Imaging techniques in medical science

Electrodiagnostics

Electrodiagnosis is the field of study that utilizes the science of electrophysiology. Specifically, electrodiagnostics study the human neurophysiology through the utilization of electrical technology. Neurodiagnostics, evoked potentials and electromyography are aspects of electro diagnosis.

Electromyography was the first electrodiagnostic examination to be developed. The procedure involves the placement of needles to several muscles to record various stages of muscle activity, minimal contraction, maximal activity and even rest. A normal muscle is electrically silent when at rest. Spontaneous depolarization of individual muscle fibers results from damaged muscle tissue. The mentioned alterations can be detected through the needle examination portion of electrodiagnostic examination. [122]

No special preparation is generally necessary. Avoid using any lotions or creams on the day of the examination. Temperature could affect the result of the test hence if the temperature is cold; the patient should wait in a warm room for a while before the test is conducted.

One concern with electromyographic testing is that needles are utilized and it could be painful. However, the new computerized technology permits the usage of needles that can records so that small insertion of it feels lesser painful than the insertion of a normal size needle. Needles with small gauge can be used, because nothing is aspirated or injected. A troublesome trend is the performance of nonphysician health care personnel in electromyographic testing. Interpretation of electromyograms and performance of

electromyography needs enough technical skill and capability to assimilate physician’s understanding. [121] In a study conducted by Rathinaraj and colleagues regarding the efficacy of spinal segmental stabilization exercise program and the efficiency to improve the muscular activity and pain reduction which is assessed through electromyography because limited studies are conducted using electromyography as an assessment parameter of muscular activity. Their study showed that exercise play a vital role in alleviating low back pain particularly in the mechanical back pain brought by spinal instability, which needs spinal segmental stabilization exercise program. Positive progress in muscular activity and pain reduction proves the exercise program.

History of low back pain is associated with higher baseline muscle activation and that electromyography responses are modulated from this activated state, rather than showing acute burst activity from inactive state, perhaps to prevent trunk displacements.

Nerve conduction studies are essential part of the complete electrodiagnostic examination. [123] In a nerve conduction studies, the contraction is caused by the electrical charge distributed to the nerves in the periphery. An electrode capable of recording is posited on a muscle innervated by the specific nerve, and information about impulse can be recorded including its latency. Latency is the time required for an impulse to travel from stimulus to the recording. Nerve conduction velocity and the distanced traveled can also be computed. The said measures are important gauge of damage to the nerve which specifically tests the integrity of the

myelin sheath of the nerves. The nerve conduction studies and needle examination are key components of a complete electromyographic examination. The amplitude of the contraction of the muscle can be compared signal's initial size thus providing information regarding the number of functional neurons that consists the nerve.

Nerve conduction study is also referred as nerve conduction velocity test. During this procedure, two electrodes will be attached to the surface of the skin. One electrode will stimulate the nerve while the other one will record it. The speed of nerve conduction studies is associated to the degree of myelination and diameter of the nerve. A nerve functioning normally transmits a stronger and faster impulse than an altered nerve. It is like an electric wire with plastic or rubber insulation around it. Generally the range of normal conduction velocity is 50 to 60 meters per second. However, the normal conduction velocity may be different from one nerve to another and one individual to another. Nerve conduction velocity test is commonly conducted along with electromyography. A condition that may be examined with nerve conduction studies includes Carpal tunnel syndrome, Guillain-Barre Syndrome, Charcot-Mari-Tooth syndrome, herniated disc, neuropathy, polyneuropathy, sciatic nerve problems and peripheral nerve injuries. Nerve conduction study techniques specifically include motor nerve conduction studies and sensory nerve conduction studies. Sensory nerve conduction studies are normal when focal sensory loss is due to nerve root damage for the nerve roots are proximal to the nerve bodies in the dorsal ganglia. [33]

Evoked potentials or evoked responses, measures the electrophysiologic responses of the nervous system to different stimuli. Theoretically, almost

any sensory modality can be tested, however in clinical practice only few are used in routine basis. [208] Evoked potentials demonstrate abnormal sensory function when the neurologic test results do not reveal abnormalities. It reveals clinically unsuspected pathology when demyelinating disease is suspected. It determines the anatomic distribution of a disease process and it objectively monitors the condition whether the patient is progressing or not. [125]

Visual evoked potential examines the function of the visual pathway beginning from the retina going to the occipital cortex. It specifically measures the capacity of the visual pathways to conduct from the optic nerve, to theoptic chiasm and optic radiations going to the occipital cortex. Brainstem auditory evoked potentials measure the function of the auditory nerve and auditory pathways in the brainstem. [124] Somatosensory evoked potential is a diagnostic test to assess the speed of impulse conduction across the spinal cord. The said methodology is consists of using electrical stimulus in the nerves of arms and legs measuring the impulse generated by different points in the body.

Electrodiagnostics is utilized to examine lumbosacral radiculopathy potentially underlying low back pain. The examinations serve as an extension of the physical examination and clinical history furthermore it complements the neuroimaging studies. Among the common low back pathologies amenable to electrodiagnostic studies include spinal stenosis and lumbosacral disc herniation. The electrodiagnostics can help in the decision making processes when considering surgical management. [126]

Electrodiagnostic studies are essential part of the diagnostic evaluation when the physical examination or history suggests that neural structures may contribute as symptom generators. Lumbosacral radiculopathies, peripheral nerve injuries and plexopathies are of primary concern when examining patients having low back pain. The study assists in quantifying neurophysiologic injuries and alterations using the said techniques.

Bone Scan

A bone scan shows the images of metabolic activity of the skeleton. Conventionally, it is accomplished by imaging radionuclide whose physiology closely resembles a metabolic activity within the bone. Nuclear scintigraphy of the bone generally uses the radionuclides fluoride-18 (F-18) or technetium-99m (Tc-99m). Tc-99m is commonly attached to medronic acid (Tc-99m MDP) and F-18 incorporated into sodium fluoride (F-18 NaF). The molecules are injected intravenously while a nuclear camera that contains salt crystal captures the decay of photons from radioisotope. This is attained through the process of fluorescence or scintillation that occurs when the photon released by the radionuclide hits the salt crystals within the nuclear camera. The scintillations are converted to images for interpretation by nuclear medicine specialist. [127] A bone scan is used utilized to: [143]

1. Diagnose a bone tumor or neoplasms
2. Ascertain if a cancer already metastasizes to the bones. The common cancers that could spread to the bones include breast, lung, prostate, thyroid, and kidney.
3. Diagnose a fracture, especially if it cannot be seen on a plain x-ray

4. Rule-out osteomyelitis or bone infection
5. Determine or diagnose the etiology of bone pain, when no other cause has been recognized
6. Assess metabolic disorders, such as renal osteodystrophy, osteoporosis, osteomalacia, primary hyperparathyroidism, complex regional pain syndrome, and Paget's disease

Bone scans are useful in a wide range of conditions. A common reason to have a bone scan is for examination of pain, in which bone scan can assist in identifying whether the source of the pain if from bone pathology or form soft tissue trauma. There are no specific preparations needed for radionuclide bone scan when using the tracer that map calcium metabolism, F-18 NaF or Tc-99m MDP. Patient should continue take their medications normally and eat normally. It is helpful to stay hydrated since the radiotracers are eliminated through the urine. Bone scans were known to emit much more radiation than CT and radiography. It must be kept in mind when considering whether or not to perform scans on a child. [108]

Before the bone scan, the patient should make it known if she is or might be pregnant and if she is breast feeding. The patient can use formula for 1 to 2 days after the scanning to wait until the radioactive tracer is gone from the body. The patient should report to the doctor if he or she have had an X-ray test utilizing barium as a contrast material, such as a barium enema or have taken a medication that contains bismuth within the past 4 days because barium and bismuth can interfere with test results of the scanning. The patient should limit his or her fluids for up to 4 hours before commencing the the test for the patient will be instructed to drink extra fluids after the

injection of the tracer. The patient will empty his or her bladder right before the scan. Most probably the patient will have to wait for at least 1 to 3 hours after the injection of the tracer before your bone scan is done. [144]

The images produced by the bone scan should depict that the radioactive material has been distributed evenly all over the body. There must be no areas of increased or decreased distribution. “ Hot spots” are portions with an increased distribution of the radioactive material. On the other hand “ cold spots” are areas that show lesser of the amount of radioactive material. [143]

Many false-positive results can be expected among older adults. Discitis, osteomyelitis, metastatic disease, rheumatoid arthritis, degenerative spondylosis and ankylosing spondylodis may result in abnormal findings in the spine that are not directly related to acute trauma. False-negative results may occur in the first hours after acute trauma. If possible, 72 hours should be allowed to pass prior to nuclear bone scanning of the lumbar spine is attempted. [127]

Thermography

Thermography is a noninvasive procedure that images infrared radiation (heat) released by the body surface. It is based on the principle that alterations in different of body functions alter the cutaneous vascular supply. Pain is a complicated phenomenon that cannot be simplified to a direct correlation with cutaneous heat production. Thermography. Thermography does not take a picture of pain itself; it does reveal pathophysiologic

conditions related with soft tissue, circulatory neurovascular and musculoskeletal disorders. There are two type of thermography. It includes liquid crystal or contact and electroninc or noncontact thermography. [129]

The contact thermography utilizes cholesterol crystals that changes in color with the variations of surface temperature. The crystals are placed inside inflatable transparent boxes with one thermosensitive, flexible side that is applied to the body of the individual. Each of the boxes has a limited temperature range and its utilization for examination requires proper selection of the box with accompanying proper temperature range. An image is taken of the box to record the patterns of surface temperature. The box is chosen by trial and error method. The advantage of contact thermography includes the absence of radiation, much lower cost than electronic thermography and much easier to use. Electronic thermography uses an infrared radiation sensor that converts heat reading to electrical signals that are displayed on a black-and-white or colored monitor. A picture can be taken from the video screen. It can be also stored on a computer. This system has the advantage of viewing large areas of the body during a single examination. Examinations must be conducted in an air-conditioned, draft-free room. The ambient temperature must be between 68 degrees to 72 degrees Fahrenheit. The patient should also be instructed to refrain from cigarette smoking for the day of the test. Furthermore, the patient should refrain from taking pain medications, physical therapy and exposure to sunlight for at least 24 hours. The patient must be in equilibrium with room temperature for 30 to 60 minutes before the beginning of the procedure. The examination will be postponed if the patient is febrile. [129]

The examination of lumbosacral spine and lower legs with contact thermography consists of individual images of buttocks, posterior and lateral thighs, lower legs, dorsa of the feet, and toes. The examination requires 1 to 2 hours to complete. Abnomalities in the physiologic temperature distribution pattern also indicates alterations. Acute pain is said to be associated with increased heat whereas chronic pain is related to decreased temperature. Increased temperature is found over areas involved in an inflammatory process. Studies have stated a close correlation between abnormal thermograms and surgically proven discs. Investigators have also found that patients with disc herniation have a thermography and myelography accuracy rate of 95% and 84% correspondingly. [214] Thermographic findings correlated with magnetic resonance, myelography and computed tomography abnormalities in 94%, 80% and 84%. Twenty two magnetic resonance scan of patients with prolapsed of the disc associated with nerve root lesion, 95% of them had leg abnormalities on thermography. [129]

There is a good relationship between changes in symmetry of heat patterns and changes in pain intensity for most of the disorders that causes chronic pain. Thermography has been reported to useful in differentiating pain-free from pained subjects reporting back pain, knee pain, and leg pain. Thermography consistently indicates painful areas among patients with spinal cord injury.

Ultrasound Imaging

Ultrasound is a type of imaging which uses high-frequency sound waves to look at visceral organs and structures of the body. Ultrasound imaging of the musculoskeletal system is painless and safe. It is also called as ultrasound scanning or sonography. It involves the use of a probe or small transducer and ultrasound gel placed directly on the surface of the skin. The transducer transmits high-frequency sound waves through the gel into the body. Then, the transducer utilizes the sounds that bounce back and use them to create images in the computer. There is no risk for radiation because ultrasound imaging does not utilize ionizing radiation like what is used in radiography. Since sonographic images are captured in real-time, they can show the structure and the body’s internal organ movements, including the blood flow through the blood vessels. Ultrasound imaging is noninvasive medical test that aids physicians diagnose and treat medical disorders. Musculoskeletal ultrasound provides pictures of muscle, ligament, tendons, joints and soft tissue throughout the body. [142]

Ultrasound images are commonly used to help diagnose certain musculoskeletal conditions such as: tendon tears; muscle tears, masses or fluid collections; tears or sprain of ligaments; fluid effusion or inflammation; early alterations caused by rheumatoid arthritis; nerve entrapment; ganglionic cysts; benign and malignant soft tissue tumors; hernias; foreign bodies; and dislocations. [142]

Patients should be instructed to wear loose-fitting, comfortable clothing for the examination. The patient may be required to remove some of the clothing and accessories in the area to be examined. Ultrasound

examinations are sensitive to motion. An active or crying child can lengthen the examination process. No other preparation is required. Musculoskeletal ultrasound evaluation is usually completed within 15 to 30 minutes but can take longer. Ultrasound may have difficulty penetrating the bone, hence only the outer surface can only be viewed. There are also limitations on the depth the sound waves can penetrate, thus deeper internal structures of larger patients may not be seen easily. [142]