CPOE: Order Entry for Diagnostic Tests
Part 1 Reading Assignment
**HOW TO USE THIS BOOK**

Follow your syllabus. This book is for the sole purpose of training students enrolled in the CPOEP Program through the AIHC eLearn or Training Camp teaching methods. This book is not available for sale and is protected under copyright.

First Edition Original Publishing Date: June, 2014
Latest Revision: January 2017

Contact Us

Mail: American Institute of Healthcare Compliance, Inc.
5000 Gateway Drive, Suite 202, Medina Ohio 44256

Phone Toll Free: 866-571-5635
Local Calls (Cleveland/Akron, Ohio): 330-241-5635
Fax: 330-952-0716

Copyright © June 2014-2019 - American Institute of Healthcare Compliance, Inc. (AIHC) All Rights Reserved. No portion of this text may be reproduced without permission from the American Institute of Healthcare Compliance. The information in this book is intended as educational only and should not be used as consulting or legal advice.

Preparing for

CPOEP
Computerized Physician Order Entry
# Table of Contents

## Chapter 1: General Compliance Standards and the Certified Provider Order Entry Professional
- Qualifications of a Certified Provider Order Entry Professional 2
- Government Rules on Authentication – Electronic Signatures 2

## Chapter 2: Introduction to Order Entry
- Medicare: Overview of Diagnostic Tests and Order Guidelines 10

## Chapter 3: Basic Elements of Diagnostic Laboratory Services
- Entering Orders for Diagnostic Lab: The Laboratory Order or Requisition 15
- Commonly Ordered Laboratory Tests 16
- Common Abbreviations and Acronyms 26

## Chapter 4: Basic Elements of Radiology Order Entry
- Entering Orders for Radiology Tests or Procedures 43
- Understanding Terminology 51
- Interpreting and appropriately using Abbreviations 53

## Chapter 5: Other Diagnostic Tests
- Entering Orders for Diagnostic Tests or Procedures 58
Chapter 1: General Compliance Standards and the Certified Provider Order Entry Professional

Qualifications of a Certified Provider Order Entry Professional

Compliance to state, Centers for Medicare and Medicaid Services (CMS) and other Federal regulations is important to ensure patient safety and uphold standards and best practices of medicine. Those entering medication and diagnostic test orders should always be working under the direct supervision of the treating provider (physician, nurse practitioner, physician assistant, etc.) and possess experience using clinical judgment with ability to query the ordering provider for clarification or correction of an order.

When entering an order, be sure to Get It Right!

- Right Patient Medication File in the Electronic Health Record (EHR) system;
- Right Order for the right patient;
- Right Medication for the right patient;
  - Right Route of Administration
  - Right Dosage
  - Right Frequency

Government Rules on Authentication – Electronic Signatures

After entering an order into an electronic system, you will be required to authenticate your entry. Medicare requires services provided/ordered be authenticated by the author. The signature for each entry must be legible and should include the practitioner’s first and last name. For clarification purposes, we recommend you include your applicable credentials. After your certification, you will be able to enter “CPOEP” after your name.

Not all orders for diagnostic tests are required to be signed by the ordering physician. The rules in 42 CFR 410 and Pub.100-02 chapter 15, §80.6.1 state that if the order for the clinical diagnostic test is unsigned, there must be medical documentation (e.g., a progress note) by the treating physician that he/she intended the clinical diagnostic test be performed.

The documentation indicating the intent of the test to be performed must be authenticated by the qualified provider or author via a handwritten or electronic signature. However, medication orders, verbal orders, and other circumstances will require your authentication of the entry and the physician (or NPP – non-physician provider) electronic signature as well. If your entry is made within a progress note, your entry should be identified by your authentication and the physician’s signature signing off on the progress note visit will support agreement of your entry within the note.

Other regulations and the CMS instructions regarding conditions of payment related to signatures (such as timeliness standards for particular benefits) take precedence. For medical review purposes, if the relevant regulation, NCD (National Coverage Determination), LCD (Local Coverage Determination) and CMS manuals are silent on whether the signature needs to be legible or present and the signature is
illegible/missing, the reviewer shall follow the guidelines listed below to discern the identity and credentials (e.g., MD, RN, etc.) of the signator. In cases where the relevant regulation, NCD, LCD and CMS manuals have specific signature requirements, those signature requirements take precedence.

The purpose of a rendering/treating/ordering practitioner’s signature in patients’ medical records, operative reports, orders, test findings, etc., is to demonstrate that services submitted for payment have been accurately and fully documented, reviewed and authenticated. Furthermore, it confirms the provider has certified the medical necessity and reasonableness for the service(s) submitted for payment consideration.

**Electronic or Digital Authentication**

Electronic signatures usually contain date and timestamps and include printed statements (e.g., 'electronically signed by' or 'verified/reviewed by') followed by the practitioner’s name and preferably a professional designation. Note that the responsibility and authorship related to the signature should be clearly defined in the record.

Digital signatures are an electronic method of a written signature that is typically generated by special encrypted software.

Unacceptable Signature Examples:

- 'Signing physician' when provider’s name is typed
  
  Example: Signing physician: ____________________________
  
  John Smith, M.D.

- 'Confirmed by' when a provider’s name is typed
  
  Example: Confirmed by: ____________________________
  
  John Smith, M.D.

- 'Signed by' followed by provider’s typed name with the signing line above, done as part of the transcription

- 'This document has been electronically signed in the surgery department' with no provider name

- 'Dictated by' when provider’s name is typed
  
  Example: Dictated by: ____________________________
  
  John Smith, M.D.

- 'Signature On File'

- 'Filled By'

- 'Electronically signed by agent of provider'
Electronic Authentication

Providers using electronic systems need to recognize that there is a potential for misuse or abuse with alternate signature methods.

For example, providers need a system and software products that are protected against modification, etc., and should apply adequate administrative procedures that correspond to recognized standards and laws.

The individual whose name is on the alternate signature method and the provider bear the responsibility for the authenticity of the information for which an attestation has been provided. Physicians are encouraged to check with their attorneys and malpractice insurers concerning the use of alternative signature methods.

When a government contractor (such as a Medicare Administrative Contractor, Zone Program Integrity Contractor, etc.) audits an encounter for compliance, the contractor will review the authentication of the note first, before proceeding to a review of the content of the note.

Audit your own procedures – using these suggested steps:

1) Review the documentation to identify the credentials of the order entry person to ensure the order is supported by an adequately credentialed order entry person and also authenticated by an appropriately credentialed provider.

2) Ability to produce system documentation that the electronic medical record has security features which “locks” the record once authenticated.
   a. Appropriate security features will not permit “auto-authentication” or “auto-signature” prohibiting the provider or order entry professional to review an entry before signing.
   b. Removing auto-stamps making a statement that the entry has been signed but not read (which is not acceptable).

3) Have your HIPAA Security Officer conduct and document Security Risk Analysis on your electronic record system to verify compliance to HIPAA Security rules.

4) Your hospital, clinic or physicians are encouraged to check with their attorneys and malpractice insurers in regard to the use of alternative signature methods for additional legal oversight and advice.

Reference: You can find complete signature requirement regulations in the Centers for Medicare and Medicaid Services (CMS) Internet-Only Manual, Publication 100-08, Chapter 3, Section 3.3.2.4.
Chapter 2: Introduction to Order Entry

Defining the Electronic Health Record

Entering an order into an electronic system is accepting a high level of responsibility requiring clinical judgment, competency and accuracy.

When an order is entered into a medical record (regardless of whether it is a paper or electronic record), you are making an entry into a legal document.

The following information is taken from the government website HealthIT.gov which provides guidelines for defining the legal health record.

A patient’s health record plays many roles in addition to those involved in caring for a patient where documentation of the patient’s health history, health status (sickness and wellness), observations, measurements, and prognosis are recorded. This documentation allows the record to serve as the legal record substantiating healthcare services provided to the patient. It also serves as a method of communication among healthcare providers caring for a patient and provides supporting documentation for reimbursement of services provided to a patient. The legal health record is a subset of the entire patient database, which serves as the legal business record for the organization. The roles of the legal health record are to:

- Support the decisions made in a patient’s care
- Support the revenue sought from third-party payers
- Document the services provided as legal testimony regarding the patient’s illness or injury, response to treatment, and caregiver decisions

There is no one-size-fits-all definition of the legal health record. Laws and regulations governing the content vary by practice setting and state. However, there are common principles to be followed in creating a definition.
Definition of the Legal Health Record

The legal health record is generated at or for a healthcare organization as its business record and is the record that will be disclosed upon request. It does not affect the discoverability of other information held by the organization. The custodian of the legal health record is the health information manager (HIM) in collaboration with information technology personnel. HIM professionals oversee the operational functions related to collecting, protecting, and archiving the legal health record. Information technology (IT) staff manages the technical infrastructure of the electronic health record.

The legal health record is the documentation of healthcare services provided to an individual during any aspect of healthcare delivery in any type of healthcare organization.

It is consumer or patient centric. The legal health record contains individually identifiable data, stored on any medium, and collected and directly used in documenting healthcare or health status. Legal health records must meet accepted standards as defined by applicable Centers for Medicare and Medicaid Services Conditions of Participation, federal regulations, state laws, and standards of accrediting agencies such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), as well as the policies of the healthcare provider.

Legal health records are records of care in any health-related setting used by healthcare professionals while providing patient care service or for administrative, business, or payment purposes. Some types of documentation that comprise the legal health record may physically exist in separate and multiple paper-based or electronic or computer-based databases.

The Legal Hybrid Health Record

When the legal health record consists of information created as paper documents and information created in electronic media, it is considered to be in a hybrid environment. Organizational policies should document the information that is considered the legal health record and identify the source (paper or electronic) of that information. A matrix can be used for this purpose.

Policies should also indicate when the record is considered complete. The hybrid record transition plan and policy should define the “legal source of truth,” reflecting whether the legal record is paper, hybrid, or fully electronic. This policy provides for a specific schedule that provides both retrospective and prospective dates wherein the user can identify the source legal record.

- The paper portion of the legal health record is collected and archived in paper or plastic folders.
- Electronic portions of the record are collected and archived in source systems or in electronic folders in the EHR system. There must be a clear indication of the locations where portions of a patient record are located.

Electronic versus Legal Health Records

An electronic health record (EHR) system is generally thought of as the portal through which clinicians access a patient’s health record, order treatments or therapy, and document care delivered to patients. Many healthcare providers have eliminated the paper record and use EHR systems as their
organizations’ legal records (although a paper record may be “published” for release of information purposes). Many other organizations are planning a similar transition.

EHR systems allow providers to gather multiple types of data about a patient (e.g., clinical, financial, administrative, and research).

Healthcare informaticists agree that an EHR system is not one or even two or more products. Rather, an EHR system consists of a plethora of integrated component information systems and technologies. The electronic files that make up the EHR system’s component information systems and technologies consist of different data types, and the data in the files consist of different data formats.

**Data Formats of the EHR**

Some data formats are structured and some are unstructured. For example, the data elements in a patient's automated laboratory order, result, or demographic and financial information system are coded and alphanumeric. Their fields are predefined and limited. In other words, the type of data is discrete, and the format of these data is structured.

Consequently, when healthcare professionals search a database for one or more discrete data elements based on the search parameters, the engine can easily find, retrieve, and manipulate the element. However, the format of the data contained in a patient's transcribed radiology or pathology result, history and physical or clinical note system using word-processing technology is unstructured. Free-text data, as opposed to discrete, structured data, are generated by word processors, and their fields are not predefined and limited. Consequently, when a healthcare professional searches unstructured text, the search engine cannot easily find, retrieve, and manipulate one or more data elements embedded in the text.

Likewise, the format of the data contained in a patient's dictated radiology or pathology result, history and physical or clinical note system using speech recognition technology (real-time speech in, text out) is unstructured. However, the speech recognition technology's engine takes the unstructured, free-text speech data and codifies the data, often with the help of templates. Hence, the format of the outputted text data becomes structured, with predefined and limited fields. Search engines then easily can find, retrieve, and manipulate one or more data elements embedded in the text.

Diagnostic image data stored in a diagnostic image management system, such as a picture archiving and communications system, represent a different type of data: bit-mapped data. However, the format of bit-mapped data is also unstructured. Saving each bit of the original image creates the image file. In other words, the image is a raster image, the smallest unit of which is a picture element or pixel. Together, hundreds of pixels simulate the image.

Examples of digital modalities that generate digital diagnostic image data are digitized x-rays or computed radiography and computed tomography, magnetic resonance, and nuclear medicine scans. Most diagnostic image data remain based on analog, photographic films, such as analog x-rays. To digitize these data, these analog films must be digitally scanned, using film digitizers.
Document image data are yet another type of data; document image data are bit mapped, and the format is unstructured. These data are stored in an electronic document management system. These data are based on analog paper documents or on analog photographic film documents.

Most often, analog paper-based documents contain handwritten notes, marks, or signatures. However, such documents can include preprinted documents (such as forms), photocopies of original documents, or computer-generated documents available only in hard copy. Analog photographic film-based documents are processed using an analog camera and film, similar to analog x-rays. Therefore, both the analog paper-based and the photographic film-based documents must be digitally scanned, using scanning devices that are similar to fax machines.

The EHR system's component information systems and technologies consist of additional data types, the formats of which also are unstructured. Real audio data consist of sound bytes, such as digital heart sounds.

Motion or streaming video or frame data, such as cardiac catheterizations (cine), consist of digitized film attributes, such as fast forwarding. The files that consist of vector graphic (or signal-tracing) data are created by saving lines plotted between a series of points, accounting for the familiar ECGs, EEGs, and fetal traces.

As such, portions of the legal EHR may be located in various electronic systems. These input systems may include laboratory information systems, pharmacy information systems, picture archiving and communications systems (PACS), cardiology information systems, results reporting systems, computerized provider order entry systems, nurse care planning systems, word-processing systems, and fetal trace monitoring systems.

Depending on their size and structure, healthcare providers may store structured clinical and administrative data in a database or clinical data repository. In addition, healthcare providers may store unstructured patient clinical data in separate databases or repositories (e.g., PACS archive, fetal trace archive) and provide pointers from the clinical portal to these various repositories. In this manner, architecturally, these databases are logically but not physically linked.

Defining the Subset of Data that Constitutes the Legal EHR

The challenge for HIM professionals in defining a legal health record in an EHR system is to determine which data elements, electronic-structured documents, images, audio files, and video files become a part of the legal electronic health record.

• The first step is to determine what legal entities enforce regulations, guidelines, standards, or laws to the healthcare organization defining its legal health record. Although these various entities may have defined a legal record in paper terms (e.g., requiring a medication sheet rather than an electronic medication administration record), these entities’ definitions must become the basis for the legal health record definition at the organization.

• The second step is to determine whether the records are created in the ordinary course of business of the healthcare provider or entity.
• The third step is creating a matrix (or other document) that defines each element in the legal health record. Such a matrix could include a column indicating whether that particular element would be released on first request or subpoena.

Considerations for Defining the Legal Health Record for Legal Purposes

As stated previously, there is no one-size-fits-all definition of the legal record because laws and regulations governing the content vary by practice setting and by state. However, there are common principles to be followed in creating a definition. This section addresses health record issues to assist healthcare organizations in defining the content of their legal records. Final definition of the legal health record rests with individual healthcare organizations and their legal counsels.

Alerts, Reminders, and Pop-Ups

Alerts, reminders, pop-ups, and similar tools are used as aides in the clinical decision-making process. The tools themselves are not considered part of the legal health record; however, associated documentation is considered a component. For example, a provider is alerted to perform a diabetic foot exam on a diabetic patient. The initial alert that prompts the provider is not part of the legal health record, but the subsequent action taken by the provider, including the condition acted upon and the associated note detailing the exam, is considered part of the record.

Similarly, any annotations, notes, and results created by the provider as a result of an alert, reminder, or pop-up are also considered part of the legal health record. Once the documentation, results, and graphs have been entered in an electronic manner, those alerts acted upon and results become a permanent part of the record and are maintained in a manner similar to any other information contained within the legal health record.

Data and Documents to Be Considered Part of the Record

• Advance directives
• Allergy records
• Alerts and reminders (see “Alerts, Reminders, and Pop-Ups,” above)
• Analog and digital patient photographs for identification purposes only
• Anesthesia records
• Care plans
• Consent forms for care, treatment, and research
• Consultation reports
• Diagnostic images
• Discharge instructions
• Discharge summaries
• E-mail messages containing patient-provider or provider-provider communications regarding care or treatment of specific patients
• Emergency department records
• Fetal monitoring strips from which interpretations are derived
• Functional status assessments
• Graphic records
• History and physical examination records
• Immunization records
• Instant messages containing patient-provider or provider-provider communications regarding care or treatment of specific patients
• Intake and output records
• Medication administration records
  • Medication orders
  • Medication profiles
• Minimum data sets (MDS, OASIS, IRF PAI)
• Nursing assessments
• Operative and procedure reports
  • Orders for treatment including diagnostic tests for laboratory and radiology
    • Pathology reports
    • Patient-submitted documentation
    • Patient education or teaching documents
    • Patient identifiers (medical record number)
    • Photographs (digital and analog)
    • Post-it notes and annotations containing patient-provider or provider-provider communications regarding care or treatment of specific patients
    • Practice guidelines or protocols and clinical pathways that imbed patient data
    • Problem lists
    • Progress notes and documentation (multidisciplinary, excluding psychotherapy notes)
    • Psychology and psychiatric assessments and summaries (excluding psychotherapy notes)
    • Records received from another healthcare provider if they were relied on to provide healthcare to the patient (see “Continuing Care Records,” above)
    • Research records of tests and treatments
    • Respiratory therapy, physical therapy, speech therapy, and occupational therapy records
    • Results of tests and studies from laboratory and radiology
  • Standing orders
    • Telephone messages containing patient-provider or provider-provider communications regarding care or treatment of specific patients
  • Telephone orders
  • Trauma tapes
  • Verbal orders
  • Wave forms such as ECGs and EMGs from which interpretations are derived
  • Any other information required by the Medicare Conditions of Participation, state provider licensure statutes or rules, or by any third-party payer as a condition of reimbursement

Medicare: Overview of Diagnostic Tests and Order Guidelines

Clinical laboratory services involve the biological, microbiological, serological, chemical, immunohematological, hematological, biophysical, cytological, pathological, or other examination of materials derived from the human body for the diagnosis, prevention, or treatment of a disease or assessment of a medical condition.
Clinical laboratory services must be ordered and used promptly by the physician or by a qualified non-physician practitioner (NPP) who is treating the beneficiary.

Medicare provides the following definitions to remember:

**Diagnostic Test:** A “diagnostic test” includes all diagnostic x-ray tests, all diagnostic laboratory tests, and other diagnostic tests furnished to a beneficiary.

**Treating Physician:** A “treating physician” is a physician who furnishes a consultation or treats a beneficiary for a specific medical problem, and who uses the results of a diagnostic test in the management of the beneficiary’s specific medical problem. A radiologist performing a therapeutic interventional procedure is considered a treating physician. A radiologist performing a diagnostic interventional or diagnostic procedure is not considered a treating physician.

**Treating Practitioner:** A “treating practitioner” is a nurse practitioner, clinical nurse specialist, or physician assistant who furnishes, pursuant to State law, a consultation or treats a beneficiary for a specific medical problem, and who uses the result of a diagnostic test in the management of the beneficiary’s specific medical problem.

**Testing Facility:** A “testing facility” is a Medicare provider or supplier that furnishes diagnostic tests. A testing facility may include a physician or a group of physicians (e.g., radiologist, pathologist), a laboratory, or an independent diagnostic testing facility (IDTF).

**Order:** An “order” is a communication from the treating physician/practitioner requesting that a diagnostic test be performed for a beneficiary. The order may conditionally request an additional diagnostic test for a particular beneficiary if the result of the initial diagnostic test ordered yields to a certain value determined by the treating physician/practitioner (e.g., if test X is negative, then perform test Y).

An order may be delivered via the following forms of communication to you to be entered into the electronic health record of the testing facility:

- A written document signed by the treating physician/practitioner, which is hand-delivered, mailed, or faxed to the testing facility.
- A telephone call by the treating physician/practitioner or his/her office to the testing facility.
- An electronic mail by the treating physician/practitioner or his/her office to the testing facility.
If the order is communicated via telephone, both the treating physician/practitioner or his/her office, and the testing facility must document the telephone call in their respective copies of the beneficiary’s medical records. While a physician order is not required to be signed, the physician must clearly document, in the medical record, his or her intent that the test be performed.

When an interpreting physician, e.g., radiologist, cardiologist, family practitioner, general internist, neurologist, obstetrician, gynecologist, ophthalmologist, thoracic surgeon, vascular surgeon, at a testing facility determines that an ordered diagnostic radiology test is clinically inappropriate or suboptimal, and that a different diagnostic test should be performed (e.g., an MRI should be performed instead of a CT scan because of the clinical indication), the interpreting physician/testing facility may not perform the unordered test until a new order from the treating physician/practitioner has been received.

Similarly, if the result of an ordered diagnostic test is normal and the interpreting physician believes that another diagnostic test should be performed (e.g., a renal sonogram was normal and based on the clinical indication, the interpreting physician believes an MRI will reveal the diagnosis), an order from the treating physician must be received prior to performing the unordered diagnostic test.

When Testing Facility Cannot Reach the Treating Provider

If the testing facility cannot reach the treating physician/practitioner to change the order or obtain a new order and documents this in the medical record, then the testing facility may furnish the additional diagnostic test if all of the following criteria apply:

- The testing center performs the diagnostic test ordered by the treating physician/practitioner.
- The interpreting physician at the testing facility determines and documents that, because of the abnormal result of the diagnostic test performed, an additional diagnostic test is medically necessary.
- Delaying the performance of the additional diagnostic test would have an adverse effect on the care of the beneficiary.
- The result of the test is communicated to and is used by the treating physician/practitioner in the treatment of the beneficiary.
- The interpreting physician at the testing facility documents in his/her report why additional testing was done.

**EXAMPLE:** The last cut of an abdominal CT scan with contrast shows a mass requiring a pelvic CT scan to further delineate the mass; a bone scan reveals a lesion on the femur requiring plain films to make a diagnosis.
The following applies to an interpreting physician of a testing facility who furnishes a diagnostic test to a beneficiary who is not a hospital inpatient or outpatient. The interpreting physician must document accordingly in his/her report to the treating physician/practitioner.

**Test Design**
Unless specified in the order, the interpreting physician may determine, without notifying the treating physician/practitioner, the parameters of the diagnostic test (e.g., number of radiographic views obtained, thickness of tomographic sections acquired, use or non-use of contrast media).

**Clear Error**
The interpreting physician may modify, without notifying the treating physician/practitioner, an order with clear and obvious errors that would be apparent to a reasonable layperson, such as the patient receiving the test (e.g., x-ray of wrong foot ordered).

**Patient Condition**
The interpreting physician may cancel, without notifying the treating physician/practitioner, an order because the beneficiary’s physical condition at the time of diagnostic testing will not permit performance of the test (e.g., a barium enema cannot be performed because of residual stool in colon on scout KUB; 170.5PA/LAT of the chest cannot be performed because the patient is unable to stand). When an ordered diagnostic test is cancelled, any medically necessary preliminary or scout testing performed is payable.

**Surgical/Cytopathology Exception**
This exception applies to an independent laboratory’s pathologist or a hospital pathologist who furnishes a pathology service to a beneficiary who is not a hospital inpatient or outpatient, and where the treating physician/practitioner does not specifically request additional tests the pathologist may need to perform. When a surgical or cytopathology specimen is sent to the pathology laboratory, it typically comes in a labeled container with a requisition form that reveals the patient demographics, the name of the physician/practitioner, and a clinical impression and/or brief history.

There is no specific order from the surgeon or the treating physician/practitioner for a certain type of pathology service. While the pathologist will generally perform some type of examination or interpretation on the cells or tissue, there may be additional tests, such as special stains, that the pathologist may need to perform, even though they have not been specifically requested by the treating physician/practitioner.

The pathologist may perform such additional tests under the following circumstances:

- These services are medically necessary so that a complete and accurate diagnosis can be reported to the treating physician/practitioner.

- The results of the tests are communicated to and are used by the treating physician/practitioner in the treatment of the beneficiary.

- The pathologist documents in his/her report why additional testing was done.
**EXAMPLE:** A lung biopsy is sent by the surgeon to the pathology department, and the pathologist finds a granuloma which is suspicious for tuberculosis. The pathologist cultures the granuloma, sends it to bacteriology, and requests smears for acid fast bacilli (tuberculosis). The pathologist is expected to determine the need for these studies so that the surgical pathology examination and interpretation can be completed and the definitive diagnosis reported to the treating physician for use in treating the beneficiary.

**Bibliography**

- HealthIT.gov
  - Guidelines for Defining the Legal Health Record for Disclosure Purposes
- Medicare Benefit policy manual 102 Chapter 15:
  - 80.1 - Clinical Laboratory Services
  - 80.6.1 - 80.6.5
- Medicare Program Integrity Manual
  - Chapter 3
- Social Security Act
  - Sections 1833 and 1861
Chapter 3: Basic Elements of Diagnostic Laboratory Services

Entering Orders for Diagnostic Lab: The Laboratory Order or Requisition

When reviewing the information for order-entry into the ePrescribing or EMR system, the following items should be included on the lab requisition (order):

- Patient 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.
- Location: inpatient, room, unit, outpatient, address.
- Patient's identification number, chart number, EMR ID number: this identification can be very useful for instance in the blood bank.
- 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.
- 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.
- 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.
- Possible diagnosis: essential for evaluating laboratory results and selecting appropriate methodology; (media selection in microbiology).
- 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.
- 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.

Accurately communicating the specific order is important.

The type of blood sample needed is very important. When the test ordered requires a blood specimen, 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.

Food Restrictions in the Order

There is usually no special diet requirement for most "routine" lab tests or procedures. However, be aware of tests that do require special food restrictions. Some tests require fasting prior to the test. Be sure to include any fasting instructions in the order, which might be “NPO” and how long the patient
should be fasting, if the patient is allowed to take medications only the morning of the test, water or nothing at all.

Also remember that some tests/procedures might require that the patient consume a light meal, a liquid meal, or other special diet.

**Commonly Ordered Laboratory Tests**

When a provider renders an order for a clinical laboratory test, the order serves to identify the type and collection of the specimen as well as the specific test result required to confirm or use as a basis of treatment for the patient.

Accurate recording of the test requisition is critical to ensure the appropriate specimen collection occurs to provide the correct results. Clinical laboratory services involve the biological, microbiological, serological, chemical, immunohematological, hematological, biophysical, cytological, pathological, or other examination of materials derived from the human body for the diagnosis, prevention, or treatment of a disease or assessment of a medical condition. What does this mean? Let’s look at each of these terms separately.

Biological is a word often used in a clinical setting meaning of or relating to biology or living organisms. Biology is the science of life. It includes their structure, functioning, evolution, distribution, and interrelationships.

Microbiological is in reference to microbiology. The word micro means "small" and bio mean "life" and loge mean "study". It is the branch of science that deals with the study of small critters such as bacteria, virus, protozoa, fungi, algae etc. You will also see the term “microbial” which is referring to a microscopic organism; commonly taken to mean a germ. A microbe is a minute life form.

Serological is a term used to describe serologic tests (laboratory techniques). Different types of serologic tests can be used to diagnose various health issues. Tests have one thing in common: they all focus on proteins made by the body’s immune system. This vital body system helps keep us healthy by destroying foreign invaders that can make us ill. It doesn’t matter what type of technique is used in the laboratory during serologic testing—the process for the patient is the same. Some antibodies are:

- agglutinins
- compliment-fixing
- hemagglutinins
- opsonins
- precipitins
- hemagglutinin inhibitors
- cytolysins
- hemolysins

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 comprehensively. 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.

**Orders for Cardiac Enzymes and Proteins**

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. 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:

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

All three of these isoenzymes make up the main enzyme CPK (creatine phosphokinase) (also called CK--creatinine 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:

- SGOT
- LDH (also called LD)
- CPK (also called CK)
**Serum electrolytes:** are mineral salts dissolved in water (the blood). The electrolytes are found throughout 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. Tests related to electrolytes may be:

- Sodium, (Na Serum)
- Potassium, (K+)
- Chloride, (Cl)
- Serum Osmolality
- Acid Phosphatase
- Ammonia Measures plasma levels of ammonia
- Creatinine

**Blood Groups and Transfusions:** There is an “ABO” blood type or grouping system. The ABO system is used clinically to type blood for transfusion, in order to assure compatibility. Blood typing may be ordered to determine the 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 identification 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 another. Blood typing then, categorizes blood in individuals according to these proteins (ABO).

- **Rh Determination** is testing for the Rh factor protein on the RBC, Red Blood Cell. 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. Testing helps detect a condition called 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.

- **Crossmatch** is a Comparison test performed on whole blood in order to ensure compatibility of transfused blood. Since there are many known and unknown antibodies in our blood, crossmatching 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 agglutination which might occur. Some of the above unknown antibodies may cause a reaction in the patient even though the blood has been shown to be compatible in the ABO and Rh systems. Therefore, the two blood specimens are mixed (crossmatched), and if a reaction occurs, there must be some other antigen on the RBC’s which is incompatible.
Additional Serology Tests

- **Syphilis**: There are several tests for syphilis. Most can be performed in the standard hospital laboratory with minimum of equipment. However, some tests will require special equipment. Most standard tests depend upon the syphilis antibody, Reagin, in order to test for positive results. 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, mononucleosis, collagen disease, and a few types of viruses. Tests for syphilis:
  - Flocculation test (also called: The Kline Test or The Kahn Test or VDRL (Venereal Disease Research Lab)) –
  - 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.
  - 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 presence in the body of antibodies for syphilis. This test is often performed in conjunction with tests similar to those above, in order to determine quantitative results in the reaction. It is also called the T. Pallidum compliment-fixation test (TPCF).
  - Fluorescent Antibody Test - It requires extensive amounts of equipment and time for the test. The principle of this test causes the antibodies to be labeled with fluorescent dye so as to detect syphilis.

Other Serological Tests

Serological examination is important for the diagnosis of other types of disorders as well as for syphilis. 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.

- **Bacterial Infections**: Antigens can readily be prepared for serological study from cultures of bacterial organisms. The most frequently used test is the agglutination test. This test takes the patient's serum with its antibodies and mixes it with a lab prepared solution of that killed disease organism. This test is used for all types of dysentery, tularemia, and brucellosis.
- **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.

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

- **Primary Atypical Pneumonia** - The cold hemagglutination test, and the antistreptococcus 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).
• 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 diagnosis.

• 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 indicated, mononucleosis is diagnosed.

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

• Inflammatory conditions- The *C-Reactive Protein Test, (CRPA)*, is a serological test for certain inflammatory diseases. C-protein is released when there is tissue inflammation or necrosis. Diseases such as these can give positive results:
  o rheumatoid arthritis
  o myocardial infarct
  o certain malignant diseases

• Rheumatoid Arthritis - The *Latex Agglutination test*, or called: the rheumatoid 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 rheumatoid arthritis, the entire mixture will agglutinate, clump, and positively diagnose the disease.

### Laboratory Testing for HIV

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, (*Enzyme-Linked Immunosorbent Assay*). The development of detectable antibodies to HIV (seroconversion) 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 determines whether or not the person's blood contains the antibodies to the HIV virus. At this time, it is the best method 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. 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.
**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, and then uses a chemical reaction to mark the virus. The markers are measured and used to calculate the amount of virus.
- 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 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.

**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.

**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.

**Viral Core Antigen Levels (p24):** Serum levels of the viral core antigen, p24, have been routinely used by clinicians to monitor disease progression.

**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.

**Virus in PBMC:** Viral load in PBMC can be measured; it is an indirect measure of viral replication, since only a small number of cells with provirus actively replicate HIV.

**Arterial Blood Gas Analysis (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). Terms used in connection with ABG’s:
• 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)

• Buffer System - combination of body systems that work to keep optimal acid-base balance

• Partial Pressure - the amount of pressure exerted by each gas in a mixture of gases

• PO2 - partial pressure of oxygen

• PCO2 - partial pressure of carbon dioxide

• PAO2 - partial pressure of alveolar oxygen

• PaO2 - partial pressure of arterial oxygen

• PACO2 - partial pressure of alveolar carbon dioxide

• PaCO2 - partial pressure of arterial carbon dioxide

• PVO2 - partial pressure of venous oxygen

• PvCO2 - partial pressure of venous carbon dioxide

• P50 - oxygen tension at 50% hemoglobin saturation

• Respiratory Acidosis - condition of lowered pH (acidosis) due to decreased respiratory rate (hypoventilation)

• Respiratory Alkalosis - condition of increased pH (alkalosis) due to increased respiratory rate (hyperventilation)

• 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.

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.

• **BSP, Bromsulphalein Test:** 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.
• **Serum Bilirubin:** This test is a measure of the bilirubin in the blood. 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.

• **Alkaline Phosphatase:** This is a liver enzyme test. Alkaline phosphatase (ALP) is produced in the liver and bone; it is also derived from the kidney, intestine, and placenta. In obstructive biliary disease, there is elevated serum ALP. 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 diagnosing cirrhosis. If a patient has bone disease, this test may be highly inaccurate, as ALP is also found in bone tissue.

• **SGOT, SGPT, LDH:** These enzymes are used to help diagnose liver disease (and also MI). 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.

• **Blood Ammonia level of ammonia in the plasma:** Ammonia is formed due to bacterial action in the intestines and by normal metabolism in all body tissues. 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 acidosis may also cause a temporary rise in plasma ammonia.

**Thyroid Function Tests**

The thyroid affects the following in our bodies:

- body metabolism and the amount of oxygen consumed
- speed of chemical reactions in the body
- 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:

- Triiodothyronine (T3) (T3 has 3 atoms of iodine)
- Levothyroxine (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.
• **BMR, Basal Metabolism Rate**: 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. 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.

• **PBI, Protein Bound Iodine Measures the amount of iodine in serum**: 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 synthesize 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.

• **Radioactive Iodine Uptake (RAI) (RAIU) (uses I131)**: 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 discomfort for the patient, it is certainly not dangerous to the staff, and the patient can eat soon after the material is ingested. Basic procedure at most facilities is:
  
  • NPO for 6-8 hours
  • Capsule or liquid is administered with the radioactive iodine (50-100 uC [micro Curie] )
  • Save urine, most hospitals will discard after 24-48 hours
  • Patient usually eats 1 hour after administering the dose
  • 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 thyroid itself. As the thyroid gland takes up the iodine, some iodine will be concentrated 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 absorbed.

• **Thyroidal Iodide Clearance**: This test measures the amount of iodine cleared by the blood in a period of time. The patient is given an intravenous injection of radioactive iodine. Blood samples are then taken frequently for 1 to 2 hours after the injection. Amounts of iodine are measured and compared to normal.
  
  • **Radioactive Iodine Excretion**: this procedure measures the amount of radioactive iodine excreted in the urine after a test dose is administered.

• **Thyroid Scan**: This test is an organ scan of the thyroid (scintillation scanner). 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.

- **Triiodothyronine levels (T3 level):** Measures the amount of hormone in blood plasma. 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, saturating 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 radioactive T3 to the patient's blood sample. No radioactive material is given to the patient; it is added to the blood sample later. No other special preparation is needed, and iodine supplements usually do not affect the results.

- **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.

- **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**

- **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. The patient should 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, it should be noted on the lab slip.

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

**Body Fluid Lab Tests**

The tests presented here are the most commonly used tests in most clinical settings 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.
Urinalysis
The urinalysis is another common 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 collecting and handling specimens. This improper handling can affect the results of the test, since contamination can occur at any point in the handling. The following tests are most common components of the urinalysis:

- Urinalysis
- Urinalysis: pH
- Specific Gravity
- Urinalysis: Protein
- Urinalysis: Glucose and ketones
- Microscopic Urine Exam: RBC's
- Microscopic exam of urine: WBC's
- Microscopic exam of urine: Casts
- Microscopic exam of urine: Crystals and other components

Other types of commonly ordered urinary tests are listed below:

- Urinary Calculi
- Concentration test
- Dilution Test

Cerebrospinal Fluid Tests
Cerebrospinal fluid, CSF, is collected via the (LP) lumbar puncture. Specimen tubes are marked very clearly for the tests to be performed on that numbered specimen. Typical orders to know are listed below.

- Cerebrospinal fluid examination, Pressure
- Cerebrospinal fluid examination: Appearance
- Cerebrospinal fluid examination: Glucose
- Cerebrospinal fluid examination: Protein
- Cerebrospinal Fluid Examination: Cell Count
- Cerebrospinal fluid examination: Culture
- Cerebrospinal fluid examination: Serology
- Cerebrospinal fluid examination

Common Abbreviations and Acronyms
Understanding terminology related to laboratory tests is important to avoid data entry errors which could lead to potential inaccurate results or the wrong test performed. Terminology related to this topic is vast. We will cover only a small portion of terms and abbreviations in this chapter.
There are two (2) lists below 1) general abbreviations and 2) laboratory diagnostic terms for you to learn. Use these lists to become familiar with all the terms, use the electronic flash cards to study terms which may be on your certification exam!

**Please go to your course page to access the Electronic Flash Cards.**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABG</td>
<td>Arterial blood gases</td>
</tr>
<tr>
<td>ACE</td>
<td>Angiotensin converting enzyme</td>
</tr>
<tr>
<td>ACL</td>
<td>Anterior cruciate ligament</td>
</tr>
<tr>
<td>ADHD</td>
<td>Attention deficit hyperactivity disorder</td>
</tr>
<tr>
<td>AFIB</td>
<td>Atrial fibrillation</td>
</tr>
<tr>
<td>AIDS</td>
<td>Acquired immunodeficiency syndrome</td>
</tr>
<tr>
<td>ALP</td>
<td>Alkaline phosphatase</td>
</tr>
<tr>
<td>ALS</td>
<td>Amyotrophic lateral sclerosis</td>
</tr>
<tr>
<td>ALT</td>
<td>Alanine aminotransferase</td>
</tr>
<tr>
<td>AMD</td>
<td>Age-related macular degeneration</td>
</tr>
<tr>
<td>AMI</td>
<td>Acute myocardial infarction</td>
</tr>
<tr>
<td>AODM</td>
<td>Adult onset diabetes mellitus</td>
</tr>
<tr>
<td>AST</td>
<td>Aspartate aminotransferase</td>
</tr>
<tr>
<td>AVM</td>
<td>Arteriovenous malformation</td>
</tr>
<tr>
<td>BID</td>
<td>Twice a day</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>BP</td>
<td>Blood pressure</td>
</tr>
<tr>
<td>BPH</td>
<td>Benign prostatic hypertrophy</td>
</tr>
<tr>
<td>BRCA</td>
<td>Breast Cancer Gene</td>
</tr>
<tr>
<td>BUN</td>
<td>Blood urea nitrogen</td>
</tr>
<tr>
<td>CA</td>
<td>Cancer OR Calcium</td>
</tr>
<tr>
<td>CA-125</td>
<td>Cancer antigen 125</td>
</tr>
<tr>
<td>CABG</td>
<td>Coronary artery bypass graft</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>CAT</td>
<td>Computerized axial tomography</td>
</tr>
<tr>
<td>CBC</td>
<td>Complete blood count</td>
</tr>
<tr>
<td>CHD</td>
<td>Congenital heart disease</td>
</tr>
<tr>
<td>CHF</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>CMV</td>
<td>Cytomegalovirus</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>CNS</td>
<td>Central nervous system</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic obstructive pulmonary disease</td>
</tr>
<tr>
<td>CPK</td>
<td>Creatine phosphokinase</td>
</tr>
<tr>
<td>CPR</td>
<td>Cardiopulmonary resuscitation</td>
</tr>
<tr>
<td>CRF</td>
<td>Chronic renal failure</td>
</tr>
<tr>
<td>CRP</td>
<td>C-reactive protein</td>
</tr>
<tr>
<td>CSF</td>
<td>Cerebrospinal fluid</td>
</tr>
<tr>
<td>CVA</td>
<td>Cerebrovascular accident</td>
</tr>
<tr>
<td>CXR</td>
<td>Chest x-ray</td>
</tr>
<tr>
<td>D&amp;C</td>
<td>Dilatation and curettage</td>
</tr>
<tr>
<td>DJD</td>
<td>Degenerative joint disease</td>
</tr>
<tr>
<td>DM</td>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>DTP</td>
<td>Diphtheria, tetanus, pertussis</td>
</tr>
<tr>
<td>DVT</td>
<td>Deep-vein thrombosis</td>
</tr>
<tr>
<td>DX</td>
<td>Diagnosis</td>
</tr>
<tr>
<td>ECG, EKG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>ECHO</td>
<td>Echocardiogram</td>
</tr>
<tr>
<td>EEG</td>
<td>Electroencephalogram</td>
</tr>
<tr>
<td>EMG</td>
<td>Electromyography</td>
</tr>
<tr>
<td>ENT</td>
<td>Ear, nose and throat</td>
</tr>
<tr>
<td>ERCP</td>
<td>Endoscopic retrograde cholangiopancreatography</td>
</tr>
<tr>
<td>ESR</td>
<td>Erythrocyte sedimentation rate</td>
</tr>
<tr>
<td>ESRD</td>
<td>End-stage renal (kidney) disease</td>
</tr>
<tr>
<td>FSH</td>
<td>Follicle stimulating hormone</td>
</tr>
<tr>
<td>GERD</td>
<td>Gastroesophageal reflux disease</td>
</tr>
<tr>
<td>GI</td>
<td>Gastrointestinal</td>
</tr>
<tr>
<td>GFR</td>
<td>Glomerular filtration rate</td>
</tr>
<tr>
<td>GU</td>
<td>Genitourinary</td>
</tr>
<tr>
<td>HAV</td>
<td>Hepatitis A virus</td>
</tr>
<tr>
<td>HBV</td>
<td>Hepatitis B virus</td>
</tr>
<tr>
<td>HCT</td>
<td>Hematocrit</td>
</tr>
<tr>
<td>HCV</td>
<td>Hepatitis C virus</td>
</tr>
<tr>
<td>HDL</td>
<td>High density lipoprotein</td>
</tr>
<tr>
<td>HGB</td>
<td>Hemoglobin</td>
</tr>
<tr>
<td>HIV</td>
<td>Human immunodeficiency virus</td>
</tr>
<tr>
<td>HPV</td>
<td>Human papilloma virus</td>
</tr>
<tr>
<td>HRT</td>
<td>Hormone replacement therapy</td>
</tr>
<tr>
<td>HTN</td>
<td>Hypertension</td>
</tr>
<tr>
<td>IBD</td>
<td>Inflammatory bowel disease</td>
</tr>
<tr>
<td>IBS</td>
<td>Irritable bowel syndrome</td>
</tr>
<tr>
<td>ICD</td>
<td>Implantable cardioverter defibrillator</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>IDDM</td>
<td>Insulin-dependent diabetes mellitus (can be type I or type II)</td>
</tr>
<tr>
<td>IM</td>
<td>Intramuscular</td>
</tr>
<tr>
<td>IUD</td>
<td>Intrauterine device</td>
</tr>
<tr>
<td>IV</td>
<td>Intravenous</td>
</tr>
<tr>
<td>IVP</td>
<td>Intravenous pyelogram</td>
</tr>
</tbody>
</table>
LDL  Low density lipoprotein
LFT  Liver function tests
MI  Myocardial infarction
MMR  Measles, mumps, and rubella
MRI  Magnetic resonance imaging
MRSA  Methicillin-resistant Staphylococcus aureus
MS  Multiple sclerosis
NG  Nasogastric
NIDDM  Non-insulin dependent diabetes mellitus
NKDA  No known drug allergies
NSAID  Non-steroidal anti-inflammatory drug
OCD  Obsessive-compulsive disorder
PAD  Peripheral arterial disease
PAP  Papanicolaou
PAT  Paroxysmal atrial tachycardia
PET  Positron emission tomography
PFT  Pulmonary function test
PID  Pelvic inflammatory disease
PMS  Premenstrual syndrome
PPD  Purified protein derivative
PRN  As needed
PSA  Prostate specific antigen
PT  Prothrombin time
PTH  Parathyroid hormone
PTSD  Post-traumatic stress disorder
PTT  Partial thromboplastin time
PUD  Peptic ulcer disease
PVC  Premature ventricular contraction
QID  Four times a day
RA  Rheumatoid arthritis
RBC  Red blood cell
RSV  Respiratory syncytial virus
Rx  Treatment
SAD  Seasonal affective disorder
SIDS  Sudden infant death syndrome
SLE  Systemic lupus erythematosus
SOB  Shortness of Breath
STD  Sexually transmitted disease
T3  Triiodothyronine
T4  Thyroxine
TB  Tuberculosis
TAH  Total abdominal hysterectomy
TIA  Transient ischemic attack
TIBC  Total iron binding capacity
TID  Three times a day
TMJ  Temporomandibular joint
TORCH  Stands for a group of infections that may cause birth defects
Glossary of Laboratory Diagnostic Terms - “talk the talk to walk the walk” – let’s get started!

**Accuracy**
Agreement between your test result value and the true value; i.e. how correct your result is.

**Affinity**
An attractive force between substances or particles that causes them to enter into and remain in chemical combination, for example; the binding of antibody to antigen.

**Aggregation**
The grouping of units or parts into a mass or whole.

**Aliquot**
The division of a sample into at least two smaller size vials.

**Amplification**
Amplification generally means an addition to or expansion of a statement or idea. In medical terminology, amplification refers to the selective copying of a gene or any sequence of DNA. This occurs naturally in the body in order to satisfy the increased requirement of individual cells for gene products such as proteins. Amplification also plays a role in cancer cells when a tumor cell copies DNA segments as a result of cell signals or external environmental factors. Artificial amplification is conducted due to its central role in gene research.

**Analyte**
The chemical substance being measured in an assay usually contained in blood or other body fluids.

**Anabolic Steroid**
Anabolic steroids are a group of synthetic steroid hormones that promote tissue growth and the storage of protein; as such they are sometimes used in food producing animals to increase the lean meat to fat ratio.

**Antibody**
A protein produced by our body in response to an antigen. There are 5 classes of antibodies (IgG, IgM, IgE, IgA, IgD). The antibody binds to and neutralizes the antigen.

**Anticoagulant**
A substance that stops the blood from clotting.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antigen</td>
<td>Antigens are usually foreign substances which enter the body and trigger the immune system to produce antibodies in order to fight off the potential infection. Antigens can be toxins, foreign blood cells, bacteria or the cells of transplanted organs.</td>
</tr>
<tr>
<td>Antimicrobial</td>
<td>The term given to a group of drugs that inhibits the growth or destroys microorganisms.</td>
</tr>
<tr>
<td>Antioxidant</td>
<td>A molecule that protects cells from oxidative damage of oxygen and free radical molecules that are chemically unstable and cause random reactions damaging proteins, nucleic acids and cell membranes.</td>
</tr>
<tr>
<td>Antiserum</td>
<td>A solution of antibody or mixture of antibodies either purified or un-purified used in the manufacture of diagnostic reagents or used as a component of a diagnostic kit.</td>
</tr>
<tr>
<td>Assay</td>
<td>A diagnostic test to measure the concentration or level of a particular analyte.</td>
</tr>
<tr>
<td>Assayed</td>
<td>Assayed controls are used for the control of accuracy and reproducibility of results. Each parameter has an assigned mean +/- 2SD range generated from up to 3000 independent laboratories world-wide and approximately 98,000 results.</td>
</tr>
<tr>
<td>Assay Range</td>
<td>The assay range describes the highest and lowest concentrations, at which a reaction is still measurable.</td>
</tr>
<tr>
<td>Aspiration</td>
<td>The withdrawal of fluid or tissue, e.g. by a wash probe on an analyzer.</td>
</tr>
<tr>
<td>Aqueous</td>
<td>The term aqueous simply means dissolved in water.</td>
</tr>
<tr>
<td>Avidity</td>
<td>The average affinity of a mixture of antibody to their corresponding antigen.</td>
</tr>
<tr>
<td>Benchtop</td>
<td>This term simply refers to a position of an object, i.e. ‘on top of a bench’. However, in a scientific setting, it is used to describe an analyzer which is small enough to fit on top of a laboratory workbench but is too large to be a point of care system.</td>
</tr>
<tr>
<td>Bias</td>
<td>The term bias refers to the difference between the expected result and an accepted reference value.</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>Biochemistry is the study of the chemical structures and vital processes which occur in living organisms. Biochemists study the compounds in the body and how these result in chemical processes. They seek to understand such processes both within healthy and unhealthy organisms.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Biochip</td>
<td>Proprietary solid substrate onto which reactive species are prefabricated for the detection of specific analytes.</td>
</tr>
<tr>
<td>Biological Variation</td>
<td>The mean for each laboratory's results will not be exactly the same. Individual homeostatic setting points usually vary. This difference is known as biological variation.</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>As the name suggests, this field of study is a combination of biology and technology. It is primarily concerned with the technical exploitation of biological processes. Through microbiological or biochemical techniques, cell cultures, microorganisms or enzymes are used to activate targeted metabolic processes. Used in conjunction with genetic engineering, biotechnology can be used to program certain microorganisms to perform specific tasks.</td>
</tr>
<tr>
<td>Blood Clotting</td>
<td>Blood clotting, also known as coagulation performs the vital task of preventing excessive blood loss in the event of injury. Leakage of blood is prevented by the blood cells sticking to the wound. However, clotting can sometimes fail to occur, this is known as hemophilia.</td>
</tr>
<tr>
<td>Blood Gas Analysis</td>
<td>The body has many functions; one critical function is to transport substances such as oxygen, carbon dioxide, nutrients and excretions. Most of these substances are gases; therefore blood gas analysis determines their concentrations in arterial and venous blood.</td>
</tr>
<tr>
<td>Blood Screening</td>
<td>Blood screening is used to detect pathogens which cause symptomless diseases. An effective diagnosis then allows correct treatment to begin in good time, thus improving the patient outcome. Blood screening is also performed on donated blood to identify and remove any infected blood.</td>
</tr>
<tr>
<td>Bovine</td>
<td>Bovine controls are prepared from certified disease-free animal source material and offer high performance when cost considerations are paramount.</td>
</tr>
<tr>
<td>Buffer</td>
<td>A liquid solution containing a combination of chemicals, which control and maintain the pH of any other solution it is added to.</td>
</tr>
<tr>
<td>Calibration</td>
<td>The process of setting up or standardizing an assay using a calibrator or standard of known concentration. When the data generated is analyzed this can then be used to calculate results for any subsequent sample of unknown concentration. It adjusts the accuracy of an assay method.</td>
</tr>
<tr>
<td>Calibrator</td>
<td>A material, generally serum based with an accurately assigned analytical value, used to calibrate diagnostic assays.</td>
</tr>
<tr>
<td>Centrifugation</td>
<td>Centrifugation is a process used to separate or concentrate materials suspended in a liquid medium by use of the centrifugal force.</td>
</tr>
</tbody>
</table>
Chemiluminescence  The process in which energy from a chemical reaction is released directly as light.

Cholesterol  Cholesterol is a very important and essential part of our diet. Cholesterol is needed for the formation of bile acids, vitamin D, progesterone and much more. LDL is known as the bad cholesterol as it is associated with increased risk of coronary heart disease. HDL is therefore the good cholesterol as elevated HDL levels are associated with decreased risk of coronary heart disease.

Chromagen  A substrate which reacts with an enzyme or directly with the analyte to produce a colored end-point which can subsequently be measured to quantify the concentration of the analyte.

Chromosome  A chromosome is the carrier of genetic information that is inherited from generation to generation. They exist in every cell nucleus. Cells in humans contain a double set of chromosomes, a total of 23 pairs of chromosomes exist in each human.

Clinical Chemistry  This field deals with analyzing blood, urine and other body fluids. Their constituents i.e. proteins and enzymes are determined. The results from this analysis is used as a basis for patient diagnosis.

Co-enzyme  A small but complex biochemical which many enzymes require to be able to carry out their function. Examples are NADH, NAD+ and ATP. Many vitamins are co-enzymes.

Colorimetric Methods  Colorimetric methods result in a colored end product, the intensity of which is directly proportional to the concentration of the analyte being measured at 400-700nm.

Conjugate  This contains the various enzymes labelled analytes or enzyme labelled detection antibodies utilized in an immunoassay to generate a measurable signal.

Consolidation  Extensive analyte menus allow significant consolidation of existing controls. An average laboratory may rationalize from 7 different control products to a single control product.

Control  A serum based material with assigned target values and acceptable ranges to evaluate the accuracy and reproducibility of a diagnostic assay.

Correlation  A clear positive relation between two methods.

Cross Reactivity  When an antibody binds or reacts with proteins other than the one it is specific for.
CSF  
Cerebrospinal fluid. CSF controls are available ensuring the same matrix as the patient sample.

Custom Made  
A custom made quality control is manufactured to meet a customer’s own specifications. Custom made sera may involve the addition of extra analytes, removal of unwanted analytes, alteration of analyte levels or alteration of vial size.

Cuvette  
A reaction vessel (similar to a tube) used in photometric analyzers.

Cytopathology  
Also histopathology; the study of tissue samples of patients to detect diseases.

Dedicated Reagent  
A reagent packed and bar-coded for specific use on one analyzer.

Diabetes Mellitus  
Diabetes is a metabolic condition characterized by high blood sugar levels which result from defects in insulin production. Blood sugar levels are controlled by the hormone; insulin. Blood sugar levels rise after eating; insulin is then released to normalize the level. However, in diabetes patients, insufficient amounts of insulin is produced causing hyperglycemia. Diabetes is a chronic condition which can lead to kidney failure, blindness, stroke and cardiovascular disease.

- There are two types of diabetes, Type 1 and Type 2:
  - Type 1: Develops when the insulin producing cells have been destroyed, meaning the body is unable to produce any insulin. Glucose then builds up in the blood. Type 1 can occur at any age, though usually appears before the age of 40.
  - Type 2: Occurs when the body can produce insulin but not enough of it or the insulin that is produced does not function correctly. Glucose then builds up in the blood. Type 2 usually develops in people aged over 40, although is now becoming more common in children, adolescents and young people.

Diagnostic Kit  
A combination of reagents liquid or freeze-dried which can be used in a laboratory to measure specific serum or urine parameters to diagnose and monitor the therapy of specific diseases.

Disease Marker  
A disease marker is any serum component which rises or falls outside its normal range in response to disease.

DNA  
Deoxyribonucleic acid. DNA is one of two types of molecules which encode genetic information, the other being RNA. DNA is the genetic material in humans and RNA is transcribed from it. DNA forms a double stranded molecule held together between the base pairs of nucleotides. This
molecule forms a double helix. There are four nucleotides in DNA, each containing a base; adenine (A), guanine (G), cytosine (C) or thymine (T).

 Drug Residue The small amount of drug left behind in animal products after treatment. Includes any degradation products which are a direct result of the drugs metabolism.

 ELISA Enzyme Linked Immunosorbent Assay. A sample containing an unknown amount of antigen is immobilized on the surface of a micro titer plate. An enzyme labelled antibody specific to the antigen of interest is added and forms a complex with the antigen, a series of washes are then carried out to remove any proteins or antibodies that are not specifically bound. Finally the substrate is added and converted to visible signal which corresponds directly to the quantity of antigen in the sample.

 End-Point In an end-point reaction the reaction is allowed to go to completion. One final absorbance is measured which will relate directly to the analyte concentration in the sample.

 Enzymatic Enzymatic methods have gradually replaced classical chemical methods. They provide the laboratory with greater specificity and greater accuracy.

 Enzyme Complex proteins that are produced by living cells and catalyze specific biochemical reactions.

 Epitope The part of the antigen (on its surface) that can be recognized by the antibody.

 Freeze Drying Also called lyophilization, is a process in which an unstable mixture of chemicals can be stabilized by removing water and then sealed under a vacuum in a glass vial.

 Fragmentation When something is broken up, the resulting smaller parts are called fragments. Fragmentation occurs during a PCR (polymerase chain reaction) and can be conducted by heating of chromosomes or parts of the DNA.

 Fully Automated With a fully automated system all assay steps are performed automatically, the operator is only required to load reagents/samples and to program the instrument.

 GC-MS Gas Chromatography-Mass Spectrophotometry. A technique that combines gas liquid chromatography and mass spectrophotometry to identify different substances or components within a test sample.

 Gene A gene is the basic biological unit of heredity or genetic features. Genes are essentially the building blocks which allow proteins to control the diversity of processes within each human body, such as fighting infections.
Gene Expression
Gene expression is the translation of the information encoded in a gene into another form, i.e. protein or RNA, this translation process is known as transcription.

Genetics
Genetics is the study of heredity, for example the passing of characteristics such as eye color and even the transmission of genetic diseases. This enables scientists to further understand such diseases and therefore potentially improve diagnostic and treatment options. There are many different types of genetics including classical genetics, clinical genetics, forensic genetics and pharmacogenetics.

Genomics
Genomics is the study of genes and their functions. It is interested in the structure of the genome, which carries all the genetic material, like a blueprint. Genomics studies how molecular mechanisms and genetic factors affect disease.

Glucose
Glucose, or dextrose, as it also known, is the main sugar produced by the body and is the primary source of energy. Glucose is made from fats, proteins and carbohydrates and is transported via the bloodstream to individual cells. Cells then require insulin to be able to use the glucose effectively.

Growth Promoter
The term growth promoter is used to describe a class of drugs that have growth promoting properties. They are often used to improve the ability of food producing animals to efficiently and effectively use nutrients in order to produce leaner, more affordable meat.

Hematology
The study of blood and its components. Blood is an important transport mechanism for essential nutrients. Hematology studies disorders associated with blood such as coagulation.

Hemoglobin
The protein in the center of a red blood cell (erythrocyte), that is responsible for binding and delivering oxygen to the body. It also gives blood its red color.

Hemolysis
Lysis of red blood cells with liberation of hemoglobin; a hemolysed sample is red.

Half-life
The time required to break down and eliminate half the concentration of a substance. At half the concentration a drug stops being effective, so the half-life indicates the amount of time that a drug will be effective.

Harvesting
To remove or extract, (as living cells, tissues or organs) from a living being or a culture.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histogram</td>
<td>Compares the distribution of your instrument group, method group and all method groups</td>
</tr>
<tr>
<td>Histopathology</td>
<td>Also Cytopathology; the study of tissue samples of patients to detect diseases.</td>
</tr>
<tr>
<td>HPLC</td>
<td>High Performance Liquid Chromatography is a method used in clinical chemistry to separate a mixture of compounds and identify the individual components.</td>
</tr>
<tr>
<td>100% Human</td>
<td>Fully human controls are preferred for immunological methods including those for serum proteins and hormones. Fully human controls are donor tested at source and found to be non-reactive for Hepatitis B and C antigen and HIV I and II antibodies. Human serum offers a matrix consistent with human patient samples.</td>
</tr>
<tr>
<td>Human-based</td>
<td>Human based controls are donor tested at source and found to be non-reactive for Hepatitis B and C antigen and HIV I and II antibodies. Human serum offers a matrix consistent with human patient samples.</td>
</tr>
<tr>
<td>Hybrid</td>
<td>A specially cultivated cell which contains components from one or more genomes.</td>
</tr>
<tr>
<td>Hybridoma</td>
<td>A hybrid cell produced by the fusion of an antibody-producing lymphocyte with a tumor cell and used to culture continuously a specific monoclonal antibody.</td>
</tr>
<tr>
<td>IFCC</td>
<td>The International Federation of Clinical Chemistry</td>
</tr>
<tr>
<td>Immunoaffinity Columns</td>
<td>Used to clean up samples for analysis by HPLC or ELISA. They work by binding and removing the target analyte from a variety of different sample types.</td>
</tr>
<tr>
<td>Immunoassay</td>
<td>An assay that makes use of the affinity of an antibody to a particular antigen. Specific antigens and antibodies in the body can be indicators of specific diseases or disorders. An immunoassay test gathers information on the quantity of these antigens and antibodies.</td>
</tr>
<tr>
<td>Immunochemistry</td>
<td>A part of immunology, immunochemistry looks into the chemical detection of immune reactions.</td>
</tr>
<tr>
<td>Immunoturbidimetry</td>
<td>A method of measuring turbidity that is created during a chemical reaction between antigen and antibody.</td>
</tr>
<tr>
<td>Inert</td>
<td>Inert means chemically non-reactive.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Interferent</td>
<td>A substance that interferes in any way with a chemical reaction and gives false results.</td>
</tr>
<tr>
<td>In Vitro</td>
<td>A procedure carried out outside a living organism.</td>
</tr>
<tr>
<td>In Vivo</td>
<td>A procedure carried out within a living organism.</td>
</tr>
<tr>
<td>ISE</td>
<td>Ion Selective Electrode</td>
</tr>
<tr>
<td>Kinetic</td>
<td>A diagnostic test where the speed of the reaction is measured and the rate at which the signal is produced will reflect the analyte concentration.</td>
</tr>
<tr>
<td>Latex Slide Test</td>
<td>Latex slide tests are simple manual tests performed on a disposable card or glass slide.</td>
</tr>
<tr>
<td>LC-MS</td>
<td>Liquid Chromatography – Mass Spectrophotometry</td>
</tr>
<tr>
<td>Ligation</td>
<td>The binding together of two substances.</td>
</tr>
<tr>
<td>Limit of Detection (LOD)</td>
<td>The LOD refers to the smallest quantity of analyte that can be detected and distinguished from the blank with a reasonable degree of certainty.</td>
</tr>
<tr>
<td>Linearity</td>
<td>In chemical terms; expression of the proportional relationship between response and concentration over a defined range. It is used to describe the highest concentration, at which a reaction is still measurable.</td>
</tr>
<tr>
<td>Lipid</td>
<td>A lipid is a water insoluble substance and is the name of a large class of structurally and functionally diverse molecules. Important lipids include fatty acids.</td>
</tr>
<tr>
<td>Lyophilized</td>
<td>The term lyophilized refers to a material that has been freeze-dried. Freeze-drying is a process by which an unstable mixture of chemicals can be stabilized by removing water and then sealed under a vacuum in a glass vial.</td>
</tr>
<tr>
<td>Lysis</td>
<td>A process of disintegration or dissolution of cells. For example, hemolysis is the dissolution of red blood cells.</td>
</tr>
<tr>
<td>Manual</td>
<td>In manual tests the functional steps are carried out by hand and the reactions measured using a spectrophotometer. Results are not produced directly and the operator will generally have to perform calculations or plot a graph to generate meaningful data.</td>
</tr>
<tr>
<td>Maximum Residue Limits (MRL)</td>
<td>The maximum residue limit refers to the maximum permissible level according to legislation of a chemical or group of chemicals in human or animal feed.</td>
</tr>
<tr>
<td><strong>Metabolism</strong></td>
<td>The general term given to describe the body’s chemistry and all its biochemical reactions and transformations. It refers more specifically to the body’s ability to turn food into energy.</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Metabolite</strong></td>
<td>Any biochemical compound which plays a key role in the metabolism of the body.</td>
</tr>
<tr>
<td><strong>Microbiology</strong></td>
<td>The study of microorganisms, such as bacteria, viruses and parasites.</td>
</tr>
<tr>
<td><strong>Microarray</strong></td>
<td>Microarrays consist of many probes attached chemically to a substrate with a very small surface. This surface could be a glass slide or a microchip. Each probe, which holds genetic information, can detect many different genes at the same time. Microarrays can be used to assist in the detection of genetic variations.</td>
</tr>
<tr>
<td><strong>Monoclonal</strong></td>
<td>Cells derived from a single origin.</td>
</tr>
<tr>
<td><strong>Molecule</strong></td>
<td>A molecule is the smallest possible unit in a chemical compound. It is made up of at least two atoms held together by bonding forces. H2O is an example of a molecule.</td>
</tr>
<tr>
<td><strong>Molecular Biology</strong></td>
<td>Molecular Biology is the study of biology on a molecular level. It examines the structure and function of biologically important molecules within an organism in order to study viruses. It also encompasses biochemistry and genetics.</td>
</tr>
<tr>
<td><strong>Mutation</strong></td>
<td>In a strict sense, mutations are changes in genes caused by genetic recombination. A change in the base sequence of DNA for example, represents to a mutational change. It is a permanent structural change in the DNA. Some mutations can be harmless and have no effect whilst others can be harmful. Mutations can be inherited.</td>
</tr>
<tr>
<td><strong>Myocardial Infarction (MI)</strong></td>
<td>This is a heart attack. A heart attack occurs when a coronary artery is suddenly blocked by a blood clot. This causes the death of heart muscle. This blockage deprives the heart of blood and oxygen, therefore causing serious injury to the heart which causes pain in the chest. The damage can be irreversible if the blood flow is not started again quickly.</td>
</tr>
<tr>
<td><strong>Near patient testing</strong></td>
<td>This term is used to describe a rapid diagnostic test or testing platform which allows clinicians to respond quickly to critical situations. Near patient testing can be performed in a doctor’s office, in the emergency room or other near patient sites. It enables the clinician to decide on diagnosis and potential treatment at the site of testing, for a rapid diagnosis thus improving patient outcome.</td>
</tr>
</tbody>
</table>
Normal Range  The normal range refers to the results expected from a healthy individual. It is important to note that results may vary with age, gender and geographical location.

Oncology  This field of medicine examines tumors and cancerous conditions and the subsequent treatment options as well as diagnosis.

Parameter  Another term often used to describe the analyte being tested in an assay.

Pathogen  A specific causative agent of disease such as bacterium, virus or chemical etc.

Pathological  The concentration of some analytes within the body are altered or caused by disease. Pathological control contains abnormal levels of analytes associated with disease.

Peer Group  A peer group consists of a number of laboratories using the same quality controls, methodology, instrument and reagents as such a peer group can be described as the ideal consensus group.

pH  This is a measure of the acidity or alkalinity of a solution. The activity of all biochemical reactions is influenced by the pH of its surroundings.

Photometry  Photometry describes the measurement of visible light.

Plasma  The clear amber liquid which is derived from whole blood that has been collected in the presence of an anticoagulant in such a way as to prevent clot formation. Plasma differs from serum in that it contains all the clotting factors and fibrinogen which are lost on clot formation.

Point of Care (POC)  The term used for diagnostic testing which takes place at or near the patient’s site of care.

Polyclonal Antibody  A mixture of different antibodies detecting different epitopes on the surface of the same antigen.

Precision  Precision refers to the reproducibility of test results and is a measure of how disperse the values are. Inter-assay and Intra-assay are two distinct measures of this.

Proliferate  To grow by rapid production of new cells.

Protein  A protein is a molecule composed of one or more chains of amino acids. Proteins are needed for the function of cells, tissues and organs. They are also essential for muscle, skin and bones.
Purify  The removal of unwanted contaminants or cleaning of a protein or chemical so it can be used in a particular application without interference.

Reagent  A component of a kit used to carry out a chemical reaction to determine levels of different analytes.

Random Access  Random access refers to the capability of an analyzer to perform any requested test in any sequence.

Recombinant Protein  A protein created by artificially inducing a DNA sequence into a living cell.

Reconstitution  The addition of water to a freeze-dried reagent or control material to return it to its former condition.

Reference Method  Reference methods are generally considered the most accurate for the determination of a specific analyte and are traceable to international standards, enabling inter-laboratory standardization.

RNA  RNA is short for ribonucleic acid. This is a nucleic acid molecule which is similar to DNA but contains ribose rather than deoxyribose. Several classes of RNA exist and all have a key role in protein synthesis. Transfer RNA (tRNA) carries amino acids leading to the formation of protein with a specific amino acid arrangement. Messenger RNA (mRNA) carries the message of the DNA to cells where protein is made. Ribosomal RNA (rRNA) is a component of ribosomes and it functions as a nonspecific site for making polypeptides.

Sandwich Assay  An immunoassay; the solid phase (such as a biochip) for the assay is coated or spotted with antibodies. When the antigen is added in the first step, the antigen binds to the antibody. Then a second antibody, or conjugate, is added, the conjugate is labelled with an enzyme soluble substrate to produce either a color (ELISA) or a chemiluminescent signal (biochips). The strength of the signal can be measured and used to calculate the analyte concentration.

Screening  Screening is conducted to detect diseases and conditions at an early stage within an at-risk group. Its main aim is to identify those individuals who have disease-causing pathogens in their system and thus initiate effective treatment as quickly as possible.

Semi-automated  Semi-automated methods still require some interaction by the operator. The pipetting of reagents and reaction incubation steps are carried out manually however results are read and calculated by the analyzer.

Sensitivity  The ability to detect small quantities of a measured component.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum</td>
<td>The clear amber liquid that is derived from clotted blood by centrifuging and removing the red blood cells. Serum is a complex mixture of hundreds of different proteins, sugars, fats and salts and is the starting material for most diagnostic tests. Many control products are serum based to ensure the matrix is the same as the patient sample.</td>
</tr>
<tr>
<td>Shift</td>
<td>The term shift is often used to describe an abrupt or sudden change in results.</td>
</tr>
<tr>
<td>Specificity</td>
<td>The ability of a method to measure solely the component of interest.</td>
</tr>
<tr>
<td>Spectrophotometer</td>
<td>An instrument for measuring the relative light intensities.</td>
</tr>
<tr>
<td>Spectrum</td>
<td>Different wavelengths of light occur when any form of light (e.g. white light, UV) is dispersed. The different wavelengths can then be filtered and used to perform various photometric assays for the detection of different analytes.</td>
</tr>
<tr>
<td>Stability</td>
<td>The shelf life of a substance or component after manufacture it has been opened or reconstituted.</td>
</tr>
<tr>
<td>Standard</td>
<td>An aqueous solution containing a known level or concentration of analyte that will not change and can be used to calculate diagnostic results. Normally used to calibrate manual or semi-automated tests.</td>
</tr>
<tr>
<td>Standardization</td>
<td>Standardization is the process of developing and agreeing upon technical standards.</td>
</tr>
<tr>
<td>Substrate</td>
<td>The specific biochemical compound or compounds which an enzyme will act upon and convert into product.</td>
</tr>
<tr>
<td>Titer</td>
<td>A value expressed as a fraction that gives the highest dilution of a solution in which a particular analyte can still be measured e.g. Antibody titer.</td>
</tr>
<tr>
<td>Throughput</td>
<td>The term throughput is used in clinical chemistry to describe the number of tests an analyzer is capable of carrying out in a given time period.</td>
</tr>
<tr>
<td>Traceability</td>
<td>Traceability ensures that laboratory results can be traced back to standards and methods that are recognized as accurate.</td>
</tr>
<tr>
<td>Troponin T (or I)</td>
<td>A sensitive and specific marker of myocardial infarction</td>
</tr>
<tr>
<td>Unassayed</td>
<td>Unassayed controls are generally referred to as precision controls and are used only for the control of reproducibility of results. Lot specific approximate values are assigned from a consensus mean of results from independent laboratories for the most common method.</td>
</tr>
</tbody>
</table>
UV Method

A method of determining the concentration of a particular analyte in a blood sample. The molecule of interest absorbs UV light and creates a detectable signal proportional to the analyte concentration.

Bibliography

- nlm.nih.gov/medlineplus
- healthline.com/health
- nurseslearning.com

Chapter 4: Basic Elements of Radiology Order Entry

Entering Orders for Radiology Tests or Procedures

Understanding Radiology Modalities

There are many types or modalities of medical imaging procedures. Each uses different technologies and techniques. Computed tomography (CT), fluoroscopy, and radiography ("conventional X-ray" including mammography) all use ionizing radiation to generate images of the body. Ionizing radiation is a form of radiation that has enough energy to potentially cause damage to DNA and may elevate a person’s lifetime risk of developing cancer.

CT, radiography, and fluoroscopy all work on the same basic principle: an X-ray beam is passed through the body where a portion of the X-rays are either absorbed or scattered by the internal structures, and the remaining X-ray pattern is transmitted to a detector (e.g., film or a computer screen) for recording or further processing by a computer.

Radiography

Radiography - a single image is recorded for later evaluation. Mammography is a special type of radiography to image the internal structures of breasts. The radiation dose the patient receives varies depending on the individual procedure, but is generally less than that received during fluoroscopy and
computed tomography procedures. The major risks associated with radiography are the small possibilities of:

- developing a radiation-induced cancer or cataracts some time later in life
- causing a disturbance in the growth or development of an embryo or fetus (teratogenic defect) when performed on a pregnant patient or one of childbearing age

When an individual has a medical need, the benefit of radiography far exceeds the small cancer risk associated with the procedure. Even when radiography is medically necessary, it should use the lowest possible exposure and the minimum number of images. In most cases many of the possible risks can be reduced or eliminated with proper shielding.

While every x-ray examination will subject the patient to some amount of radiation, the ones mostly likely to subject the patient to a high dose of radiation are:

- computed tomography (CT), especially of the abdomen and pelvis with and without contrast
- interventional fluoroscopic examinations, especially complicated cardiac and neurological procedures
- some nuclear medicine examinations, such as stress cardiac studies

In addition, patients who undergo repeated examinations are at increased risk of receiving high radiation doses.

**Fluoroscopy**

Fluoroscopy - a continuous X-ray image is displayed on a monitor, allowing for real-time monitoring of a procedure or passage of a contrast agent (“dye”) through the body. Fluoroscopy can result in relatively high radiation doses, especially for complex interventional procedures (such as placing stents or other devices inside the body) which require fluoroscopy be administered for a long period of time.

Fluoroscopy procedures are performed to help diagnose disease, or to guide physicians during certain treatment procedures. Some fluoroscopy procedures may be performed as outpatient procedures while the patient is awake – for example, upper gastrointestinal series to examine the esophagus, stomach and small intestine, or a barium enema to examine the colon. Other procedures are performed as same-day hospital procedures or sometimes as inpatient procedures, typically while the patient is sedated – for example, cardiac catheterization to examine the heart and the coronary arteries that supply blood to the heart muscle. Still other fluoroscopy procedures may be performed under general anesthesia during surgery – for example to help align and fix fractured bones.

Fluoroscopy is used in a wide variety of examinations and procedures to diagnose or treat patients. Some examples are:

- Barium X-rays and enemas (to view the gastrointestinal tract)
- Catheter insertion and manipulation (to direct the movement of a catheter through blood vessels, bile ducts or the urinary system)
• Placement of devices within the body, such as stents (to open narrowed or blocked blood vessels)
• Angiograms (to visualize blood vessels and organs)
• Orthopedic surgery (to guide joint replacements and treatment of fractures)

Fluoroscopy carries some risks, as do other X-ray procedures. The radiation dose the patient receives varies depending on the individual procedure. Fluoroscopy can result in relatively high radiation doses, especially for complex interventional procedures (such as placing stents or other devices inside the body) which require fluoroscopy be administered for a long period of time.

Radiation-related risks associated with fluoroscopy include:

• radiation-induced injuries to the skin and underlying tissues ("burns"), which occur shortly after the exposure
• radiation-induced cancers, which may occur sometime later in life

The probability that a person will experience these effects from a fluoroscopic procedure is statistically very small. Therefore, if the procedure is medically needed, the radiation risks are outweighed by the benefit to the patient.

**Angiography**

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:

• **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.

• **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.

• **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.
Cardiac Catheterization (Cardiac Angiography, Angiocardiography, Coronary Arteriography)

Cardiac catheterization is a procedure used for visualizing the heart structures and/or coronary arteries. 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.

- **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.

- **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 regurgitation, aortic regurgitation, left ventricle hypertrophy; aneurysm--ventricle.

Computed tomography (CT)

Computed tomography (CT), sometimes called "computerized tomography" or "computed axial tomography" (CAT), is a noninvasive medical examination or procedure that uses specialized X-ray equipment to produce cross-sectional images of the body. Each cross-sectional image represents a “slice” of the person being imaged, like the slices in a loaf of bread. These cross-sectional images are used for a variety of diagnostic and therapeutic purposes. CT scans can be performed on every region of the body for a variety of reasons (e.g., diagnostic, treatment planning, interventional, or screening). Most CT scans are performed as outpatient procedures. A CT exam involves a higher radiation dose than conventional radiography because the CT image is reconstructed from many individual X-ray projections.

MRI (Magnetic Resonance Imaging)

Magnetic resonance imaging (MRI) is a medical imaging procedure that uses strong magnetic fields and radio waves to produce cross-sectional images of organs and internal structures in the body. Because the signal detected by an MRI machine varies depending on the water content and local magnetic properties of a particular area of the body, different tissues or substances can be distinguished from one another in the study image.
MRI does not use ionizing radiation (high-energy radiation that can potentially cause damage to DNA, like the x-rays used CT scans).

Safety Concerns

There are no known harmful side-effects associated with temporary exposure to the strong magnetic field used by MRI scanners. However, there are important safety concerns to consider before performing or undergoing an MRI scan. Be sure all pre-screening forms have been completed or follow the MRI protocols of the hospital or facility where the order is being placed.

Pre-screening forms help the radiology team prevent injury for the following reasons:

- The magnet may cause pacemakers, artificial limbs, and other implanted medical devices that contain metal to malfunction or heat up during the exam.
- Any loose metal object may cause damage or injury if it gets pulled toward the magnet.
- If a contrast agent is used, there is a slight risk of an allergic reaction. MRI contrast agents can cause problems in patients with significant kidney disease.
- Dyes from tattoos or tattooed eyeliner can cause skin or eye irritation.
- Medication patches can cause a skin burn.
- The wire leads used to monitor an electrocardiogram (ECG) trace or respiration during a scan must be placed carefully to avoid causing a skin burn.
- Prolonged exposure to radio waves during the scan could lead to slight warming of the body.

MRI can give different information about structures in the body than can be obtained using a standard x-ray, ultrasound, or computed tomography (CT) exam. For example, an MRI exam of a joint can provide detailed images of ligaments and cartilage, which are not visible using other study types. In some cases, a magnetically active material (called a contrast agent) is used to show internal structures or abnormalities more clearly.

Using MRI scans, physicians can diagnose or monitor treatments for a variety of medical conditions, including:

- Abnormalities of the brain and spinal cord
- Tumors, cysts, and other abnormalities in various parts of the body
- Injuries or abnormalities of the joints
- Certain types of heart problems
- Diseases of the liver and other abdominal organs
- Causes of pelvic pain in women (e.g. fibroids, endometriosis)
- Suspected uterine abnormalities in women undergoing evaluation for infertility

Nuclear medicine

Nuclear medicine is a branch of medical imaging that uses small amounts of radioactive material to diagnose and determine the severity of or treat a variety of diseases, including many types of cancers, heart disease, gastrointestinal, endocrine, neurological disorders and other abnormalities within the body. Because nuclear medicine procedures are able to pinpoint molecular activity within the body, they
offer the potential to identify disease in its earliest stages as well as a patient’s immediate response to therapeutic interventions.

They typically involve the delivery of a radioactive contrast medium to the patient and collecting the products of radioactive decay. These may be detected in a single plane, much like a conventional radiographic image or in a manner similar to the creation of a CT scan, where a computer can depict the locations of concentration of the radioactive tracer in cross-sectional planes or even in three-dimensional reconstructions. The latter procedures typically utilize SPECT (single photon emission computerized tomography) technology.

Nuclear medicine imaging procedures are noninvasive and, with the exception of intravenous injections, are usually painless medical tests that help physicians diagnose and evaluate medical conditions. These imaging scans use radioactive materials called radiopharmaceuticals or radiotracers.

In many centers, nuclear medicine images can be superimposed with computed tomography (CT) or magnetic resonance imaging (MRI) to produce special views, a practice known as image fusion or co-registration. These views allow the information from two different exams to be correlated and interpreted on one image, leading to more precise information and accurate diagnoses.

In addition, manufacturers are now making single photon emission computed tomography/computed tomography (SPECT/CT) and positron emission tomography/computed tomography (PET/CT) units that are able to perform both imaging exams at the same time. An emerging imaging technology, but not readily available at this time is PET/MRI.

**Benefits of Nuclear Medicine Examinations**

- Nuclear medicine examinations offer information that is unique—including details on both function and structure—and often unattainable using other imaging procedures.
- For many diseases, nuclear medicine scans yield the most useful information needed to make a diagnosis or to determine appropriate treatment, if any.
- Nuclear medicine is less expensive and may yield more precise information than exploratory surgery.
- Nuclear medicine offers the potential to identify disease in its earliest stage, often before symptoms occur or abnormalities can be detected with other diagnostic tests.
- By detecting whether lesions are likely benign or malignant, PET scans may eliminate the need for surgical biopsy or identify the best biopsy location.
- PET scans may provide additional information that is used for radiation therapy planning.

**Associated Risks**

- Because the doses of radiotracer administered are small, diagnostic nuclear medicine procedures result in relatively low radiation exposure to the patient, acceptable for diagnostic exams. Thus, the radiation risk is very low compared with the potential benefits.
- Nuclear medicine diagnostic procedures have been used for more than five decades, and there are no known long-term adverse effects from such low-dose exposure.
• The risks of the treatment are always weighed against the potential benefits for nuclear medicine therapeutic procedures. You will be informed of all significant risks prior to the treatment and have an opportunity to ask questions.
• Allergic reactions to radiopharmaceuticals may occur but are extremely rare and are usually mild. Nevertheless, you should inform the nuclear medicine personnel of any allergies you may have or other problems that may have occurred during a previous nuclear medicine exam.
• Injection of the radiotracer may cause slight pain and redness which should rapidly resolve.
• Women should always inform their physician or radiology technologist if there is any possibility that they are pregnant or if they are breastfeeding.

Therapeutic Procedures

Nuclear medicine also offers therapeutic procedures, such as radioactive iodine (I-131) therapy that use small amounts of radioactive material to treat cancer and other medical conditions affecting the thyroid gland, as well as treatments for other cancers and medical conditions.

Non-Hodgkin’s lymphoma patients who do not respond to chemotherapy may undergo radioimmunotherapy (RIT). Radioimmunotherapy (RIT) is a personalized cancer treatment that combines radiation therapy with the targeting ability of immunotherapy, a treatment that mimics cellular activity in the body's immune system.

Physicians use radionuclide imaging procedures to visualize the structure and function of an organ, tissue, bone or system within the body. In adults, nuclear medicine can be ordered as follows:

Heart
• visualize heart blood flow and function (such as a myocardial perfusion scan)
• detect coronary artery disease and the extent of coronary stenosis
• assess damage to the heart following a heart attack
• evaluate treatment options such as bypass heart surgery and angioplasty
• evaluate the results of revascularization procedures
• detect heart transplant rejection
• evaluate heart function before and after chemotherapy (MUGA)

Lungs
• scan lungs for respiratory and blood flow problems
• assess differential lung function for lung reduction or transplant surgery
• detect lung transplant rejection

Bones
• evaluate bones for fractures, infection and arthritis
• evaluate for metastatic bone disease
• evaluate painful prosthetic joints
• evaluate bone tumors
• identify sites for biopsy
Brain
- investigate abnormalities in the brain, such as seizures, memory loss and abnormalities in blood flow
- detect the early onset of neurological disorders such as Alzheimer disease
- plan surgery and localize seizure foci
- evaluate for abnormalities in a chemical in the brain involved in controlling movement in patients with suspected Parkinson’s disease
- evaluation of brain tumor recurrence, surgical or radiation planning or localization for biopsy

Other Systems
- identify inflammation or abnormal function of the gallbladder
- identify bleeding into the bowel
- assess post-operative complications of gallbladder surgery
- evaluate lymphedema
- evaluate fever of unknown origin
- locate the presence of infection
- measure thyroid function to detect an overactive or underactive thyroid
- help diagnose hyperthyroidism and blood cell disorders
- evaluate for hyperparathyroidism
- evaluate stomach emptying
- evaluate spinal fluid flow and potential spinal fluid leaks

In adults and children, nuclear medicine is also used to:

Cancer
- stage cancer by determining the presence or spread of cancer in various parts of the body
- localize sentinel lymph nodes before surgery in patients with breast cancer or skin and soft tissue tumors.
- plan treatment
- evaluate response to therapy
- detect the recurrence of cancer
- detect rare tumors of the pancreas and adrenal glands

Renal
- analyze native and transplant kidney function
- detect urinary tract obstruction
- evaluate for hypertension related to the kidney arteries
- evaluate kidneys for infection versus scar
- detect and follow-up urinary reflux

In children, nuclear medicine is also used to:
- investigate abnormalities in the esophagus, such as esophageal reflux or motility disorders
- evaluate the openness of tear ducts
- evaluate the openness of ventricular shunts in the brain
- assess congenital heart disease for shunts and pulmonary blood flow
Nuclear medicine therapies include:
- Radioactive iodine (I-131) therapy used to treat some causes of hyperthyroidism (overactive thyroid gland, for example, Graves' disease) and thyroid cancer
- Radioactive antibodies used to treat certain forms of lymphoma (cancer of the lymphatic system)
- Radioactive phosphorus (P-32) used to treat certain blood disorders
- Radioactive materials used to treat painful tumor metastases to the bones
- I-131 MIBG (radioactive iodine labeled with metaiodobenzylguanidine) used to treat adrenal gland tumors in adults and adrenal gland/nerve tissue tumors in children

Understanding Terminology

To reduce order entry errors, it is important to interpret acronyms and abbreviations related to radiology. The list below is a short list of required terms you should know.

Introduction to Radiology Anatomical Terms - Orders may involve specific instructions for the radiology department to follow. The information below covers basic anatomical terms you may encounter when entering radiology orders. The human body is divided up into 3 planes to describe the positions of a body.

1. **Anterior – Posterior**: Is defined by the coronal plane as shown. Posterior areas on the body are behind this plane and anterior areas to the front of this plane.

2. **Lateral - Medial**: Is defined by the Median Plane. Medial describes areas closer to the central plane and lateral away from the body and center of the plane.

3. **Superior – Inferior**: This plane is parallel to the ground and defines the vertical position on the body.

[Diagram of body showing directional references]
Directional, Anatomical and Other Terms

The physician may want the patient positioned in a specific manner during the test. There are other terms important for you to learn to avoid mistakes or errors during the order-entry process.

**Anatomical position** is that of the human body standing erect with palms turned forward, used as the position of reference in designating the site or direction of structures of the body.

**Bozeman’s position**: the knee-elbow position with straps used for support.

**Decubitus position**: an act of lying down; the position assumed in lying down.
- **dorsal decubitus**: lying on the back.
- **lateral decubitus**: lying on one side, designated *right lateral d.* when the subject lies on the right side and *left lateral d.* when he lies on the left side.
- **ventral decubitus**: lying on the stomach.

**Fowler’s position**: that in which the head of the patient’s bed is raised 18–20 inches above the level, with the knees also elevated.
**Knee-chest position:** the patient resting on knees and upper chest.

**Knee-elbow position:** the patient resting on knees and elbows with the chest elevated.

**Lithotomy position:** the patient supine with hips and knees flexed and thighs abducted and externally rotated.

**Mayer position:** a radiographic position that gives a unilateral superoinferior view of the temporomandibular joint, external auditory canal, and mastoid and petrous processes.

**Rose's position:** a supine position with the head over the table edge in full extension, to prevent aspiration or swallowing of blood.

**Semi-Fowler position:** one similar to Fowler’s position but with the head less elevated.

**Sims position:** the patient on the left side and chest, the right knee and thigh drawn up, the left arm along the back.

**Trendelenburg position:** the patient is supine on a surface inclined 45 degrees, head at the lower end and legs flexed over the upper end.

**Verticosubmental position:** a radiographic position that gives an axial projection of the mandible, including the coronoid and condyloid processes of the rami, the base of the skull and its foramina, the petrous pyramids, the sphenoidal, posterior ethmoid, and maxillary sinuses, and the nasal septum.

**Waters' position:** a radiographic position that gives a posteroanterior view of the maxillary sinus, maxilla, orbits, and zygomatic arches.

**Interpreting and Appropriately Using Abbreviations**

Another error of potential error is lack of understanding acronyms and abbreviations. If you are unsure, always ASK for clarification. NEVER ASSUME OR GUESS. Learn the Acronyms & Abbreviations list below.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAPM</td>
<td>American Association of Physics in Medicine</td>
</tr>
<tr>
<td>AAS</td>
<td>Acute Abdominal Series</td>
</tr>
<tr>
<td>ABC</td>
<td>Automatic Brightness Control</td>
</tr>
<tr>
<td>ABD</td>
<td>Abdomen</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ACR</td>
<td>American College of Radiology</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog-to-Digital Converter</td>
</tr>
<tr>
<td>AEC</td>
<td>Automatic Exposure Control</td>
</tr>
<tr>
<td>AGC</td>
<td>Automatic Gain Control</td>
</tr>
<tr>
<td>AHRA</td>
<td>American Healthcare Radiology Administrators</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>AI</td>
<td>Aluminum</td>
</tr>
<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable.</td>
</tr>
<tr>
<td>AMU</td>
<td>Atomic mass units</td>
</tr>
<tr>
<td>AP</td>
<td>Anterior-Posterior</td>
</tr>
<tr>
<td>APR</td>
<td>Anatomical Programmed Radiography</td>
</tr>
<tr>
<td>ARNA</td>
<td>American Radiological Nurses Association</td>
</tr>
<tr>
<td>ARR</td>
<td>Academy of Radiology Research</td>
</tr>
<tr>
<td>ARRS</td>
<td>American Roentgen Ray Society</td>
</tr>
<tr>
<td>ARRT</td>
<td>American Registry of Radiologic Technology</td>
</tr>
<tr>
<td>a-Se</td>
<td>Amorphous Selenium</td>
</tr>
<tr>
<td>a-Si</td>
<td>Amorphous Silicon</td>
</tr>
<tr>
<td>ASRT</td>
<td>American Society of Radiologic Technologists</td>
</tr>
<tr>
<td>Ba</td>
<td>Barium</td>
</tr>
<tr>
<td>BAS</td>
<td>Barium Swallow</td>
</tr>
<tr>
<td>Be -</td>
<td>Beryllium</td>
</tr>
<tr>
<td>BE</td>
<td>Barium Enema</td>
</tr>
<tr>
<td>BIR</td>
<td>British Institute of Radiology</td>
</tr>
<tr>
<td>BS</td>
<td>British Standard</td>
</tr>
<tr>
<td>BW</td>
<td>Bandwidth</td>
</tr>
<tr>
<td>C/kg</td>
<td>Coulomb per Kilogram</td>
</tr>
<tr>
<td>CAT</td>
<td>Computed Axial Tomography</td>
</tr>
<tr>
<td>CAU</td>
<td>Caudal</td>
</tr>
<tr>
<td>CCD</td>
<td>Charge Coupled Device</td>
</tr>
<tr>
<td>CD</td>
<td>Compact Disc</td>
</tr>
<tr>
<td>CDR</td>
<td>Recordable Compact Disc</td>
</tr>
<tr>
<td>CEU</td>
<td>Continuing Education Unit</td>
</tr>
<tr>
<td>CHD</td>
<td>Coronary Heart Disease</td>
</tr>
<tr>
<td>CINE</td>
<td>Cinematographic</td>
</tr>
<tr>
<td>CNR</td>
<td>Contrast-to-Noise Ratio</td>
</tr>
<tr>
<td>CPR</td>
<td>Cardio-Pulmonary Resuscitation</td>
</tr>
<tr>
<td>CR</td>
<td>Computed Radiography</td>
</tr>
<tr>
<td>CRA</td>
<td>Cranial</td>
</tr>
<tr>
<td>CRT</td>
<td>Cathode Ray Tube</td>
</tr>
<tr>
<td>CsI</td>
<td>Caesium Iodide</td>
</tr>
<tr>
<td>CT</td>
<td>Computed Tomography</td>
</tr>
<tr>
<td>CTDI</td>
<td>Computed Tomography Dose Index</td>
</tr>
<tr>
<td>Cu</td>
<td>Copper</td>
</tr>
<tr>
<td>CXR</td>
<td>Chest X-ray</td>
</tr>
<tr>
<td>DAP</td>
<td>Dose Area Product</td>
</tr>
<tr>
<td>DAS</td>
<td>Data Acquisition System</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DDR</td>
<td>Direct Digital Radiography</td>
</tr>
<tr>
<td>DECUB</td>
<td>Decubitis</td>
</tr>
</tbody>
</table>
DH  Department of Health
DICOM  Digital Imaging and Communication in Medicine
DLP  Dose-Length Product
DQE  Detective Quantum Efficiency
DSA  Digital Subtraction Angiography
DTPA  Diethylenetriaminepentaacetic Acid
DVD  Digital Video Disc
Eb  Electron Binding Energy
EBCT  Electron Beam Computed Tomography
ECG  Electro Cardiogram
EPI  Echo Planar Imaging
ESR  Electron Spin Resonance
ETL  Echo Train Length
eV  Electron Volt
FA  Flip Angle
FATSAT  Fat Saturation
FDA  Food and Drug Administration
FDD  Focus to detector distance
FE  Field Echo
FFT  Fast Fourier Transform
FID  Focus to Isocentre Distance, Free Induction Decay
FOV  Field Of View
FPR  Fluoroscopy Programmed Radiography
FPS  Frames Per Second
FSE  Fast Spin Echo
FT  Fourier Transform
GCF  Grid Conversion Factor
Gd  Gadolinium
Gd2O2S  Gadolinium Oxysulphide
GE  Geometric Efficiency, General Electric, Gradient Echo
GI  Gastrointestinal
Gy  Gray
H+  Hydrogen Density
HIS  Hospital Information System
HU  Hounsfield Unit
Hz  Hertz
ICRP  International Commission on Radiological Protection
II  Image Intensifier
IM  Intramuscular
IR  Inversion Recovery, Interventional Radiology
ISO  International Organization for Standardization
IV  Intravenous
IVP  Intravenous Pyelogram
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVU</td>
<td>Intravenous Urogram</td>
</tr>
<tr>
<td>JRCERT</td>
<td>Joint Review Committee on Education in Radiologic Technology</td>
</tr>
<tr>
<td>KeV</td>
<td>Kiloelectron Volt</td>
</tr>
<tr>
<td>Kg</td>
<td>Kilogram</td>
</tr>
<tr>
<td>kVp</td>
<td>Kilovoltage Peak</td>
</tr>
<tr>
<td>LAO</td>
<td>Left Anterior Oblique</td>
</tr>
<tr>
<td>LCD</td>
<td>Low Contrast Detail, Liquid Crystal Display</td>
</tr>
<tr>
<td>LCR</td>
<td>Low Contrast Resolution</td>
</tr>
<tr>
<td>LI</td>
<td>Linear Interpolator</td>
</tr>
<tr>
<td>LIH</td>
<td>Last Image Hold</td>
</tr>
<tr>
<td>LPO</td>
<td>Left Posterior Oblique</td>
</tr>
<tr>
<td>LSF</td>
<td>Line Spread Function</td>
</tr>
<tr>
<td>LT</td>
<td>Left</td>
</tr>
<tr>
<td>LUT</td>
<td>Look Up Table</td>
</tr>
<tr>
<td>MAMMO</td>
<td>Mammography, Mammogram</td>
</tr>
<tr>
<td>mA</td>
<td>Milliamperage</td>
</tr>
<tr>
<td>mAs</td>
<td>Milliampere Seconds</td>
</tr>
<tr>
<td>MDA</td>
<td>Medical Devices Agency</td>
</tr>
<tr>
<td>MDCT</td>
<td>Multi-Detector Computed Tomography</td>
</tr>
<tr>
<td>MDD</td>
<td>Medical Device Directive</td>
</tr>
<tr>
<td>MinIP</td>
<td>Minimum Intensity Projection</td>
</tr>
<tr>
<td>MIP</td>
<td>Maximum Intensity projection</td>
</tr>
<tr>
<td>Mo</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>MOD</td>
<td>Magneto-Optical Disc</td>
</tr>
<tr>
<td>MRA</td>
<td>Magnetic Resonance Angiography</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>MRS</td>
<td>Magnetic Resonance Spectroscopy</td>
</tr>
<tr>
<td>MSAD</td>
<td>Multiple Scan Average Dose</td>
</tr>
<tr>
<td>MSCT</td>
<td>Multi-Slice Computed Tomography</td>
</tr>
<tr>
<td>MTF</td>
<td>Modulation Transfer Function</td>
</tr>
<tr>
<td>Mz</td>
<td>Magnetization Vector</td>
</tr>
<tr>
<td>NCRP</td>
<td>National Council on Radiation Protection and Measurement</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Equipment Manufacturers Agency</td>
</tr>
<tr>
<td>NEQ</td>
<td>Noise Equivalent Quanta</td>
</tr>
<tr>
<td>NEX</td>
<td>Number of Excitations</td>
</tr>
<tr>
<td>NRC</td>
<td>Nuclear Regulatory Commission</td>
</tr>
<tr>
<td>NRPB</td>
<td>National Radiological Protection Board</td>
</tr>
<tr>
<td>OBL</td>
<td>Oblique</td>
</tr>
<tr>
<td>OD</td>
<td>Optical Density</td>
</tr>
<tr>
<td>PA</td>
<td>Postero-Anterior</td>
</tr>
<tr>
<td>PACS</td>
<td>Picture Archive and Communications System</td>
</tr>
<tr>
<td>Pb</td>
<td>Lead</td>
</tr>
<tr>
<td>PBL</td>
<td>Positive Beam Limitation</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>PMT</td>
<td>Photomultiplier Tube</td>
</tr>
<tr>
<td>POSL</td>
<td>Pulse Optically Stimulated Luminescence Dosimeter</td>
</tr>
<tr>
<td>PPS</td>
<td>Pulses Per Second</td>
</tr>
<tr>
<td>PRE-SAT</td>
<td>Presaturation</td>
</tr>
<tr>
<td>PSF</td>
<td>Point Spread Function</td>
</tr>
<tr>
<td>PSP</td>
<td>Photostimulable Phosphor</td>
</tr>
<tr>
<td>PTCA</td>
<td>Percutaneous Transluminal Coronary Angioplasty</td>
</tr>
<tr>
<td>R&amp;F</td>
<td>Radiography and Fluoroscopy</td>
</tr>
<tr>
<td>RAD</td>
<td>Radiation Absorbed Dose</td>
</tr>
<tr>
<td>RAO</td>
<td>Right Anterior Oblique</td>
</tr>
<tr>
<td>REM</td>
<td>Radiation Equivalent Man</td>
</tr>
<tr>
<td>RFOV</td>
<td>Reconstruction Field Of View</td>
</tr>
<tr>
<td>Rh</td>
<td>Rhodium</td>
</tr>
<tr>
<td>RIS</td>
<td>Radiology Information System</td>
</tr>
<tr>
<td>ROI</td>
<td>Region of Interest</td>
</tr>
<tr>
<td>RPO</td>
<td>Right Posterior Oblique</td>
</tr>
<tr>
<td>RSNA</td>
<td>Radiological Society of North America</td>
</tr>
<tr>
<td>RT</td>
<td>Right / Registered Technologist</td>
</tr>
<tr>
<td>SAR</td>
<td>Specific Absorption Rate</td>
</tr>
<tr>
<td>SCP</td>
<td>Service Class Provider</td>
</tr>
<tr>
<td>SCAR</td>
<td>Society for Computer Applications in Radiology</td>
</tr>
<tr>
<td>SCR</td>
<td>Silicon Controlled Rectifier</td>
</tr>
<tr>
<td>SCU</td>
<td>Service Class User</td>
</tr>
<tr>
<td>SE</td>
<td>Spin Echo</td>
</tr>
<tr>
<td>SFOV</td>
<td>Scan Field Of View</td>
</tr>
<tr>
<td>SID</td>
<td>Source to Image Distance</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal to Noise Ratio</td>
</tr>
<tr>
<td>SONO</td>
<td>Sonogram, Sonography</td>
</tr>
<tr>
<td>SPR</td>
<td>Scan Projection Radiograph</td>
</tr>
<tr>
<td>SSD</td>
<td>Surface Shaded Display</td>
</tr>
<tr>
<td>Sv</td>
<td>Svéïvert</td>
</tr>
<tr>
<td>T</td>
<td>Tesla</td>
</tr>
<tr>
<td>TCDD</td>
<td>Threshold Contrast Detail Detectability</td>
</tr>
<tr>
<td>TDI</td>
<td>Time Delay Integration</td>
</tr>
<tr>
<td>TE</td>
<td>Echo Time</td>
</tr>
<tr>
<td>TFT</td>
<td>Thin Film Transistor</td>
</tr>
<tr>
<td>TI</td>
<td>Inversion Time</td>
</tr>
<tr>
<td>TLD</td>
<td>Thermoluminescent Dosimeter</td>
</tr>
<tr>
<td>TOMO</td>
<td>Tomography, Tomogram</td>
</tr>
<tr>
<td>TR</td>
<td>Repetition Time</td>
</tr>
<tr>
<td>UGI</td>
<td>Upper Gastrointestinal Series</td>
</tr>
<tr>
<td>US</td>
<td>Ultrasound, Ultrasonography</td>
</tr>
<tr>
<td>VR</td>
<td>Volume Rendered, Volume Rendering</td>
</tr>
</tbody>
</table>
Chapter 5: Other Diagnostic Tests

Entering Orders for Diagnostic Tests or Procedures

There are many diagnostic tests which do not fall under “lab” or “radiology”. This chapter addresses only a few of the volumes of additional tests for your review.

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, and coma. Several types of EEG are used to diagnose epilepsy, including:

- Routine EEG
- Ambulatory EEG
- Video-EEG Monitoring
Electromyography

Electromyography, or EMG, is used to diagnose nerve and muscle dysfunction and spinal cord disease. It records the electrical activity from the brain and/or spinal cord to a peripheral nerve root (found in the arms and legs) that controls muscles during contraction and at rest.

- An EMG is usually done in conjunction with a nerve conduction velocity (NCV) test, which measures electrical energy by assessing the nerve’s ability to send a signal. This two-part test is conducted most often in a hospital.
  - Patients who are preparing to take an EMG or NCV test may be asked to avoid caffeine and not smoke for 2 to 3 hours prior to the test, as well as to avoid aspirin and non-steroidal anti-inflammatory drugs for 24 hours before the EMG.
  - There is no discomfort or risk associated with this test.

Electronystagmography (ENG)

Electronystagmography (ENG) describes a group of tests used to diagnose involuntary eye movement, dizziness, and balance disorders and to evaluate some brain functions. The test is performed at an imaging center.

Evoked potentials

Evoked potentials (also called evoked response) measure the electrical signals to the brain generated by hearing, touch, or sight. These tests are used to assess sensory nerve problems and confirm neurological conditions including multiple sclerosis, brain tumor, acoustic neuroma (small tumors of the inner ear), and spinal cord injury. Evoked potentials are also used to test sight and hearing (especially in infants and young children), monitor brain activity among coma patients, and confirm brain death.

- **Auditory evoked potentials** (also called brain stem auditory evoked response) are used to assess high-frequency hearing loss, diagnose any damage to the acoustic nerve and auditory pathways in the brainstem, and detect acoustic neuromas. The patient sits in a soundproof room and wears headphones. Clicking sounds are delivered one at a time to one ear while a masking sound is sent to the other ear. Each ear is usually tested twice, and the entire procedure takes about 45 minutes.

- **Visual evoked potentials** detect loss of vision from optic nerve damage (in particular, damage caused by multiple sclerosis). The patient sits close to a screen and is asked to focus on the center of a shifting checkerboard pattern. Only one eye is tested at a time; the other eye is either kept closed or covered with a patch. Each eye is usually tested twice. Testing takes 30-45 minutes.

- **Somatosensory evoked potentials** measure response from stimuli to the peripheral nerves and can detect nerve or spinal cord damage or nerve degeneration from multiple sclerosis and other degenerating diseases. Tiny electrical shocks are delivered by electrode to a nerve in an arm or leg. Responses to the shocks, which may be delivered for more than a minute at a time, are recorded. This test usually lasts less than an hour.
Polysomnogram

A polysomnogram measures brain and body activity during sleep. It is performed over one or more nights at a sleep center. Electrodes are pasted or taped to the patient’s scalp, eyelids, and/or chin. Throughout the night and during the various wake/sleep cycles, the electrodes record brain waves, eye movement, breathing, leg and skeletal muscle activity, blood pressure, and heart rate. The patient may be videotaped to note any movement during sleep. Results are then used to identify any characteristic patterns of sleep disorders, including restless legs syndrome, periodic limb movement disorder, insomnia, and breathing disorders such as obstructive sleep apnea.

Tonometry

High pressure inside the eye is caused by glaucoma, which can damage vision if it is not treated. Tonometry is a test to measure pressure in the eyeball. During tonometry, eye drops are used to numb the eye. Then a doctor or technician uses a device called a tonometer to measure the inner pressure of the eye. A small amount of pressure is applied to the eye by a tiny device or by a warm puff of air.

The range for normal pressure is 12-22 mm Hg (“mm Hg” refers to millimeters of mercury, a scale used to record eye pressure). Most glaucoma cases are diagnosed with pressure exceeding 20mm Hg. However, some people can have glaucoma at pressures between 12 -22mm Hg. Eye pressure is unique to each person.

Ophthalmoscopy

This diagnostic procedure helps the doctor examine the optic nerve for glaucoma damage. Eye drops are used to dilate the pupil so the doctor can see through the eye to examine the shape and color of the optic nerve. The doctor then uses a small device with a light on the end to light and magnify the optic nerve. If your intraocular pressure is not within the normal range or if the optic nerve looks unusual, the doctor may ask the patient to have one or two more glaucoma exams: perimetry and gonioscopy.

Perimetry

Perimetry is a visual field test that produces a map of the complete field of vision. This test will help a doctor determine whether vision has been affected by glaucoma. During this test, the patient is asked to look straight ahead and then indicate when a moving light passes peripheral (or side) vision. This helps draw a "map" of your vision. The physician may want to repeat the test to see if the results are the same the next time. After glaucoma has been diagnosed, visual field tests are usually done one to two times a year to check for any changes in vision.

Gonioscopy

This diagnostic exam helps determine whether the angle where the iris meets the cornea is open and wide or narrow and closed. During the exam, eye drops are used to numb the eye. A hand-held contact lens is gently placed on the eye. This contact lens has a mirror that shows the doctor if the angle
between the iris and cornea is closed and blocked (a possible sign of angle-closure or acute glaucoma) or wide and open (a possible sign of open-angle, chronic glaucoma).

**Pachymetry**

Pachymetry is a simple, painless test to measure the thickness of your cornea -- the clear window at the front of the eye. A probe called a pachymeter is gently placed on the front of the eye (the cornea) to measure its thickness. Pachymetry can help your diagnosis, because corneal thickness has the potential to influence eye pressure readings. With this measurement, your doctor can better understand your IOP reading and develop a treatment plan that is right for you. The procedure takes only about a minute to measure both eyes.

**Snellen Test for Visual Acuity**

A Snellen test uses a chart with different sizes of letters or forms to evaluate your visual acuity—that is, the sharpness of your vision. The test shows how accurately you can see from a distance.

**Scratch Test for Allergies**

This test checks for a skin reaction to common allergy-provoking substances, such as foods, molds, dust, plants, or animal proteins. If your skin reacts to a substance, chances are that you are allergic to it. Some tests detect immediate allergic reactions, which develop within minutes of exposure to an allergen. Other tests detect delayed allergic reactions, which develop over a period of several days.

- **Skin prick test** - A skin prick test, also called a puncture or scratch test, checks for immediate allergic reactions to as many as 40 different substances at once. This test is usually done to identify allergies to pollen, mold, pet dander, dust mites and foods. In adults, the test is usually done on the forearm. Children may be tested on the upper back. To see if skin is reacting normally, two additional substances are scratched into the skin's surface:
  1. **Histamine.** In most people, this substance causes a skin response. If you don't react to histamine, your allergy skin test may not reveal an allergy even if you have one.
  2. **Glycerin or saline.** In most people, these substances don't cause any reaction. If you do react to glycerin or saline, you may have sensitive skin. Test results will need to be interpreted cautiously to avoid a false allergy diagnosis.

- **Skin injection test** –This method uses a needle to inject a small amount of allergen extract just into the skin on the arm (intradermal test). The injection site is examined after about 15 minutes for signs of an allergic reaction.

- **Patch test** - Patch testing is generally done to see whether a particular substance is causing allergic skin irritation (contact dermatitis). Patch tests can detect delayed allergic reactions, which can take several days to develop. Patch tests don't use needles. Instead, allergens are applied to patches, which are then placed on the skin.
Electrocardiogram (ECG or EKG)

The coordinated pumping of the heart is controlled by natural electrical currents within the heart. An EKG (sometimes referred to as ECG) measures those currents. An EKG is especially useful for diagnosing heart attacks and rhythm abnormalities, but it can also provide many clues about other conditions.

- The standard 12-lead electrocardiogram is a representation of the heart's electrical activity recorded from electrodes on the body surface. This section describes the basic components of the ECG and the lead system used to record the ECG tracings.

- Certain factors or conditions may interfere with or affect the results of the test. These include, but are not limited to, the following:
  - Obesity, pregnancy, or ascites (accumulation of fluid in the abdomen)
  - Anatomical considerations, such as the size of the chest and the location of the heart within the chest
  - Movement during the procedure
  - Exercise or smoking prior to the procedure
  - Certain medications
  - Electrolyte abnormalities, such as too much or too little potassium, magnesium, and/or calcium in the blood

Electrophysiological Testing of the Heart

An electrophysiology study (EP study) is a detailed evaluation of the electrical activity in the heart. Cardiac catheters and computers are used to create electrocardiogram (EKG) tracings and electrical measurements from inside the heart. Cardiologists can use an electrophysiologic study (EPS) to find out what part of the heart is causing a change in rhythm and what medicines will work best to bring that rhythm back to normal.

The doctor may recommend an EP study when other tests, such as a standard EKG, Holter monitor, event recorder, stress test, echo or angiogram cannot provide enough information to thoroughly evaluate the abnormal heart rhythm. Sometimes doctors will recommend a treatment called ablation that can be done during EPS testing. Ablation uses electricity to kill the cells in the heart muscle that seem to cause the abnormal rhythm.

Exercise Stress Test

The exercise stress test, also known as the treadmill test or exercise tolerance test, indicates whether the heart gets sufficient blood flow and oxygen when it's working its hardest, such as during exercise.
Often, stress tests are given to people with chest pain or other symptoms who appear to have coronary artery disease, based on a medical exam and EKG. In addition, these tests are sometimes used for other purposes, from assessing the effectiveness of heart disease treatment to gauging the safety of a proposed exercise program. Stress tests are among the best tools for diagnosing heart disease, and some research suggests that they may also be useful in estimating disease risk in people who don’t have symptoms but have risk factors such as high cholesterol.

- **A thallium stress test** is a nuclear imaging test that shows how well blood flows into the heart during exercise and at rest. A radioisotope (nuclear material) is administered intravenously. It settles into the heart muscle and pinpoints spots that are abnormal.

**Holter Monitor**

A Holter monitor is a portable EKG device that records heart rhythm over time, outside the hospital or doctor's office. The Holter monitor examines changes over a sustained period of time—usually a 24- to 48-hour period—while the patient goes about daily activities and even during sleep. Doctors use it to evaluate symptoms that come and go and that might be related to heart-rhythm changes.

**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 restrictive); 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, capacities, and flow rates can be measured.

**Bronchoscopy – diagnostic / therapeutic**

Bronchoscopy is usually done to obtain a sample of deep lung mucus or lung tissue to help diagnose cancer, pneumonia, or other lung disease. Sometimes doctors use bronchoscopy to treat lung problems. For example, the procedure might be done to insert a stent in an airway. An airway stent is a small tube that holds the airway open. It might be used if a tumor or other condition blocks the airway.

- In children, bronchoscopy most often is used to remove an object blocking an airway. Sometimes it’s used to find out what’s causing a cough that has lasted for at least a few weeks.
Researchers are studying new types of flexible bronchoscopy. They might make it easier to detect tumors and other lung problems, especially in the lungs’ small airways. These procedures also might make it easier to take fluid and tissue samples from your lungs. Newer types of bronchoscopy include:

- **Endobronchial ultrasound** - This procedure uses sound waves to create pictures of the insides your airways.

- **Fluorescence bronchoscopy** - This procedure uses fluorescent light instead of white light to look inside your airways.

- **Virtual bronchoscopy** - This procedure uses a new method of computed tomography (to-MOG-rah-fee) scan, or CT scan. Virtual bronchoscopy can create detailed pictures of your airways.

**Pleural Fluid Sampling (or Thoracentesis)**

Some infections and diseases cause fluid to accumulate in the space between the lung and the rib cage or between the lung and the diaphragm. This collection of fluid is called a pleural effusion. A pleural effusion might be detected on a chest x-ray. Sampling this fluid is important because it enables doctors to understand what caused the fluid to collect and how to treat the problem. The fluid can be sampled with a needle.

**Lumbar Puncture (LP or Spinal Tap) Diagnostic / Therapeutic**

A lumbar puncture, also known as a spinal tap, uses a needle to remove a sample of fluid from the space surrounding the spinal cord. This fluid is known as cerebrospinal fluid (CSF). The test is used to diagnose meningitis infections, such as suspected meningitis (infection of the covering of the brain and spinal cord); leukemia or lymphoma; evaluation for neurological diseases, such as multiple sclerosis, neuropathy, or recurrent seizures; fever of unknown origin. Some therapeutic approaches of LP:

- Lumbar puncture is also done by anesthesiologists to administer spinal anesthesia (also known as subarachnoid block) for some types of surgery.

- For cancer treatment, chemotherapy medications are sometimes injected directly through the lumbar puncture needle into the CSF. The medicine flows freely in the CSF and can go to the brain or spinal cord where it is needed.

**Fecal Occult Blood Test (Stool guaiac test)**

This test detects blood in the stool, which can be a sign of bleeding anywhere from the nose and mouth to the rectum, such as from an ulcer, a polyp, or cancer. If over 50, the patient should have this test annually during the years when s/he does not have either a colonoscopy or sigmoidoscopy to screen for colon cancer.
Some foods can affect test results. Do not eat the following foods for 3 days before the test:

- Red meat
- Cantaloupe
- Uncooked broccoli
- Turnip
- Radish
- Horseradish

Some medicines may interfere with the test. These include vitamin C, aspirin, and nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen.

Abnormal results may be due to problems that cause bleeding in the stomach or intestinal tract, including:

- Colon cancer or other gastrointestinal (GI) tumors
- Colon polyps
- Bleeding veins in the esophagus or stomach (esophageal varices and portal hypertensive gastropathy)
- Inflammation of the esophagus (esophagitis)
- Inflammation of the stomach (gastritis) GI infections
- Hemorrhoids
- Inflammatory bowel disease
- Peptic ulcer

Other causes of positive test may include:

- Nosebleed
- Coughing up blood and then swallowing it.

**Colonoscopy**

Order for bowel prep is important for patients prior to colonoscopy procedures. An endoscope is passed through the anus and all the way up through the entire colon (also called the large intestine) so the doctor can see any abnormalities. This screening test is used to find early cancers and potentially cancerous polyps (growth on the colon lining). With colonoscopy, the doctor can immediately remove polyps and take biopsies of suspicious tissue.

- **Flexible Sigmoidoscopy** - Sigmoidoscopy uses an endoscope to look inside the lower portion of the large intestine. The endoscope used for this test is about a half-inch wide and long enough to reach about two feet into the colon. A sigmoidoscopy can detect early cancers as well as polyps that could later become cancerous.

- **Virtual colonoscopy (VC)** - is an imaging or x-ray test that looks for cancer, polyps, or other disease in the large intestine (colon). Virtual colonoscopy is done in the radiology department of a hospital or medical center. No sedatives are needed and no colonoscope is used.
Upper Endoscopy (Esophagastroduodenoscopy or "EGD")

This test inspects the esophagus and stomach using an endoscope. An upper endoscopy allows the doctor to explore the cause of such symptoms as difficulty swallowing, abdominal pain, vomiting up blood, or passing blood in the stool. It can also diagnose irritation, ulcers, and cancers of the lining of the esophagus and stomach. During this type of endoscopy, the doctor can also take biopsy samples of tissue. A computer combines all the images to form three-dimensional pictures of the colon. The doctor can then view the images on a video monitor.

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 analyses are the most common:

- **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.

- **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.

- **Tubeless Gastric analysis** - This test is for screening purposes only for the presence of hydrochloric acid in the stomach and is performed by administering a gastric stimulant such as caffeine or histalog.

- **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 stimulation 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 is rarely performed any more.

Hysteroscopy (Operative hysteroscopy, Uterine endoscopy, Uteroscopy)

Hysteroscopy gets its name from the tool used to view the womb. This tool is called a hysteroscope. It is a thin, lighted tube. It sends images of the inside of the womb to a video monitor. Small tools can be used through the scope to remove abnormal growths or tissue for examination.
Certain treatments, such as ablation, can also be done through the scope. Ablation uses heat, cold, or electricity to destroy the lining of the womb. Another treatment that can be done through the scope is called the Essure procedure. This places coils into the fallopian tubes to block them.

**Amniocentesis**

Amniocentesis involves using a needle to take a sample of amniotic fluid, the fluid that surrounds a developing fetus during pregnancy. Tests of fetal cells found in this fluid can reveal the presence of Down syndrome or other chromosome problems in the baby. Amniocentesis can also show whether the lungs of the baby are mature enough to allow it to survive if it were delivered right away.

Amniocentesis is often recommended for pregnant women over age 35, women who have an abnormal “triple screen” blood test during pregnancy, or women who have (or whose husbands have) a family history of certain diseases or birth defects. Amniocentesis is most often offered to women who are at increased risk for bearing a child with birth defects. This includes women who:

- Will be 35 or older when they give birth
- Had a screening test result that shows there may be a birth defect or other problem
- Have had babies with birth defects in other pregnancies
- Have a family history of genetic disorders

This test:

- Is a diagnostic test, not a screening test
- Is 99% accurate for diagnosing Down syndrome
- Is usually done between 14 and 20 weeks
- Is used to diagnose many different gene and chromosome problems in the baby, including:
  - Anencephaly
  - Down syndrome
  - Rare, metabolic disorders that are passed down through families
  - Other genetic abnormalities, like trisomy 18

**Chorionic Villus Sampling**

Chorionic villi are small structures in the placenta that act like blood vessels. These structures contain cells from the developing fetus. A test that removes a sample of these cells through a needle is called chorionic villus sampling (CVS). This transabdominal procedure is performed by inserting a needle through the abdomen and uterus and into the placenta. Ultrasound is used to help guide the needle, and a small amount of tissue is drawn into the syringe. The sample is placed in a dish and evaluated in a laboratory. CVS answers many of the same questions as amniocentesis about diseases that the baby might have. Diseases that can be diagnosed with CVS include Tay-Sachs, sickle cell anemia, cystic fibrosis, thalassemia, and Down syndrome. (Rh incompatibility and neural tube defects, however, can be diagnosed only through amniocentesis.)

CVS can be done earlier in pregnancy than amniocentesis and can be done when there is not enough amniotic fluid to allow amniocentesis. However, it has some extra risks when compared with amniocentesis.
Cystoscopy

A long, flexible, lighted tube, called a cystoscope, is inserted into the urethra and advanced into the bladder. In addition to allowing visualization of the internal urethra and bladder, the cystoscope enables the doctor to irrigate, suction, and access these structures with surgical instruments. The urologist can also instill substances into the bladder using the cystoscope.

During a cystoscopy, the doctor may remove tissue for further examination (biopsy) and possibly treat any problems that may be detected. The cystoscope can also be used to instill saline or water into the bladder. There are two types of cystoscopes:

- Standard, rigid cystoscope
- Flexible cystoscope

The way the cystoscope is inserted varies, but the test is the same. The physician orders a cystoscopy to:

- Check for cancer of the bladder or urethra
- Diagnose and evaluate urinary tract disorders, polyps, bladder stones
- Diagnose repeated bladder infections
- Help determine the cause of pain during urination

Bibliography

- American Heart Association
- ECG.Utah.edu
- Cleveland Clinic.org
- Glaucoma.org
- Harvard health education
- Heart.org
- Hopkins Medicine.org
- JAMA, October 25, 2006—Vol 296, No. 16
- Medline Plus
- Practical Clinical Skills

IT IS TIME TO REVIEW TERMS AND ABBREVIATIONS USING “QUIZLET” LOCATED ON YOUR COURSE PAGE, THEN PASS THE PART 1 ONLINE QUIZ

(PASSING IS 80%, BUT YOU CAN RETAKE THE QUIZ OVER AND OVER – THE TESTING SOFTWARE WILL REGISTER YOUR HIGHEST SCORE)

Your course continues after successfully completing the Online Quiz with focus on pharmacology and order entry of medications.