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Great advancements in medicine

Imaging Techniques for the Nervous System

By Lloyd Maimer, M.D.

One of the great advancements in medicine, which only occurred in the last century, was the use of x-rays or roentgenograms to image the body. This was the first time the inside of the body could be viewed without making an incision. Of course early x-rays were quite crude, even dangerous since overexposure to radiation was not yet known. Now it is common knowledge that exposure to x-rays should be limited, but how many people remember shoesizing fluoroscopes. Since those early days of x-rays, imaging techniques have improved dramatically. The most dramatic improvements have occurred in the last 25 years due to computer developments, giving us CT and MRI. Despite all these improvements there are still many limitations ensuring modern medicine remains more an art than an exact science.

The basic roentgenogram is still quite useful. This imaging technique uses x-rays, which are a form of electromagnetic radiation, as are visible light waves and radio waves. An x-ray picture is based on the principle that x-rays are able to pass completely through the body, unlike visible light waves. Some of the x-rays are blocked by the body tissue, and the amount blocked is dependent on the density of the tissue. Therefore bone, which is the densest, blocks the most x-rays, as opposed to skin or muscle. The picture is formed by looking at the x-ray 'shadow' made by the object in the x-ray beam. This is the same concept as making shadow figures with a light projector (Figure 1).

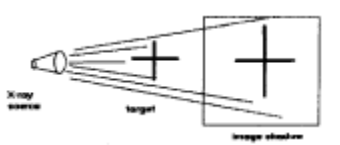


Figure 2: The x-ray image is the shadow caused by the dense object blocking the x-rays.

There are three major drawbacks to the simple roentgenogram, which is the most basic x-ray technique. One problem is that x-rays cause radiation damage to living tissues. Modern machines generally expose the patient to less radiation per picture than occurs naturally over a year from such things as cosmic rays. Unfortunately the radiation damage is cumulative, meaning it is not only important how much exposure occurs at one time, but over a lifetime. This is a particular problem for pregnant patients, as the early fetus is very susceptible to radiation injury. The only way to fully avert radiation concerns is to not use x-rays.

Another drawback is that x-rays only show bones well, which is not always the problem. A regular x-ray is inadequate if we need to see the brain or spinal cord. This has led to the concept of injecting something into the body to make the areas of interest more apparent with x-ray. In the old days they would inject air into the brain cavities in a very unpleasant procedure called a "pneumoencephalogram". The air acts the opposite of bone, it blocks very little of the x-rays, in the same way glass blocks very little of regular light. The result would be that the air pockets are more obvious than the skull, giving a "reverse shadow" image of the brain. As this description implies, this is a crude imaging technique that is not really done anymore. The pneumoencephalogram was replaced by the arteriogram or angiogram, another x-ray technique involving injections.

The angiogram is a study that is still widely used today throughout the body. This technique involves injecting an iodine-based contrast agent into the blood vessels. The contrast material is very dense, denser than bone, and therefore shows up very well on x-rays. Basically the contrast allows the blood vessels to be seen on x-rays. In the brain, the brain tissue can be inferred from the position of the blood vessels, since the blood vessels have a fairly reliable pattern. There are modern imaging techniques that are better at showing the brain and other soft tissue anatomy, but the angiogram is still the best way to see the blood vessels themselves. In the neurosciences the angiogram is used to detect cerebral aneurysms, vascular malformations, and carotid stenosis. (Figure 2).

There is another x-ray technique involving a contrast injection that is still used today, the myelogram. This technique involves the injection of an iodine-base material into the cerebral spinal fluid, which surrounds the spinal cord and nerve roots. Myelograms were developed years ago using an oil-based contrast agent that had to be removed at the end of the study to prevent nerve scarring. Now the contrast agent is water-based and much safer, but it still involves a lumbar puncture, which is inserting a needle between the vertebrae. This procedure is not the most enjoyable test, and a severe headache is a fairly common side effect. The myelogram is another technique that gives a "reverse shadow" of the areas of interest, which in this case are the spinal cord and nerve roots. This means that the anatomy is inferred but not directly seen.

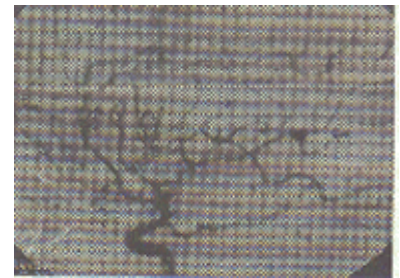


Figure 2: Cerebral angiogram, lateral view.

This lack of detail on roentgenograms is another drawback to the studies based on the simple x-ray view. All that is seen is the shadow, not the details. For instance, two boxes that differ only in their width will have the same shadow if directly in front of the projector (Figure 3). This is useful for showing the general alignment of bones, such as with the spinal column, but limiting. In order to see an entire bone at least two views are required, and even then perspective is tricky. (Figures 4a and 4b) Overall, x-rays are most useful for looking at bones. Even today there is nothing better for evaluating a broken arm or leg. Roentgenograms can also give an idea about the character of the bone density, which is important for osteoporosis or cancer. Unfortunately once the pathology becomes complicated, simple x-ray views become inadequate.

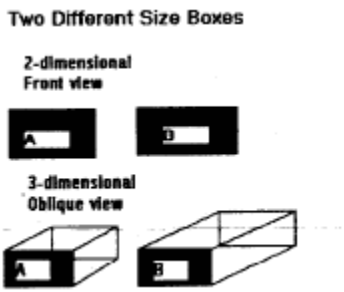


Figure 3: The loss of detail with perspective in 2 versus 3 dimensions.

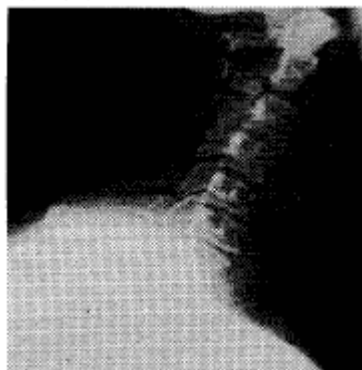


Figure 4a: Lateral or side x-ray view of cervical spine.

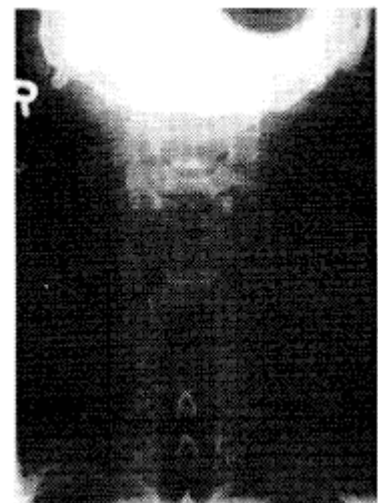


Figure 4b: Front or anterior-posterior x-ray of cervical spine.

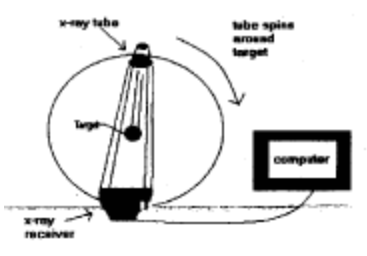


Figure 5: A CT Scanner takes multiple x-rays around the target and the computer combines the images.

This problem of lack of detail with x-ray techniques was overcome with the development of computer tomography (CT or Cat) scanning. A CT scan still relies on x-rays, but uses a computer to generate a more detailed two-dimensional image. A CT scanner is an x-ray tube that spins around the target, basically obtaining multiple "single shot" pictures through a section of the target. The computer then "adds" the pictures together to give a single two-dimensional view through the volume of the target. (Figure 5) Going back to our example of the two different size boxes, the CT scan can now show that the boxes are different, at least in width. In fact, the CT scan can even show what is in the boxes, unless they are lead lined. That is, the CT scan can show the soft tissues of the body as well as the bone. It does this because the computer "adds up" the subtle shadows from the soft tissues to give a meaningful picture. With CT we were finally able to look inside the skull and see the brain, or inside the spine and see the spinal cord and nerves.

Unfortunately CT does have limitations. It is based on x-rays, so the previously mentioned shortcomings still exist. There are still the radiation concerns, though admittedly a CT results in a very low exposure for each study. The entire process is still based on x-ray "shadows", so we do not see the actual tissues. This means the CT can show an abnormal mass in the brain, but not type of mass. A little more information about the tissue can be obtained by injecting contrast into the vasculature, just as with the angiogram. On the other hand, the soft tissue detail can be particularly bad when adjacent to thick bone. This occurs at the base of the brain and with the entire spinal cord. The thick bone basically "shadows" the other tissues. Since CT is based on x-rays, it is still best for bone detail. A final issue is that CT gives a two-dimensional image and we live in a three-dimensional world.

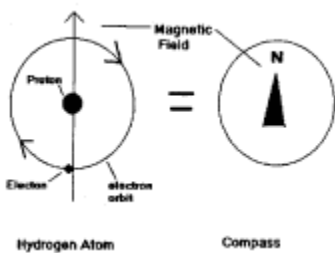


Figure 6: The spinning electron of a hydrogen atom acts like a magnet in a small compass.

The newest imaging technology, and the best for general anatomic detail, is Magnetic Resonant Imaging, or MRI. This breakthrough technology was developed in the 1980's and has continued to improve. One aspect of MRI's advantage over earlier techniques is that there are no x-rays involved. MRI is based on another form of electromagnetic radiation that has no known effect on living tissues, magnetic waves. The physics behind MRI is that a revolving electron generates a magnetic field. This is commonly seen in an electromagnet, which is basically a coil of wire hooked up to electricity. On the atomic scale, the electron of an atom also generates a magnetic field, albeit a very small one. (Figure 6) The second part of the physics is that an atom behaves differently depending on its neighbors. That means a hydrogen atom by itself acts differently than a hydrogen atom in water, which is different than a hydrogen atom in sugar. The way we detect these differences is by observing the hydrogen atom's reaction to external energy. So the MRI machine somehow combines the properties of an individual atom's magnetic field and its reaction to external energy stimulation to determine what type of material is being evaluated.

This process is simplified a little by having the machine only look at hydrogen atoms, which are mostly associated with water (H₂O), a very plentiful substance in living tissues. The machine first aligns all the hydrogen atoms by using a very big magnet to affect all the hydrogen atoms' little magnetic fields. Just imagine that each hydrogen atom is a little compass and you are putting them near a big magnet. Then the machine inputs energy to the atoms in the form of a radio wave. The atoms react by "absorbing" the energy momentarily, then re-emitting the energy as another radio wave. It is this re-emitted signal that is characteristic for the individual hydrogen atoms' surroundings. The MRI machine detects these re-emitted signals and then uses a computer to assemble the information into an understandable image. (Figure 7).

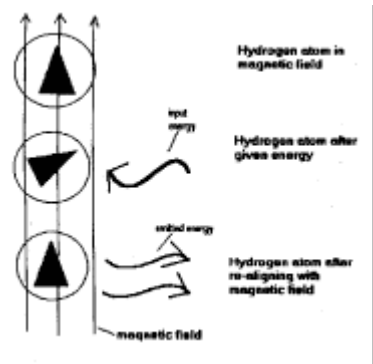


Figure 7: Each hydrogen atom reacts to input energy differently depending on its neighboring atoms.

This process is performed with patients on a grand scale. The patient is placed inside a large magnet that looks like a tight tunnel. Once inside, the machine "shoots" radio waves at the patient, (which do not hurt). The entire process usually takes around thirty minutes for each target, which is a vast improvement from ten minutes per slice in the original machines. The experience is not painful, but the claustrophobic atmosphere of the tight tunnel and loud noise bothers some patients. Recently differently configured magnets called "open MRI" have been introduced to make the

experience less intimidating. These do make the test more palatable to the claustrophobic, but they result in poorer quality images. The end result in any machine is a series of anatomic "slices" of the body part in question. These images would be nothing short of miraculous to a physician a century ago. In fact, the images are so revealing that the study of anatomy itself has been enhanced. Each slice is two-dimensional, but the MRI is performed in several planes so each body portion is seen from various angles, which is not the case with CT.

Of course there are always limitations. It is still not the machine of science fiction that images the whole body at once. A single body part, such as the neck or right knee is targeted. The MRI is best at imaging tissues with higher water content, which means that bone anatomy is not as well defined (the opposite of x-ray technology). Any metal in the body, such as a bone screw, can distort the images beyond use. It is because of this concern that as MRI has become common, the metal used for implants has changed from steel to titanium, which causes much less artifact. Functioning implants, such as pacemakers, will malfunction in the strong magnetic field of a MRI excluding patients with such implants from any MRI studies. In fact, the magnetic field is so strong that small metal particles inside the body can be moved, meaning patients with metal fragments in delicate places such as the eyes cannot have an MRI performed. The MRI's use of magnetic waves means there are no radiation concerns, but we are not entirely sure of the effects of strong magnetic fields on living tissues. The effect is minimal, if at all, but this still is a concern for the developing embryo. Therefore a MRI during pregnancy is done with caution.

Even though the MRI is so good at showing the internal anatomy non-invasively, there is still the occasional need to inject a contrast agent intravenously. As opposed to the iodine-based contrast of x-ray studies, MRI contrast is iron-based. The concept behind MRI contrast is similar to CT contrast; it better defines more vascular tissues. This allows better delineation of the blood vessels themselves, and even functions as a crude angiogram. The contrast also helps define lesion pathology depending on its vascularity. Despite the detail provided by the images, the cellular pathology is not necessarily obvious even with MRI. This means that a tumor can be detected, but not necessarily whether or not the tumor is a cancer.

The MRI, along with the CT scan, angiogram, myelogram, and plain roentgenogram comprise the majority of imaging techniques used today for evaluating the human patient, especially for neurological disease processes. Which of these techniques is best depends on the problem. The MRI gives the most information for the brain, spinal cord, and nerves. However, if a fracture is suspected, then perhaps a roentgenogram or CT is more appropriate. If a cancer is found, then both MRI and CT may give complimentary information, especially for surgical planning. On the other hand, if the problem is more obvious, such as an acute muscular back sprain, then all these tests are not only unnecessary, but also not helpful. The truth is, sometimes too much information can be confusing. Sometimes "abnormal" pathology is found on MRI that though "abnormal", is not causing any trouble. A common example is the notorious "bulging disc", which is a type of "abnormal" pathology that should be more appropriately called a "normal variant". When deciding on which tests are indicated the physician must consider the possible negative effects of the test, such as radiation exposure; the use of the information found, such as possible surgical intervention; and even the cost of the test, over one thousand dollars for a MRI or CT scan. Again, as opposed to the science fiction scenario, each test should be used only as necessary. Even in the 21st century, every student of the art of medicine learns that the best diagnostic tool is listening to the patient.

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Essential Tremor: All that shakes is not Parkinson's Disease

By John Tanner, M.D.

Classic essential tremor is a condition in which the upper limbs and to a lesser extent the head, face, voice, trunk, and legs exhibit a tremor without other neurologic abnormalities. It is thought that essential tremor is inherited as an autosomal dominant disease. The prevalence of essential tremor in the population over age 40 is up to 5%.

The type of tremor seen is described as fairly rhythmic that occurs when a limb is held motionless against the force of gravity or when the limbs moves in a voluntary movement toward a target. These type of tremors are called postural and kinetic action tremors respectively. The frequency of these tremors range from 4 to 12 Hertz. They are usually bilateral and symmetric.

In contrast a tremor that occurs in the arms or legs when a limb is at rest when no skeletal muscle activation or contraction occurs is called a resting tremor or a tremor in repose. This tremor is the classic Parkinsonian tremor.

Essential tremor occurs without any other neurologic abnormality. There is no weakness, no rigidity, no slowing of movement of the body. In contrast, Parkinsonism has resting tremor, rigidity, and bradykinesia. The bradykinesia, rigidity and rest tremor causes instability of gait as well in Parkinson's disease.

Other tremors that are neither Parkinson's disease nor essential tremor might include the rubral tremor as a result of midbrain dysfunction from stroke. This is an interesting tremor that combines the resting tremor with the postural and action kinetic tremor. Another tremor, as a result of damage to the cerebellum, causes a severe goal directed action tremor. These may be unilateral. Many medications and metabolic diseases such as thyrotoxicosis can cause enhancement of normal physiologic tremor.

Conditions that might be confused with essential tremor would include action myoclonus, focal dystonia, and asterixis.

Pharmacological treatment for essential tremor is important as this type of tremor can cause functional disability. Options for drug therapy include two drugs that have been shown to be most efficacious, Primidone and Propranolol. These drugs typically reduce the tremor amplitude but not the tremor frequency. Interestingly, patients with essential tremor often report that small amounts of alcoholic beverages transiently cause a dramatic reduction of their tremors. Generally, treatment for essential tremor includes Propranolol and Primidone, either one in monotherapy or can be used together in smaller doses increasing the doses to benefit.

Other treatments for specific circumstances might include botulinum toxin. In extreme situations where drugs fail to reduce the disability associated with essential tremor surgical options such as thalamotomy or thalamic electrical stimulators can be considered.

Essential tremor is a common movement disorder. It is a disorder of too much movement in contrast with Parkinson's disease which is a disorder of not enough movement. The tremors of the two diseases are quite different. Diagnosis of the proper movement disorder determines the medication treatment. Essential tremor responds well to Inderal and Primidone for the vast majority of patients.

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Now available in Polk county

New spine fracture repair technique

By Lloyd Maliner, M.D.

Vertebroplasty Approved for use in Osteoporotic and Metastatic Fractures

Finally there is promising option for the unfortunate victims suffering from painful vertebral compression fractures due to either osteoporosis or metastatic cancer. Until recently the only options for the incapacitating pain were narcotic pain medication and a brace, which are both less than optimal. The medication doses required to afford any level of comfort are often high enough to keep the patient incapacitated due to sedation. The medications also have the side effects of nausea and constipation, which are problematic in these already medically challenged patients. The braces are rarely sufficiently helpful and themselves are nuisances, especially in our warm climate.

Now percutaneous vertebroplasty, a technique considered new in this country, though it has been offered for over ten years in Europe, promises a release from the suffering of compression fractures in select patients. It is the fairly simple concept of injecting bone cement into a collapsed vertebra. This technique partially fills the collapsed bone with cement, though it does not return it to a normal shape. The concept may seem obvious, but the truth is we still are not sure why it relieves the pain. The two major theories are that the cement strengthens the collapsed bone, or that the cement kills off the pain-sensing nerve endings. In any case the relief is usually immediate and dramatic.

For the procedure the patient lies on their belly. Intravenous sedation is used to keep the patient comfortable and make the entire experience more palatable. Under x-ray guidance a needle is introduced through the skin and into the vertebral body. Then, again using x-ray guidance, special bone cement that is visible under x-ray is slowly pushed into the vertebral body. It usually takes two needles per vertebral body, one on each side. Two to three vertebral bodies can be done at a single session. Each vertebral body takes between 30 - 60 minutes to complete. Once the procedure is completed the patient recovers from their sedation and then goes home. No stitches, no braces, no pain.

Of course there are always risks to a procedure, some of which are not always intuitive. The more obvious risks include infections and bleeding. There is the possibility of cause a nerve injury, spinal cord injury, or spinal fluid leak during placement of the needle. There is also the risk of paralysis from the cement leaking through the bone and surrounding the spinal cord and nerves. This is more likely to happen if the fracture involves the posterior aspect of the vertebral body, which is adjacent to the neural elements. The unintuitive risk is for the cement to flow into the venous system and then into the lungs. This can happen because the vertebral bodies often have a rich blood supply with a fairly surprising flow. Of course cement plugs in the lungs are not good, even potentially fatal. To prevent this we use cement that is visible under x-ray so we can see if it "flows", plus the cement has to be the right thickness. Overall the risks are not so great if the patient is appropriately screened, and the benefit for these suffers is tremendous.

Generally this procedure is reserved for patients that are significantly incapacitated due to pain from a fairly recent compression fracture. The patient should be given at least 1 to 2 months to spontaneously recover from the fracture. On the other hand, the results are not as good with fractures that are over 6 to 12 months old. This technique is not used in younger patients suffering from traumatic fractures as the cement does interfere with normal healing. The procedure is useful in patients suffering from metastatic bone pain even if there is no fracture, though it does not "cure" the cancer. If you or someone you know is suffering from compression fractures please ask further. In Polk County the suffering can now be stopped.

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Two doctors join staff at Neurology and Neurosurgery Associates

Dr. Neeraj Dubey has recently joined Neurology and Neurosurgery Associates. Dr. Dubey graduated from medical school in 1988. Since, he has pursued his post graduate education in Internal Medicine initially in India and then subsequently in United Kingdom.



Dr. Neeraj Dubey

He joined the Neurology Residency program at North Shore University Hospital in New York in 1995, and served as a Chief Resident in 1997-1998.

He completed his fellowship training in Neuroimaging/Neurosonology at the Dent Neurologic Institute University of Buffalo New York.

After having completed his neuro-imaging fellowship, he joined a cerebro-vascular disease fellowship at the University of Texas in Houston where he gained valuable experience in the management of acute stroke and changing management of strokes.

His interest include cerebro-vascular disease research and neuroimaging. He has published nearly 28 papers in reputed journals.

Dr. Michael Campanelli Joins Staff in Lakeland

Dr. Michael Campanelli joined Neurology and Neurosurgery Associates on August 7, 2000. Dr. Campanelli will be full-time in the Lakeland office and provide in-patient care for patients at Lakeland Regional Medical Center.

After completing a family medicine residency in Buffalo, New York, Dr. Campanelli completed his neurosurgery training from Ohio University / Grandview Hospital and Medical Center in Dayton, Ohio. During his residency, he participated in a neuro-trauma fellowship at Orlando Regional Medical Center in Orlando, Florida. He then completed a one year fellowship in spinal reconstructive surgery with Carolina Neurosurgery and Spine Associates in Charlotte, North Carolina. Dr. Campanelli is extensively trained in current techniques and therapies. He will be practicing a broad range of neurosurgery including spinal reconstruction and re-operative



spinal surgery.

Dr. Michael Campanelli

Dr. Campanelli is accepting new patients at the Lakeland office located at 519 Buena Vista, Lakeland, Florida 33805. Make appointments by calling 863-802-9707.

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