Spine Pain
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According to Wikipedia¹: “Back pain is one of humanity’s most frequent complaints. In the U.S., acute low back pain (also called lumbago) is the fifth most common reason for all physician visits. About nine out of ten adults experience back pain at some point in their life, and five out of ten working adults have back pain every year.” In caring for patients with spine pain (pain from the neck or low back and/or radicular symptoms), there are multiple diagnostic tests and therapeutic options available. Diagnostic imaging offers plain films, computed tomography, myelography, combined myelography/CT, nuclear medicine bone scans, magnetic resonance imaging, and fluoroscopically guided injections. Therapy includes doing nothing, oral medications, physical rehabilitation, spine injections, surgery, and then sometimes surgery again. This chapter covers three key concepts to guide the choice in diagnosis and treatment of spine pain. These concepts are:

2. MRI has supplanted other modalities for the imaging work-up of spine pain.
3. Injections often provide diagnostic or therapeutic benefit for patients with spine pain.

“RED FLAGS” IN THE PATIENT’S PRESENTATION CALL FOR PRIORITY IMAGING

Gordon Waddell, a Glasgow spine surgeon, uses the term “red flag” to denote those clinical findings that indicate the potential of a medically serious diagnosis, and which should prompt priority imaging. Waddell’s book The Back Pain Revolution (Churchill Livingston, 2004) is an excellent book for anyone who treats those with back pain.

Spine pain is such a common disorder, and so often runs a benign course, that common advice (although not necessarily often followed) is to wait 4-6 weeks before pursuing costly diagnostic measures. However, in the presence of a “red flag”, it is prudent to expedite imaging. This does not necessarily mean that the examination has to be performed in the next five minutes, but it would probably be better to get imaging done this week rather than waiting a month.

Red flags include a personal history of malignancy, unremitting pain, pediatric patients with back pain, and constitutional symptoms (for example, weight loss or fever).

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**A personal history of cancer**

This particular scenario, with patients presenting to primary care physicians with spine pain after successful cancer therapy, will likely increase in frequency as oncologists become better at curing, or at least putting into remission, various tumors. In the case of a patient with the new onset of spine pain and cancer, it makes most sense to first review any existing imaging studies, to see if they indicate (even in retrospect) a malignant cause of the pain. Studies done for tumor imaging such as CT of the abdomen and pelvis may show bone destructive changes which are easy to overlook. Nuclear medicine studies such as bone scans and PET-CT studies usually show more conspicuous and easily appreciated abnormalities which are less likely to be missed. If these studies do not show an explanatory abnormality, plain films of the painful region may be ordered but will likely not be the final study performed regardless of the outcome: if they are negative MR will need to be performed (because

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Figure 1. Metastatic lung cancer in a 65 year old man with back pain and known primary malignancy. A. Sagittal thoracic spine T1 weighted MR image shows decreased signal at T6 and T12 (arrows). B. Sagittal thoracic spine fat saturated T2 weighted MR image shows increased signal intensity (arrows), also at T6 and T12.
plain films are insensitive), and if positive, MR will likely still need to be performed (to evaluate the extent of tumor including neural compression) (Figure 1).

**Unremitting pain**

This red flag emphasizes that, typically, benign spine pain is “mechanical” in the sense that it is brought on by mechanical factors (assuming a certain position, bearing a certain load), whereas spine pain secondary to such factors as tumor (Figure 2), osteomyelitis, or fracture is “non-

mechanical”. The patient cannot find comfort standing, sitting, or lying down, and finds little relief with medications which would normally offer benefit. Note that while a young, healthy adult would not normally sustain a spine fracture without significant trauma, the amount of trauma necessary to fracture an elderly, osteoporotic spine can be so trivial that it escapes notice, and therefore the patient may present with an osteoporotic fracture but not recall a specific incident that initiated the pain.

Figure 2. Lymphoma in a 65 year old man with new onset of unremitting back pain. A. Sagittal lumbar spine T1 weighted spine MR shows decreased signal in the L2 vertebral body and a mass extending into the spinal canal (arrow). B. Sagittal T2 weighted spine MR shows increased signal within the vertebral body, and also demonstrates the soft tissue mass.
Figure 3. Neuroblastoma in a 2 year old with back pain, fatigue, and fussiness. A. Lateral plain film of the lumbar and thoracic spine shows a mass (arrow) along the posterior upper chest. B. Sagittal T2 MR shows a paraspinal mass (arrow).

The pediatric patient

Any child with spine pain should be evaluated carefully. Children rarely if ever have “degenerative” causes of backache. Occasionally, teenagers may present with central low back pain from spondylolysis. However, any younger child with spine pain should be suspected of having a possible serious medical condition such as tumor (Figure 3), infection, or unreported trauma.

MRI HAS SUPPLANTED OTHER METHODS FOR IMAGING BACK PAIN

In the short space of approximately 25 years, magnetic resonance imaging has revolutionized medicine. MRI has changed the way neurologists, neurosurgeons, and orthopedic surgeons evaluate and care for patients by providing detailed images of both pre- and post-operative anatomy that were the stuff of science fiction a few short decades ago. Paul C. Lauterber from the University of Illinois and Peter Mansfield from the University of Nottingham...
won the Nobel Prize in Medicine for their key role in the development of magnetic resonance imaging in 2003, and rightly so, for this technology has allowed not only academic research on many of the most devastating diseases, but also found widespread use in community practice. It would be difficult to find a family in the United States that has not had a member to undergo MRI, and we are all familiar with the sports announcers’ refrain “The team doctor is waiting for the MR results to make a decision on the player’s return to action”. MR not only demonstrates the causes of the “red flags” just mentioned, but also shows soft tissue and bony causes of back and leg pain.

Plain films may be obtained prior to performing an MR, but (as noted in the case of evaluating tumor patients, above) almost always need to be supplemented by MR. One possible exception: in cases of trauma where the plain film documents a simple compression fracture, MR is typically not necessary (although often even in this scenario, the MR will provide significant additional information; see below).

**MR shows the causes of “red flags”**

As noted above, patients with a history of cancer, unremitting pain, and pediatric patients may have serious medical diseases. These patients require priority imaging and prompt diagnosis and management. MR is the method of choice for evaluation of these patients. Please note that while many patients with tumor, fracture, or infection do demonstrate these red flags, probably as many do not, making MR all the more valuable.

**MR shows symptom producing, benign soft tissue abnormalities**

MR’s superiority comes predominantly from its ability to visualize soft tissues. Prior to MR, imaging relied on the use of x-rays, either to produce plain films or myelograms, or CT scans. While a wonderful invention and tremendously useful, x-ray based techniques have limitations, the main one of which is that the x-ray attenuation of different tissues such as the intervertebral disc, muscle, synovium, and even tumor is virtually identical, and the x-ray attenuation of fluid within the cerebrospinal space is not much different. Neuroradiologists relied, for decades, on secondary phenomenon to diagnose spine disease: the lost intervertebral disc space on plain films as a sign of disc herniation, or the filling defect on myelography or myelo-CT. MR easily shows each type of tissue separately, MR evaluates different physical properties of protons within the patient to create pictures showing anatomic detail and unparalleled demonstration of disease processes.

**Disc Herniation**

Since the original description by Mixter and Barr in 1934, the herniated disc has gotten much press. The North American Spine Society (NASS) originally proposed, and various other medical societies have adopted, a specific nomenclature that distinguishes subtypes of herniation. If viewed axially, the normal intervertebral discs are like a tree trunk with concentrically arranged layers of oblique fibers constituting the annulus fibrosus. In the middle of the tree trunk, having a consistency of toothpaste, is the nucleus pulposus. When the annular fibers degenerate and/or tear, the nuclear material may extend or herniate beyond the fibers of the annulus, and if this happens posteriorly the effect may be compression and/or inflammation of adjacent nerves (Figure 4). The NASS terminology calls small disc herniations “protrusions” and these are much less likely to be symptomatic. The NASS terminology calls large disc herniations “extrusions” and these are much more likely to be symptomatic. Note that large, acutely symptomatic disc herniations may show significant regression when sequentially imaged, even without surgical intervention.
Figure 4. Disc herniation in a 59 year old woman with sudden onset of left back pain radiating down the posterior left lower extremity to the heel. A. Sagittal T2 spine MR image shows a caudally dissecting disc herniation (arrow). B. Axial T2 spine MR shows the disc herniation (arrow) indenting the thecal sac. The sagittal image has been cropped and originally included up to the T11 level.

Figure 5. Spinal stenosis in an 82 year old woman with back pain and left leg pain. A. Sagittal T2 lumbar spine MR shows L3-L4 degenerative spondylolisthesis with stenosis (arrow). B. Axial T2 spine MR shows spinal stenosis (arrow). The sagittal image has been cropped and originally included from T11 through the lower sacrum.

Spinal Stenosis

Spinal stenosis refers to narrowing of those passageways through which the nerve roots and spinal segmental nerves travel, including the spinal canal, sub-articular recess, and neural foramen (Figure 5). Fibrocartilaginous tissue (“soft” tissue) causes this narrowing as or more frequently than bone (“hard” tissue), and therefore spinal stenosis is included in this section on soft tissue abnormalities.
While plain films usually show degenerative changes in patients with spinal stenosis, and CT often better shows the degree of narrowing, MR is capable of showing not only the narrowing but also demonstrating the neural structures, and any associated compression, directly. Compression of the nerves may result in pain or radiculopathy, but may also result in less specific generalized leg weakness and disability, a finding that may be exacerbated during extension and relieved during flexion. Indeed, these patients often find relief of their symptoms at the grocery store, for they use the grocery cart as an ambulation assistant which allows them to walk in a forward-flexed position which opens the spinal canal.

Synovial Cyst

A three-joint complex comprises each level of the lumbar spine. In addition to the intervertebral disc, a cartilaginous joint, in the front of the spine, there are two facet joints, which are synovial joints, at the back of the spine. These joints are prone to the same sorts of degenerative processes as other synovial joints, including cartilage loss, synovial proliferation, and secondary osteophytic spur formation. The synovial proliferation may occur posteriorly, in which case it is rarely symptomatic. Unfortunately, the proliferation and cyst formation may also occur anteriorly, where it may compress the nerve roots in the spinal canal (Figure 6) or the dorsal root ganglion in the neural foramen. These cysts may account for up to 10% of those patients that present with radicular pain; clinically, these patients are indistinguishable from those with disc herniation.

Figure 6. Synovial cyst in a 65 year old man with chronic back pain and new onset of right leg pain, right leg numbness, and right foot drop. A. Sagittal T2 lumbar spine MR shows a synovial cyst posterior to the L4 vertebra (arrow). B. Axial T2 lumbar spine MR shows a synovial cyst filling much of the right side of the spinal canal, compressing both the exiting L4 and traversing L5 nerve roots. The sagittal image has been cropped and originally included from T11 through the lower sacrum.
MR shows symptom producing, benign bone abnormalities

MR imaging is outstanding in the diagnosis of soft tissue abnormalities. It may be somewhat surprising to hear that MR is also outstanding in evaluation of most of the bone abnormalities afflicting the spine as well. This follows from the fact that while plain films can show cortical bone discontinuity and displaced bone fragments in the case of a fracture, plain films are relatively insensitive to marrow abnormalities. In fact, most of “bone” consists of bone marrow and/or trabecular bone. While MR does not show the trabeculae as well as, for example, CT, it reveals abnormal marrow tissue, whether from post-traumatic fibrovascular changes or hemorrhage, tumor, or infection. Direct visualization of the marrow allows MR to make diagnoses that are difficult or impossible with other imaging methods (Figure 7).

Figure 7. Radiographically occult post-traumatic fractures in a 39 year old man with back pain after falling off scaffolding. A. Lateral plain film of the lumbar spine taken in the emergency room is normal. The patient had persistent pain. B. Sagittal T2 spine MR (performed three days later, when pain persisted) demonstrates extensive abnormal marrow at the L1 and L2 levels (arrows) from contusion and trabecular fracture.
Radiographically occult post-traumatic fractures
Fractures through the marrow invariably result in fibrovascular tissue and hemorrhage. Nondisplaced but painful fractures may be impossible to see on plain films, even when you know exactly where the fracture is. At the same time, MR, through its superior soft tissue visualization, offers a specific diagnosis of bone contusion or fracture, evaluates any associated spinal canal compromise, and also excludes associated post-traumatic disc herniations (Figure 7).

Radiographically occult stress fractures
Sacral stress fractures (Figure 8) are difficult to diagnose since they may present with low back, sacro-iliac, gluteal, or hip pain, and plain films are notoriously unreliable in their diagnosis. Stress fractures of lumbar levels are much less frequent than sacral fractures.

Establishing fracture age
Many patients, particularly the elderly, will have sustained fractures earlier in life but not remember that they had prior trauma. The plain film, of course, will continue to show deformity of the vertebral body. Without a prior film, it is often not possible to distinguish between old and new fractures. MR is the study of choice for evaluation of fracture age (Figure 9). MR turns positive almost immediately and goes through a known temporal evolution of healing that allows more precise dating of the fracture. A nuclear medicine bone scan may be performed if MR cannot be done. The nuclear medicine study turns positive 1–3 days following injury, but may persist for months or in some cases years after the event, making precise fracture dating difficult.
Figure 9. T10 fracture in an 85 year old white female with back pain for four days. A. Plain films showed multiple compression deformities, but no prior studies were available to determine how many, if any, of these were acute fractures. B. Sagittal STIR spine MR shows increased signal at T10 (arrow), establishing that this is the acute fracture.

**SPINAL INJECTIONS MAY PROVIDE DIAGNOSTIC OR THERAPEUTIC BENEFIT**

While diagnostic and therapeutic injections have been around for decades, they continue to evolve and to be more widely used. Diagnostic injections include nerve blocks, discography, facet injections including intra-articular injections and median branch blocks, and sacro-iliac joint injections. Therapeutic injections typically use the same techniques as diagnostic injections but add a long acting form of steroid to the injected material. Therapeutic epidural injections may treat multiple levels at one time. Injection of the hip and shoulder may also further delineate pain and differentiate pain emanating from these joints and the spine.
Injections may localize or treat a “pain generator”

The three fundamental assumptions of diagnostic and therapeutic injections include:

1. Needle placement and injection close to or at the site of a symptomatic structure will stimulate nociceptors and thus reproduce the patient’s typical pain.
2. Anesthetic placed through the needle will (at least temporarily) decrease activity within nociceptors and thus relieve the patient’s typical pain.
3. Pain may be secondary to inflammation contributing to nociceptor stimulation and may respond to steroid injection.

Note that because of the placebo effect, regression to the mean, and the intermittent natural history of back pain, it is difficult to be certain that relief of pain upon injection of a structure is genuine “proof” that the structure is the cause of that pain.

Nerve blocks can localize and treat radicular pain

At each level of the spine, the two nerve roots come together at the level of the dorsal root ganglion, which then forms the spinal segmental nerve. The spinal segmental nerve carries with it a short sleeve connecting to the epidural space called the “circumneural sheath”. Depending upon the amount of contrast material and/or medicine injected, material may seep back into the epidural space and cover other levels. For this reason, if one is performing a nerve root block for diagnostic purposes, it is necessary to limit the volume of injected material. Typically, this will consist of only 0.1 to 0.2 mL of nonionic contrast to establish that the needle is appropriately positioned, followed by injection of 0.3 to 0.5 mL of 2.0% lidocaine (Figure 10). If the patient has typical pain upon placement of the needle and during injection, and then excellent pain relief shortly thereafter, this constitutes a positive test. It is of note that placement of a needle tip in the vicinity of an irritated spinal segmental nerve is much more painful than is placement by a “normal” segmental nerve, even without injection.

Sacro-iliac joint injections can localize and treat SI joint pain

The sacro-iliac joint has been in and out of favor as a cause of low back and hip pain for the past 100 years or so. Since very few surgeons advocate intervention regardless of the results of injection,
there seems to be little diagnostic role for injections (Figure 11). The injections may provide pain relief.

Figure 12. Discography. Fluoroscopically directed spot film obtained during the procedure shows the needle tip located at the L3-L4 disc space with contrast within the disc (arrow). Contrast has already been introduced into the L4-L5 and L5-S1 levels.

Discography diagnoses “internal disc derangement”

Discography (Figure 12) remains the most controversial diagnostic injection done, and, for that matter, one of the most controversial diagnostic maneuvers done in medicine. There are a number of reasons for this, not the least of which is the fact that the “disease” that discography is supposed to diagnose, “internal disc derangement”, is very controversial itself, and has no widely accepted reference standard for diagnosis. Add to this the cost, risk, and pain of discography, and the fact that researchers continue to debate the role of false-positive diagnoses and even whether the injections may cause permanent exacerbation of backache, and you can understand why discography is so controversial. Advocates maintain that injection into a normal nucleus will not cause pain, whereas injection into a symptomatic nucleus will reproduce the patient’s typical back pain. Surgeons who make use of the results of discography assume that fusing a painful level will eliminate or at least lessen the pain caused by the abnormal disc.

Epidural injections may be used to treat back and leg pain

Epidural injections, on the other hand, are much less controversial. They have been around for fifty years, and multiple controlled, randomized, blinded studies have shown efficacy of steroid over placebo. While many patients tend to be frightened of the injections - indeed, the words “spine” and “needle” just don’t seem to fit well in the same sentence for many patients - in fact the injections when properly performed take about five minutes and are about as painful as having blood drawn or an IV started.

It should be noted that it is fairly standard procedure to perform these procedures with fluoroscopic guidance and with the benefit of nonionic positive contrast material to document needle tip position and contrast flow. Studies have demonstrated that up to 30% of injections done without fluoroscopic guidance and contrast injection are incorrectly placed. This number improves somewhat with increased experience on the part of the injector and favorable body habitus on the part of the injected patient, but is hard to get much below 10-15%. Given this fact, it is difficult to know what to make of a patient who has had a “blind” injection who doesn’t improve. Was the material injected at the target location?
Lumbar interlaminar injections cover several levels

The simplest and typically least painful epidural injection to perform is the interlaminar lumbar injection (Figure 13). In this procedure the needle is advanced between the lamina of adjacent vertebrae and the injected contrast material (and drugs) will typically flow both superiorly and inferiorly for several levels. Typically, the material will also pass on both sides of the midline, although it often favors the side of the needle. Rarely, patients will have a dividing plica mediana dorsalis which keeps left sided injection from reaching the right side and vice versa. In general, the older the patient, the less likely the material will spread widely or well: scarring and limited flow within the epidural space seem to accompany gray hair.

Frequency of injection varies widely: some authorities advocate three injections done at one week intervals, while others use a single injection. One reasonable method is to plan to see the patient back a week after the injection if pain continues and if the patient is willing to undergo an additional injection. If the first injection provides partial relief, an additional injection usually provides additional benefit. If the first injection provides no relief, changing the method of injection (for example, from interlaminar to transforaminal, or from an epidural steroid injection to a facet injection) may be helpful.

Lumbar transforaminal injections target specific nerves

If this injection reminds you of the nerve block discussed above, there’s a good reason: they are virtually the same procedure (Figure 14). The only real difference is the volume of material placed in the circumneural sheath. Since epidural injections are therapeutic maneuvers, it does not matter that the specificity of the nerve block is lost, and these injections bring medicine to an area in the epidural space (and therefore to certain neural structures) that may not be reached by interlaminar injections. As noted above, as people age, the flow of contrast in the epidural space diminishes, and posteriorly injected material may not reach the segmental nerves or the dorsal disc margin. In addition, material injected on the inside of the spinal canal may not pass readily through the foramen to the spinal segmental nerve if there is foraminal stenosis from osteophytic spurring along the disc margin and facet joint.
Facet joint procedures diagnose and treat posterior element abnormalities

As noted previously, a three-part joint comprises each level in the spine, with the intervertebral disc positioned anteriorly and the two, paired facet joints posteriorly. While the intervertebral disc has occupied most of the attention of those caring for back pain for the last seventy years or so, some estimate that facet joint abnormalities cause the pain in at least 15% of patients with back pain. 15% may sound like a small number until you multiply it by the number of people that have backache, with the result of several million patients in the United States.

As with other injections, the reasons to inject the facet joints are to diagnose whether they are the source of pain, and to treat this pain, if possible.

Facet joint injection can localize or treat facet joint pain

Experts have developed techniques to enter the facet joint (Figure 16). Facet joints are small structures, so the injection volume needs to be limited in order to make the injection specific. Just as with a diagnostic spinal nerve block, a total of only a few tenths of a cc of anesthetic is injected into the joint. If more than this is injected, the facet joint will rupture, and typically the material will flow into the epidural space and have the same effect as...
an epidural steroid injection by covering several adjacent segments, and both sides, of the spine.

Figure 17. Facet blocks. Fluoroscopically directed spot film obtained during the procedure shows the needle tips located at the expected positions of the dorsal root branches which enervate the L4-L5 and L5-S1 facet joints. A small amount of contrast shows an appropriate, nonvascular appearance of the contrast material (arrows).

Rhizotomy can provide long-term relief from facet joint pain

In addition to injecting within the joint, the anatomy of the facet joints allows an alternative approach to diagnosis and treatment. This is the so-called median branch block (Figure 17). Facet joint innervation comes from the median branches of the dorsal rami of the spinal segmental nerves above and below the level of the joint. What this means is that small amounts of anesthetic injected at the known location of the median branches will anesthetize the joint just as effectively as intraarticular injection. Figure 17 demonstrates needles in place at the location of the medial branches of the lower lumbar facet joints. If the patient achieves pain relief from these injections, the patient may be a good candidate for a rhizotomy, which is percutaneous lesioning of the nerves supplying the facet joints. These nerves typically perform no other function, and rhizotomies have been shown in randomized, controlled studies, to provide benefit beyond placebo needle placement.

Figure 18. Facet injection performed for synovial cyst rupture. Fluoroscopically directed spot film obtained during the procedure shows the needle tip along the dorsal recess of the L4-L5 facet joint, with contrast material extending through the joint and into the synovial cyst (arrow).

Synovial cyst rupture can cure radiculopathy

As illustrated previously (Figure 6), synovial cysts may arise from the facet joints and extend into the spinal canal or neural foramen. When small, these cysts are typically considered an asymptomatic accompaniment of facet arthropathy. However, when large, they may compress nerve roots or spinal segmental nerves and thus cause radicular pain. When this happens, the patient has the same symptoms as if he or she had a disc herniation. With this diagnosis, the three major options are:

1. Treat with oral anti-inflammatory medication. The cysts are said to eventually go away, particularly if the joint inflammation subsides, and this is one way of approaching the problem, although for patients in radicular pain the wait may be agonizing.

2. Resect the joint and fuse the spine. This seems a particularly aggressive approach, but unlike disc herniations which are amenable to microscopic discectomy, fixing a bad facet joint generally entails removing ...
the entire thing, and stabilization is necessary following this maneuver.

3. Percutaneous rupture (Figure 18). By placing a needle in the joint and vigorously injecting it, it is often possible to rupture the joint, as mentioned above. In this case, that’s a good thing, because it can cure the radicular pain in minutes.

These injections may help those patients with multilevel disease or with both disc and facet abnormalities by providing a more specific diagnosis. They may provide patients with back and leg pain, even without a specific diagnosis, relief from their discomfort.

One final pearl about these injections is that while the steroids injections would seem to have a time-limited effect, the relief of pain often extends for weeks or even months following injection. There are a couple of potential explanations for this prolonged benefit:

1. Back pain in general is a symptom given to exacerbation and remission. If the patient comes for injection when most painful, he or she would improve whether the injection was done or not, a phenomenon called “regression to the mean”. Nonetheless, if their pain is relieved when it is most severe, this is of benefit.

2. Nerve nutrition requires appropriate blood flow, both on the arterial and venous side. Studies have shown that impaired flow prompts nerve swelling and a minimal superimposed insult may start a vicious cycle where the swelling actually contributes to the impaired flow. If the anti-inflammatory effect of the steroid makes the nerve smaller, blood flow may improve and the patients may therefore experience long-term relief of symptoms.

SUMMARY

1) “Red flags” in the patient’s presentation call for priority imaging.
2) MRI has supplanted other modalities for the imaging work-up of back pain.
3) Injections often provide diagnostic or therapeutic benefit for patients with back and leg pain.

REFERENCES