful for detecting small airway obstructive disease such as emphysema or advanced restrictive disease.
Nursing Implications

1. Explain the purpose of the test to the patient.

2. Explain the procedure to the patient. It is sometimes helpful to practice the breathing techniques before the patient goes for the test (unless contraindicated). Many patients are apprehensive if they have never had these tests. It will help them to practice normal breathing, forced breathing, etc.

3. Explain any restrictions to the patient:

a. There are usually no food or fluid restrictions. The patient should not eat a heavy meal right before the test.

b. No smoking for 4-6 hours before the test.

c. Take all regular medications except sedative-type drugs.

d. Omit any IPPB or respiratory treatments 4-6 hours before the test.

e. Patient should wear dentures for the test.

f. The tests are usually postponed if patient has an active cold, has a communica-ble disease, has had recent cardiac catheterization, or a recent acute myocardial infarction.

g. Have patient void before the test(s).

4. The nurse should note and record when the last IPPB treatment was taken; list oral bronchodilators, steroids; the patient's age, height, weight, and vital signs; especially note pulse, respirations, and if any dyspnea or unusual breathing patterns noted; also note any cyanosis or grayish skin color.

STRESS/EXERCISE TESTING, STRESS TESTING, EXERCISE ELECTROCARDIOLOGY (ECG)

Stress testing is based on the theory that patients with coronary artery disease will have marked S-T segment depression on the ECG when exercising. Depression of the S-T segment and depression or inversion of the T-wave indicate myocardial ischemia. In 1928, Fiel and Siegel reported on the relationship of exercising and S-T segment depression in patients complaining of angina. Master used an exercise test (two-step) in 1929 to demonstrate ischemia but used only the pulse and blood pressure to note changes. In 1931, Wood and Wolferth felt exercise was a useful tool for diagnosing coronary disease but that it could be dangerous. Later it was discovered that S-T segment depression usually occurred before the onset of pain and was still present for some time after the pain subsided. Mild S-T segment depression after exercise can occur without CAD present.

In 1956, R.A. Bruce established guidelines on performing stress testing on a treadmill. Master's Step Test (1955) was also accepted as a method for stress testing. Another method used today is the bicycle ergometer test. However, the treadmill seems to be the choice for testing cardiac status. With the treadmill stress test, the work rate is changed every 3 minutes for 15 minutes by increasing the speed slightly and the degree of incline (grade) by three percent each time (3 percent, 6 percent, 9 percent, etc.). The body muscles do not seem to tire with the treadmill method as much as leg muscles (quadriceps) tire with the bicycle ergometer.

The uses for the stress/exercise test include: screening for coronary artery disease, evaluating the work capacity of cardiac patients, and developing a cardiac rehabilitation program.

Nursing Implications:

1. Explain the purpose of the test.
2. Explain the test procedure:

a. consent form should be explained and signed by the patient

b. no food or liquids 2-3 hours before the test; Breakfast should be light, no foods with caffeine, alcohol, etc. Usually the patient is requested not to smoke prior to the test.

c. All regular medications should be given unless contraindicated or unless held by the physician.

d. The patient should wear comfortable clothes and suitable shoes or sneakers, most hospital slippers will not be adequate.

e. Electrodes will be placed on patient's chest and/or back. The area will be cleansed and sanded slightly for proper electrode placement.

f. A baseline ECG, pulse rate, and blood pressure will be taken, then monitored throughout the test.

3. Ask patient not to lean on the rails of the treadmill or the handles of the bicycle

4. The test will continue for about 15 minutes or until pulse parameters have been reached. Emergency stopping of the test will occur only if severe symptoms are seen.

5. Teaching--Although the rate of having an MI during a stress test is low (0.2%), have patient report chest pain, dyspnea, or severe fatigue.

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EXAMINATION BOOKLET

LAB TESTS INTERPRETATION

Please read the instructions carefully
before taking this examination.

Return only the Answer Sheet for grading.
(do not return this booklet)

LABORATORY TESTS INTERPRETATION
PRETEST-POSTTEST

Please use pencil or black pen on the answer sheet provided. Always keep a copy of your answers for future reference. Read ALL the choices carefully. Sometimes, ALL of the choices may be considered correct, but there is ***only one best answer*** for each question. Return only the answer sheet for grading. Do not send us pretest results. The pretest is for your own benefit. Pretest and posttest is the same test below.

Chapter I Questions:

1. A diagnostic test is any inquiry into a _____ condition.

A. laboratory B. pathological C. viral D. bacterial E. benign

2. In this text, we will use "diagnostic test" to refer to the _____ studies involving more than just analyzing blood.

A. more sophisticated B. physical assessment C. clinical D. viral

3. The nurse should always keep in mind that normal values should be considered only as _____ of what is normal or abnormal.

A. guidelines B. borderline C. confirmation D. theoretical

4. Based on the statistical definition of normal, _____ of independent test results will be outside this normal range (of test results).

A. 5% B. 12% C. 20% D. 25% E. 50%

5. Special notations should be made on the lab request form such as_____.

A. time B. IV infusion C. source D. relations to meals E. a, b, c, d

Chapter II questions

6. _____ may occur due to prolonged tourniquet constriction.

A. hemodilution B. hemoconcentration C. hemostasis

7. The quantity of the sample usually dictates the method of _____.

A. evaluation B. collection C. reporting results D. normal value

8. Avoid drawing blood in an extremity used for infusing _____.

A. glucose B. NaCl C. IV fluids D. blood E. medications

9. After 20 minutes of strenuous exercise, serum _____ is decreased by about 8%.

A. albumin B. sodium C. potassium D. ALT E. SGPT

10. This lab test may be affected by patient posture:

A. sodium B. potassium C. cholesterol D. SGOT E. SGPT

Chapter III Questions

11. Fetal Hb, HbF, constitutes _____ of Hb in a newborn.
A. 5% B. 25% C. 2-03-% D. 50-90% E. none of these

12. This test is used to detect normal and abnormal types of hemoglobin:
A. HbF B. HB trait C. HB-HCT D. Hb electrophoresis

13. This test is the volume of the average RBC:
A. MCH B. MCV C. MCHC D. MCHV E. Retic

14. MCHC can be useful for the diagnosis of conditions which are not dependent upon the number of _____.
A. Retics B. RBC's C. platelets D. WBC's E. neutrophils

15. The sickle cell test, also called _____, is used to detect sickle cells.
A. Hb S B. HCT C. TIBC D. Sic T E. Hb T

16. Increased serum Ferritin levels may indicate acute _____ disease.
A. hepatic B. anemia C. sickle cell D. cardiac E. viral

17. The blood sample for the ESR test must be examined within _____.
A. 2 hours B. 12 hours C. 24 hours D. 48 hours E. 72 hours

18. This is a lab test that counts actual numbers of different types of WBC's:
A. HCT B. MCV C. MCHC D. retic count E. diff

19. In order to interpret the WBC and differential, the nurse must consider the relative and the _____ values of the differential.
A. normal B. ionic C. pathological D. absolute E. interpreted

20. Basophils are increased by:
A. ulcerative colitis B. trauma C. pregnancy D. hepatitis E. SLE

21. Monocytes are increased by:
A. herpes B. lymphomas C. stress D. shock E. burns

22. Fibrinogen plus factor 8, plus Thrombin yields:
A. prothrombin B. thromboplastin C. a clot D. a platelet

23. Many medications will decrease platelet count, these are:

A. antimony/gold salts C. thiazide
B. isoniazid D. sulfonamides/methyldopa E. all of these

24. The PTT will usually detect deficiencies in all clotting factors except:
A. factor 4 B. factors 6&7 C. factor 8 D. factors 7&8 E. none of these

25. The ____ test has the ability to exactly pinpoint the defect in clotting.
A. TGT B. PTT C. PT D. Bleeding Time E. Pro Time

Chapter IV Questions

26. Enzymes are proteins in the body and they act as _____.
A. buffers B. catalysts C. proteins D. isoenzymes E. antibiotics

27. The main cardiac enzymes are CPK, LDH, and _____.
A. PTT B. AAS C. SGOT D. SGPT E. none of these

28. Isoenzymes of LDH that appear primarily in the heart are LD1 and:
A. LDH-3 B. LD4 C. LD5 D. LD-4 E. LD2

29. Narcotic drugs and _____ can elevate serum LDH (and other enzyme) levels.
A. antibiotics B. IV infusions C. stress D. Im injections

30. The ingestion of alcohol and _____ could also cause (enzyme) elevations.
A. trauma B. antibiotics C. food D. vitamins

31. The Myoglobin test is often used to help ____results of cardiac enzyme tests.
A. report B. confirm C. obtain D. determine

32. _____ is the major cation in the extracellular fluid in the body.
A. potassium B. chloride C. sodium D. acid phosphatase

33. Cardiac arrhythmias and _____ disturbances are seen with high or low levels of potassium electrolyte.
A. muscle B. renal C. GI D. vascular E. neurological

34. Increased serum osmolality is associated with _____.
A. overhydration B. excessive fluid intake C. hypoglycemia D. dehydration

35. Plasma ammonia levels may help indicate the severity of _____ damage.
A. hepatocellular B. kidney C. hepatosplenic D. messenteric

36. _____ levels are directly related to glomerular filtration rate. Therefore, this test will be used to assess renal damage.

A. Creatine B. Creatinine C. Ammonia D. AST E. ESP

37. Comparison test performed on whole blood in order to ensure compatibility of transfused blood:

A. Rh compatibility B. crossmatch C. blood typing D. RBC count

Chapter V Questions

38. Turbidity and other terms are used to characterize the _____ of urine.

A. acidity B. odor C. appearance D. color E. specific gravity

39. ___ amount of protein should be excreted into the urine in 24-hour period.

A. very large B. large C. moderate D. very small

40. ____ are solid, formed elements which appear in the urine, secondary to some other type of cell destruction.

A. casts B. veriforms C. cells D. membranes E. mucus

41. (Urinary) calculi commonly form in the _____ and pass into the ureter.

A. bladder B. urethra C. ureter D. bloodstream E. kidney

42. Normal CSF fluid pressure is _____ mm H2O.

A. 10-20 B. 40-80 C. 80-100 D. 100-200 E. 200-250

43. The main pathologies occur when the CSF glucose is _____ than normal.

A. much higher B. moderately higher C. lower D. none of these

44. Some disorders which can cause an increase in (CSF) protein, can also cause an increase in the _____ as well.

A. RBC count B. WBC count C. platelets D. Hb S E. Hb F

45. Many times when the blood serology test is negative, the CSF test is positive; and example of this is:

A. tertiary syphilis B. HIV infection C. AIDS D. early syphilis

46. Low (CSF) soluble amyloid beta protein precursor levels correlate with:

A. AIDS B. syphilis C. diabetes D. cancer E. Alzheimer's disease

Chapter VI Questions

47. The indirect bilirubin is _____ accurate than the direct bilirubin test.

A. less B. more C. much less D. none of these

48. The SGPT enzyme test is used to help diagnose an MI, but the highest levels of this enzyme are seen in _____ disease.
A. kidney B. splenic C. liver D. infectious E. HIV

49. Which is the stronger of the thyroid hormones?
A. T3 B. T2 C. T4 D. thyrotoxin E. Levotoxin

50. In the blood, iodine is not a free molecule, but rather it is bound to:
A. glucose B. protein C. RBC's D. WBC's E. hemoglobin

51. A low concentration of PBI in blood, indicates:
A. infection B. Hypothyroidism C. hyperthyroidism D. anemia

52. Prior to AML test, be sure to withhold drugs that elevate results, such as:
A. tylenol B. vitamins C. aspirin D. thyroid drugs

53. High Lipase levels suggest pancreatic duct obstruction or acute:
A. hepatitis B. infection C. pancreatitis D. none of these

Chapter VII Questions

54. Most standard tests for syphilis depend upon the syphilis antibody:
A. agglutinin B. opsonins C. HIV antibody D. Kline E. Reagin

55. This is the most specific test for syphilis.
A. VDRL B. TPCF C. Kolmer test D. Kline test E. Kahn test

56. The Compliment-Fixation test is used to help diagnose mycotic infections and:
A. rickettsial infections B. viral infections C. malignancies

57. The CRPA test is used to help diagnose the MI and:
A. HIV B. all viruses C. mononucleosis D. rheumatoid arthritis

58. Prior informed consent (for HIV testing) is usually not needed for:
A. anonymous testing B. military personnel C. prisoners D. all of these

59. Some (HIV) testing sites give a repeat ELISA test or they may be given the:
A. Agglutination B. Kline C. Western Blot D. all of these

60. The Viral Load test measures the _____ of HIV virus in the blood.

A. strength B. amount C. susceptibility D. virulence

61. The blood for a viral load test should not be drawn within 4 weeks of a (an):
A. HIV test B. Lipase test C. Flocculation test D. immunization

62. The T-cells called: T-4 cells and also called CD4+ cells, are also called:
A. suppressor cells B. infection cells C. helper cells

63. The T-cell value bounces around a lot; _____ can affect the test results.
A. aspirin B. antibiotics C. stress D. meals E. none of these

64. When CD4+ count goes below _____ most doctors begin antiviral drugs.
A. 500 B. 750 C. 1,000 D. 5,000 E. 10,000

Chapter VIII

65. The ABG analysis is mainly used to evaluate _____ in the lungs.
A. gas exchange B. pH C. hypoxemia D. acidosis

66. ____ is the term which refers to the condition of excessive bicarbonate ions.
A. hyperkalemia B. alkalemia C. hypokalemia D. hypoxemia

67. Normal (arterial) blood pH is:
A. 7.00 B. 7.40 C. 7.55 D. 7.80 E. 7.005

68. Hyperventilation causes the body to exhale, and "get rid of" _____ from the blood, through the lungs.
A. fluids B. O2 C. RBC's D. carbon ions E. CO2

69. Respiratory alkalosis can be reversed by merely stopping the _____.
A. IV infusion B. stress C. hypoventilation D. hyperventilation

70. Respiratory acidosis might be caused by:
A. hyperventilation B. CNS stimulation C. anxiety D. CNS depression

71. Metabolic Alkalosis can be caused by:
A. steroid therapy B. nausea C. renal failure D. shock

72. The normal PO2 (partial pressure of oxygen) is _____ mm Hg.
A. 25-50 B. 80-100 C. 90-120 D. 75 E. none of these

73. The SO2 value (oxygen saturation of the blood) is defined as the extent to which oxygen saturates the _____.

A. hemoglobin B. WBC's C. RBC's D. cells of the body

74. A patient is hyperventilating causing alkalosis; the kidneys respond by:

A. conserving HCO3; thus restoring pH to normal
B. excreting HCO3; thus restoring pH to normal

75. Since the body's own defense mechanism (in compensation) will last just a short time, the nurse must look for and accurately report _____.

A. results B. comments C. ABG's D. pH E. symptoms

Chapter IX Questions

76. Histology is the study of the microscopic structure of tissues and _____.

A. blood B. tumors C. cells D. biopsies

77. Frozen sections may provide results in 10-15 minutes, however, they are not:

A. large enough B. standardized C. consistent D. reliable

78. Tissue scraping is a type of _____ test.

A. blood B. biopsy C. histological D. cytological E. none of these

79. Cell-washing is performed by instilling a solution into:

A. bronchial tree B. esophagus C. stomach D. all of these

80. Stereotactic breast biopsy immobilizes the breast and allows the computer to calculate the exact _____ of the mass.

A. location B. size C. make-up D. contents E. all of these

81. After the ultrasound-guided core biopsy, the nurse should apply pressure for:

A. 10 minutes B. 20 minutes C. 30 minutes D. no pressure needed

82. Closed (lung biopsy) technique is performed under _____ anesthesia.

A. twilight B. local and then general C. general D. local

83. Open (lung biopsy) technique is performed under _____ anesthesia.

A. twilight B. local and then general C. general D. local

84. Lymph node biopsy is the surgical excision of a (an) _____ lymph node.

A. deep B. active C. superficial D. enlarged E. none of these

85. Lymphatic cancer accounts for up to _____ of all cancers.

A. 1 percent B. 5 percent C. 15 percent D. 50 percent

86. Today, he is referred to as the “father” of modern cytology:
A. Dr. Lister B. Dr. Cyto C. Dr Papanicolaou D. Dr. Spock

87. The Pap Smear is known as a _____ test for cervical cancer.
A. tissue B. cytological C. biopsy D. surgical E. none of these

88. The RAIU test measures the amount of _____ that accumulates in the thyroid.
A. blood B. ions C. T3 D. iodine 123 E. all of these

89. Some facilities may perform another test at the same time (as RAIU) this is:
A. thyroid scan B. T3 C. T4 D. Hb T E. none of these

90. The following factors may increase iodine uptake (RAIU): phenothiazines and:
A. age B. hydration C. iodine-deficient diet D. stress

91. The gallium scan is a _____ scan used to assess certain neoplasms.
A. total-body B. localized C. organ D. radioactive iodine

92. Angiography is an invasive procedure and carries risks similar to those of the _____ patient.
A. infectious B. elderly C. pediatric D. medical E. surgical

93. With coronary arteriography, dye is injected directly into the coronary arteries; with angiocardiography, the dye is injected into the _____.
A. heart B. coronary vessels C. pulmonary vessels D. all of these

94. One of the (rare but serious) complications of cardiac catheterization is:
A. shock B. Abdominal aneurism C. MI D. pneumothorax

95. After the cardiac catheterization, nursing implications include:
A. peripheral pulses below

insertion site
C. Blood Pressure Q2h
B. bedrest for 2 hours
D. NPO for 12 hours

96. Gastric analysis is accomplished by a _____ inserted into the stomach.
A. Blakemore tube B. nasogastric tube C. Linton tube

97. Observe for any adverse reactions to the gastric stimulants (if administered for gastric analysis), such as dizziness, flushing, or _____.
A. nausea B. headache C. vomiting D. leg pain E. hypertension

98. Expiratory reserve volume is the ____ amount of air that can be exhaled after normal breathing.
A. normal B. minimum C. maximal D. none of these

99. Prior to PFT's, the nurse should note and record which of the following:
A. last IPPB B. oral bronchodilators used C. dyspnea D. all of these

100. The uses for the stress/exercise test include screening for:
A. coronary artery disease B. GI disorders C. infectious diseases

STOP! END OF TEST