Pain Diagnostic Methods

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Conflict of Interest and Disclosures

- Nothing to Disclose
Learing Objectives

- Identify basic studies used for the diagnosis of pain disorders.
- Describe the clinical utility and limitations of such studies for the differential diagnosis of pain pathologies.
- Explain strategies to enhance the clinical yield of pain diagnostic studies.

When More Medicine is Less

- Nine United States specialty societies representing 374,000 physicians developed lists of Five Things Physicians and Patients Should Question

  - American Academy of Allergy, Asthma & Immunology
  - American Academy of Family Physicians
  - American College of Cardiology
  - American College of Physicians
  - American College of Radiology
  - American Gastroenterological Association
  - American Society of Clinical Oncology
  - American Society of Nephrology
  - American Society of Nuclear Cardiology

http://choosingwisely.org/?page_id=13
Choosing Wisely
(Initiative of ABIM Foundation):

- Not only are many procedures unnecessary, some are actually harmful and can lead to mistaken diagnosis or endless rounds of follow-up testing when nothing is wrong.
- “Over testing and over treating is harming people and unethical.” (Dr. Glen Stream President American Academy of Family Practice Physicians & Panel member)

Medical Necessity of Imaging for LBP

- Low back pain is the fifth most common reason for all physician visits.
- Don’t do imaging for low back pain within the first six weeks, unless red flags are present.
  - Red flags include, but are not limited to, severe or progressive neurological deficits or when serious underlying conditions such as osteomyelitis are suspected.
  - Imaging of the lower spine before six weeks does not improve outcomes, but does increase costs.

http://choosingwisely.org/?page_id=13
MRI and CT Scans for Headaches

- Don't do imaging for uncomplicated headache.

"Imaging headache patients absent specific risk factors (such as loss of vision, seizures, etc) for structural disease is not likely to change management or improve outcome. Those patients with a significant likelihood of structural disease requiring immediate attention are detected by clinical screens that have been validated in many settings. Many studies and clinical practice guidelines concur. Also, incidental findings lead to additional medical procedures and expense that do not improve patient well-being."

http://choosingwisely.org/?page_id=13

Choosing Wisely Update

- 72 Societies and 17 community groups have joined the initiative.
- 66 Lists as of early 2014.
- Hundreds of potentially unnecessary medical tests and treatments have been identified to date.
- Several societies have released 2nd and 3rd lists.
- Estimated 5 billion in potential savings for unnecessary testing
Choosing Wisely Update

Most Important Tools for Differential Diagnosis . . .

- History
- Clinical Examination
- Experience of Clinician

Adverse Factors Affecting Physical Diagnosis

- Limitations of Time
  - Volume of patients may limit face-to-face time with clinician.
  - Reimbursements tend to devalue clinical component.

- Reliance Upon Technology
  - MRI shows disc hernations so that must be the cause of the patient’s neck pain.

- Clinical Experience
  - Has the clinician evaluated patients with similar symptoms before

Functional X-ray - Clinical Pearl

- More information may be gleaned from looking at the X-rays than the interpretation
- Aberrant movement or function may be demonstrated by motion x-ray examination
MRI - Magnetic Resonance Imaging

- Uses a powerful magnetic field to align the hydrogen atoms in water in the body. Radio frequency (RF) fields are used to systematically alter the alignment of this magnetization, causing the hydrogen nuclei to produce a rotating magnetic field detectable by the scanner. This signal can be manipulated by additional magnetic fields to build up enough information to construct an image of the body.

- Newer technology than x-ray, with the first study performed on a human took place 1977.

How MRI Works

- The body is mainly composed of water molecules with 2 hydrogen nuclei or protons. When a person goes inside the powerful magnetic field of the scanner, these protons align with the direction of the field.

- A second radio frequency electromagnetic field is then briefly turned on causing the protons to absorb some of its energy. When this field is turned off the protons release this energy at a radio frequency which can be detected by the scanner. The position of protons in the body can be determined by applying additional magnetic fields (using gradient coils) during the scan, which allows an image of the body to be created.
MRI

- Contrast between different types of body tissue is created by changing the parameters on the scanner. Diseased tissue, such as tumors, can be detected because the protons in different tissues return to their equilibrium state at different rates.
- MRI is used to image every part of the body, and is particularly useful for neurological conditions, for disorders of the muscles and joints, for evaluating tumors, and for showing abnormalities in the heart and blood vessels.

MRI Imagers

- Typical MRI
- Open MRI
- Upright MRI
- On a T2-weighted scan, water- and fluid-containing tissues are bright and fat-containing tissues are dark, the reverse is true for T1.
- Damaged tissue tends to develop edema, which makes a T2-weighted sequence sensitive for pathology

Nerve Root Compression
Clinical Pearl

MRI may demonstrate disc compression of a nerve, but current technology **does not** describe inflammation of a nerve (radiculitis).

Which patient is suffering from severe chronic low back pain?

While providing valuable structural, they do not necessarily reflect whether a pathology is clinically relevant.
Clinical Pearl

Facet joint inflammation

The individual reading the MRI or other imaging study is often not clinically familiar with the patient.

Clinical Pearl

Always request axial images to include C8 & T1 roots on order for Cervical MRI

- Brachial Plexus is C5-T1 spinal nerve roots
- All intrinsic muscles of the hand are innervated by C8/T1, as are most muscles for grip
- If upper extrem symptoms extend to hand or include decrease grip strength, then there is a high likelihood C8 or T1 is involved
- Most Cervical MRIs do not image the T1 root, and many do not include C8
On MRI examination of the lumbar spine, many people without back pain have disc bulges or protrusions but not extrusions. Given the high prevalence of these findings and of back pain, the discovery by MRI of bulges or protrusions in people with low back pain may frequently be coincidental.

Thirty-six percent of the 98 asymptomatic subjects had normal discs at all levels. With the results of the two readings averaged, 52% of the subjects had a bulge at least one level, 27% had a protrusion, and 1% had an extrusion. 38% had an abnormality of more than one intervertebral disc.


Abnormalities on magnetic resonance images must be strictly correlated with age and any clinical signs and symptoms before operative treatment is contemplated.

In asymptomatic subjects….Of those who were less than 60 years old, 20% had a herniated nucleus pulposus and one had spinal stenosis. In the group that was 60 years old or older, the findings were abnormal on about 57% of the scans 36% of the subjects had a herniated nucleus pulposus and 21% had spinal stenosis.

MRIs were not predictive of the development or duration of low-back pain. Individuals with the longest duration of low-back pain did not have the greatest degree of anatomical abnormality on prior scans. Clinical correlation is essential to determine the importance of abnormalities on magnetic resonance images.

…77 asymptomatic individuals with no history of back pain underwent magnetic resonance imaging of the lumbar spine. 21 subjects (31%) had an identifiable abnormality of a disc or of the spinal canal. In the current study, we investigated whether the findings on the scans of the lumbar spine that had been made in 1989 predicted the development of low-back pain in these asymptomatic subjects.


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**Over Reliance Upon Technology**

Inflammation of a nerve root is quite painful and does not show up on an MRI or other imaging studies.
Miscellaneous Consideration

“Among workers with LBP, early MRI is not associated with better health outcomes and is associated with increased likelihood of disability and its duration.”


MRA - Magnetic Resonance Angiography

- generate pictures of the arteries in order to evaluate them for stenosis or aneurysms with the use of contrast or flow-related enhancement.
- MRA is often used to evaluate the arteries of the neck and brain, the thoracic and abdominal aorta, the renal arteries, and the legs.
**fMRI**

To see how well fMRI could do at measuring pain, the authors evaluated an fMRI-based measure of pain intensity across four studies with 114 total healthy participants.

The authors felt that it may be possible to assess and differentiate pain through an fMRI scan.


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**Diffusor Tensor Imaging dMRI**

Maps diffusion process of molecules (water) in biological tissues.

Provides the ability to visualize anatomical connections between different parts of the brain.

Combined with fMRI (DfMRI) may be able to generate images of neuronal activation of the brain.

Hagmann et al, "Understanding Diffusion MR Imaging Techniques: From Scalar Diffusion-weighted Imaging to Diffusion Tensor Imaging and Beyond."
CT - Computed Tomography

- Earlier referred to as CAT (computed axial tomography) scan, employs tomography. Digital geometry processing is used to generate a 3D image of the inside of an object from a large series of 2D x-rays images taken around a single axis of rotation.
- Has become the gold standard for diagnosis of a large number of different diseases or pathologies.

CT - Advantages over traditional radiography

- CT completely eliminates the superimposition of images of structures outside the area of interest.
- Since CT inherently demonstrates high-contrast resolution, differences between tissues that differ in physical density by less than 1% can be distinguished.
- Data from a single CT imaging procedure can be viewed as images in the axial, coronal, or sagittal planes.
CT with 3D Reconstruction
X-ray vs. CT
CT Myelogram

- Address a limitation of CT to assess neural structures in the spine by combining with Myelography (injecting radiographic contrast into the spinal canal (CSF) to help illuminate the spinal canal, cord, and nerve roots during imaging, particularly sensitive at detecting small herniations resulting in root compression.
- Often ordered by surgeons for operative planning or as a substitute for MRI imaging for patients who cannot have an MRI.
Bone Scan

- A nuclear scanning test that can identify areas of new bone growth or destruction. It can be done to evaluate damage to the bones, find cancer that has spread (metastasized) to the bones, and monitor conditions that can affect the bones (including infection and trauma).
- A bone scan can often find a pathology days to months earlier than a regular X-ray test.


Bone Scan

- Radioactive trace is injected into the patient. After 2-5 hours, a gamma camera is then used to image the body.
- Abnormalities are identified by “hot spots” and “cold spots.”
  - Hot – accumulation of tracer caused by a fracture that is healing, bone cancer, a bone infection or a disease of abnormal bone metabolism.
  - Cold - certain type of cancer (such as multiple myeloma) or bone infarction.
Ultrasound

- Ultrasound is cyclic sound pressure with a frequency greater than the upper limit of human hearing
- Can capture size and structure of anatomical structures or pathological lesions in real time
Handheld Technology

- Handheld Diagnostic Ultrasound
  - black and white anatomic and color-coded blood flow images in real-time
  - heart, abdominal organs, urinary bladder and will provide insights in areas of Ob/Gyn, pleural fluid, motion detection and pediatrics

Structure vs. Function

- All pain has a neurological component.
- While providing valuable structural information, imaging studies do not reflect whether a pathology is clinically relevant.
- For now most Electrodiagnostic procedures assess general nerve function and play an important role in characterizing neuropathy.
- As technology develops, a means of assessing each component will likely evolve.
Most Common Electrodiagnostic Studies

- Electromyography
- Nerve Conduction Velocity
- Evoked Potentials (SEP, BAEP, VEP)
- Electroencephalography
- Electrocardiography

Electromyography (basics)

- Inserting a needle in a muscle, assessing the electrical activity of muscle.
- Looking at the waveform on a computer, listening for characteristic sounds unique to that waveform

Needle EMG
EMG Abnormal Electrical Activity

At rest abnormal spontaneous and insertional activities are represented by fibrillation potentials and positive sharp waves. This usually reflect a muscle that has lost its nerve supply (Denervated Muscle).

Abnormal Electrical Activity (*ephatic*)

Spontaneous needle activity associated with more chronic denervation include complex repetitive discharge and myotonic discharge.
Motor Unit Assessment is performed during voluntary contraction (including the motor neuron and the muscle fiber it innervates). The result is an interference pattern.

**Interference Pattern at Maximal Effort**

![Interference Pattern Image]

*Courtesy of Oxford Instruments*

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**EMG Study Lower Extremity Muscles**

![EMG Study Diagram]

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Typical EMG of Lower Extremities (L3-S2)

- The extensor digitorum brevis or extensor hallucis longus
  - (peroneal nerve L5-S1)
- The flexor digitorum longus
  - (posterior tibial nerve L5-S1,2)
- The tibialis anterior
  - (peroneal nerve L4,5)
- The medial gastrocnemius
  - (posterior tibial nerve S1,2)
- The vastus lateralis
  - (femoral nerve L3,4)
- The gluteus medius
  - (superior gluteal nerve L4,5 and S1)

EMG Study Upper Extremity Muscles
Typical EMG Study Upper Extremity

- The first dorsal interosseous  
  - (ulnar nerve C8, T1)
- The flexor pollicis longus  
  - (anterior interosseous nerve C7,8)
- The flexor carpi radialis  
  - (median nerve C7)
- The brachioradialis  
  - (radial nerve C5,6)
- The triceps  
  - (radial nerve C7,8)
- The deltoid  
  - (axillary nerve C5,6)
- Related Cervical Paraspinals

Nerve Conduction Velocity (NCV/NCS)

- Assessment of the transmission of an electrical impulse along a large nerve fiber.
  
  - Sensory
  - Motor

- Evaluate damage to the peripheral nervous system. Nerve conduction studies are used to help identify the location of abnormal sensations, such as numbness, tingling, or pain associated with nerve disorders.
Sensory NCVs

- Median
- Ulnar
- Radial
- Sural

Motor NCVs

- Median
- Ulnar
- Peroneal
- Tibial
Clinical Pearls

- Pre-ganglionic sensory radiculopathies cannot be identified by classic EMG/NCV.
- Cookie-cutter studies are very limited in their ability to identify pathology by being narrowly focused. In this regard, tailoring the study to the patient can significantly increase diagnostic yield.


Somatosensory Evoked Potentials (SEPs)

SSEP: “Short latency” SEP—Portion of test results that occur within 25 msec for the upper extremities, 50 msec for the lower.

Dermatomal (or DSEPs): Responses generated when stimulating a dermatome.

Segmental SEPs: Responses generated when stimulating a nerve with a primary innervation of one nerve root.
SEP Results

*Latency* -- the period of time for the signal to travel between the stimulation and recording sites

*Amplitude* -- reflects the volume of conduction

The presence of pathology is identified by “prolonged” or “increased” latencies, or “diminished” amplitudes.
Patient B

- 47 year old right handed male in significant distress and discomfort with respect to his cervical spine, complaining of neck pain accompanied with “shock-like” and “knife-like” shooting pains with seemingly the slightest movements. There is a constant the focal area of pain centralized to the mid-to-lower cervical spine. He complains of headaches that appear more left-sided and radiate frontally that appears to be directly related to exacerbations of his neck pain. Other complaints include occasional tingling into the anterior left forearm and left upper extremity weakness. Onset six months prior while a front seat passenger in an MVA.

- X-ray – Unremarkable
- MRI – Mild DJD C3/C4, C4/C5
- EMG – Pt could not tolerate
- SEP – T1 Radiculitis
- Bone Scan – Inconclusive
Patient C

- 21 year old collage student with gradual onset of right shoulder pain, now reported as deep and aching and some perceived shoulder weakness.
  - Pain is aggravated with certain shoulder and neck movements.

- MRI Shoulder & C spine – Negative
- EMG - CTS

- The first dorsal interosseous (an ulnar C8, T1 muscle)
- The flexor pollicis longus (an anterior interosseous C7,8 muscle)
- The flexor carpi radialis (a median C7 muscle)
- The brachioradialis (a radial C5,6 muscle)
- The triceps (a radial C7,8 muscle)
- The deltoid (an axillary C5,6 muscle)
- Related Cervical Paraspinals

Suprascapular nerve entrapment

Brachial plexus image © Medcom studios – Renee Cannon www.medcomstudios.com
Take Home Message

- The reliability or the clinical relevance of any diagnostic procedure is never 100%.
- The studies themselves may be deficient in that particular clinical situation.
  - Inadequately structured for that particular patient.
  - Adversely effected by other influences (technical considerations).
- Objective clinical examination findings should not be dismissed based solely upon negative test results.