

Pain Management ROUNDS

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THE MGH PAIN CENTER, MASSACHUSETTS GENERAL HOSPITAL

The Interventional Approach to Low Back Pain

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Over the last decade, anesthesia procedures for low back pain have evolved significantly. Whereas blind epidural steroid injections were formerly the mainstay of procedural treatments, today, interventional pain physicians provide a variety of “minimally invasive,” targeted, and technically sophisticated treatment options for patients suffering with low back pain. As a mark of the increased importance of the role of procedural treatments, interventional pain medicine has recently been designated a separate specialty by Medicare.

Low back pain (LBP) is one of the leading causes of disability. Up to 70%-85% of all people have back pain at some time in their lives.¹ LBP is the most common cause of a limitation of activity in people <45 years old, the second most frequent reason for visits to a physician, the third most common indication for surgery, and the fifth-ranking cause of hospital admissions.¹

Some of the most important features of new interventional treatments for LBP are their favorable risk/benefit ratio, improved outcome, and diagnostic capability, which is superior to that provided by conventional imaging alone (eg, computed tomography [CT], magnetic resonance imaging [MRI]). The technical aspects of regional procedures have been greatly improved.² Most of these procedures are now performed with fluoroscopic guidance, achieving improved accuracy of medication delivery, thereby improving outcome.^{2,3}

When considering interventions for the treatment of LBP, it is important to appreciate that the etiology of LBP is often multifactorial, having one or multiple pain generators. The most common pain generators in patients with LBP are:

- lumbar radiculopathy
- facet joint disease
- discogenic (internal disc disruption) pain
- failed back surgery syndrome (FBSS)
- myofascial pain
- sacroiliac joint syndrome.

Because of recent changes in interventional pain medicine, particularly its diagnostic options, a new trend that has been observed recently is for interventional pain specialists to see LBP patients *before* they are considered for surgery. Thus, in some cases, surgery can be avoided, which may have a significant financial impact, considering the cost of surgical options and hospitalizations for LBP patients. Interventional approaches have traditionally been plagued by the lack of clinical outcome studies to support their efficacy. Although randomized controlled trials are still needed to support interventional pain procedures, recent well-designed studies have shown favorable outcomes.

EPIDURAL STEROID INJECTIONS (ESIs)

The purpose of an ESI is to deliver medication directly to the affected nerve roots, discs, and adjacent tissues, thereby avoiding the effects of systemically-administered steroids. The first report of an epidural injection used to treat LBP (and sciatica) was in 1901 by Cathelin,⁴ who injected cocaine via the caudal route. In 1953, Lievre and associates reported the use of epidural hydrocortisone in 20 patients.⁵ Since then, ESIs have been used to treat patients with back pain due to a wide variety of spinal pathology, including spinal stenosis, disc space narrowing, annular tears,



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spondylosis, spondylolisthesis, vertebral fractures, and post-laminectomy syndrome. Despite the wide range of etiologies, a common denominator of these different causes of back pain appears to be nerve root irritation. Besides reducing inflammation, the mode of action of epidural steroids is to decrease conduction in injured nerves.

Although ESIs have been used for decades to treat LBP with radiculopathy, controversy still exists as to whether or not the procedure affords long-term benefits to patients. More than 40 publications have described clinicians' experiences with ESIs. The reported success rates have varied greatly, ranging from 18% to 90%;^{6,7} however, the number of published, randomized, controlled trials is small and most contain serious methodological flaws. The best reported outcomes have been achieved when a "transforaminal" approach for ESI has been used (Figure 1).⁸ Potential benefits of the transforaminal approach to the epidural space may include minimal risk of dural puncture, better delivery of medication to the site of pathology, a greater spread into the ventral epidural space and, subsequently, a reduction in the amount of medication necessary to produce the desired effect. This approach can be beneficial in post-laminectomy patients.² It appears that using the caudal approach to the epidural space limits the amount of medication that can be delivered to the desired pathology due to medication dilution and aberrant spread due to epidural scar tissue.

Many recent studies have revealed that the use of fluoroscopy and epidurography can substantially improve medication delivery to targeted pathology.^{3,9} Evidence for the safety of epidurography is substantial. Johnson and colleagues reported only 4 minor complications out of a total of 5334 ESIs administered at various spinal levels.¹⁰ According to a recent national survey,² the average number of ESIs that one patient may receive per year is 5 to 7. If ESIs decrease pain and improve function in a given patient and other treatments are ineffective, it is safe to repeat ESIs on a regular basis over many years since the systemic effects of steroids are minimal. Overall, the best use of ESIs is for patients with radicular pain and as the "first treatment approach" in many other causes of LBP.

FACET MEDIAL BRANCH BLOCKS/DORSAL RAMUS BLOCKS, AND RADIOFREQUENCY LESIONING

Recently, abnormalities in the lumbar facet (zygapophysial) joints have been identified as a frequent cause of LBP in selected patients, with a prevalence ranging from 15%-40%.^{11,12} The facet joint is innervated by medial branches emerging from the dorsal rami of the spinal nerves and the L5 dorsal ramus itself. At each level, this innervation is derived from the dorsal ramus of the adjacent spinal nerve, as well as the medial branches located one level above and, possibly, one level below. Patients experiencing facet joint pain usually present with LBP that increases with back extension and radiates to the posterior thigh. However, the

FIGURE 1: Transforaminal epidural steroid injection at L5 –S1 level as seen in anteroposterior fluoroscopic view



only way to confirm the diagnosis of this condition is to perform 1 or 2 diagnostic medial branch/dorsal ramus blocks. Two separate blocks are necessary to reduce the high false positive rate of these procedures. It appears that the current practice of a "single needle" technique may further reduce the rate of false positive medial branch blocks.¹³ In clinical studies, medial branch blocks and intra-articular facet joint injections have been shown to be of equal value as a diagnostic tool for facet joint pain. Patients experiencing at least 50% pain relief with diagnostic medial branch blocks may then go on to experience long-term pain relief following radiofrequency denervation (RF) of these nerves (Figure 2). The long-term success rate of RF is 50%-70%.¹⁴ RF is an excellent alternative to spinal fusion in many patients with LBP.

DISCOGENIC PAIN

While the cause of pain in disc protrusion is compression of the nerve root, a different process occurs in discogenic LBP. In discogenic LBP with progressive degeneration of the disc, the disc annulus undergoes delamination and develops fissures. The annular nociceptors become sensitized and there is a decrease in their firing thresholds. The increased stimulation of the dorsal root ganglion (DRG) by sensitized nociceptors may cause a referred pain pattern to the lower extremities. Furthermore, the damaged disc promotes the growth of nerve fibers along radial tears into the inner annulus.^{15,16}

Most patients with discogenic LBP have increased pain with prolonged sitting. Their pain can be limited to the back area (axial pain) or it can radiate to one or both lower extremities. The physical exam and diagnostic studies (eg, MRI), including the straight leg-raising test, can be normal.

FIGURE 2: Radiofrequency lesioning of lumbar medial branches at L3, L4, and L5 levels as seen in anteroposterior fluoroscopic view



Provocation discography remains the gold standard for the diagnosis of discogenic pain. The key feature of discography is the reproduction of the patient's pain. Discography is performed at 3 to 4 lumbar levels, using unaffected discs as controls. It is important to point out that discography is a diagnostic procedure with no therapeutic value. The concordant pain is sought with low pressures and low volumes of contrast injected into the disc. The reproduced LBP (or pain referred to the lower extremity) is considered to be discogenic in origin. Disc disruption and leakage of dye through the annular tear is usually seen with the onset of pain. Disc disruption alone, without reproduction of the patient's pain, is an insufficient finding for the diagnosis of discogenic pain. A post-discography CT is a helpful, but not absolutely necessary diagnostic tool. If used, it can help in planning further treatments. The CT should be performed within 2 hours of discography. The most serious complication of discography is discitis. Although rare, it is resistant to treatment due to the limited disc blood supply. Intradiscal antibiotic administration minimizes the risk of discitis. Otherwise, discography has been shown to be a safe procedure that does not cause any disc damage.^{17,18}

There are several treatment options in a patient presenting with discogenic pain. Conservative therapy such as physical therapy or dynamic lumbar stabilization exercises can be helpful in some, while others may opt for lumbar fusion surgery.

Intradiscal electrothermal therapy (IDET) for discogenic LBP pain

IDET is a new minimally invasive approach for the treatment of discogenic LBP. Initial results with this treatment modality are encouraging; however, more clinical studies are needed. In a fluoroscopically-guided procedure,

IDET involves percutaneously threading a flexible catheter into the disc tissue. A thermal resistive coil in the catheter enables the distal part to be heated to the desired temperature. The technique for approaching the disc in the IDET procedure is similar to that used in discography. The final position of the electrode is such that the end of the catheter is placed circumferentially around the inner surface of the posterior annulus. Once the catheter is in a satisfactory position, its tip is heated to a target temperature of 80°-90°C for 16.5 minutes.

The putative mechanisms of IDET action are thermal modification of collagen fibers and destruction of sensitized nociceptors in the annular wall. Besides the usual risks (eg, infection and bleeding), a possible serious complication from IDET is catheter tip shearing due to forceful manipulation. Inappropriate catheter handling can result in more serious complications, such as nerve damage or cauda equina injury. However, complications are reported to be extremely rare. Several studies support IDET treatment, with average success rates of 70%. A recent, randomized, double-blind study revealed significant advantages of IDET over placebo.¹⁹ As IDET evolves, it could become the treatment of choice for discogenic pain, possibly filling the gap between conservative treatment and surgical options.

PERCUTANEOUS DISC DECOMPRESSION

For patients with lumbar radiculopathy due to minor to moderate disc protrusion who are not surgical candidates, a new treatment option – percutaneous disc decompression – is available. This procedure is performed on an outpatient basis under sedation. It is rarely necessary to perform diagnostic discography before the percutaneous disc decompression procedure and the history, physical examination, and MRI findings are sufficient patient selection tools. There are several technical approaches to this procedure.

- The “Dekompressor” achieves disc decompression via mechanical removal of the disc tissue. Its discectomy probe utilizes a highly efficient method to remove intervertebral disc nucleus pulposus through a small channel and allows discectomy to be performed entirely under fluoroscopic control. The specimen of the nucleus pulposus is obtained during the procedure. Initial outcome reports are encouraging.
- Another technique for percutaneous disc decompression – nucleoplasty – uses “coblation” technology, which combines ablating and coagulating disc tissue. Its “spinwand” catheter creates small channels within the disc, therefore, reducing the disc tissue mass. The radiofrequency waves create an ionic plasma field from sodium atoms within the nucleus that removes tissue from the treatment area via a molecular dissociation process that converts the tissue into gases that exit at the treatment site.

Although various approaches to percutaneous disc decompression are already used widely in interventional pain settings, more studies are needed to improve patient selection criteria.²⁰

SPINAL CORD STIMULATION

The first time electrical stimulation was used to treat pain was in 600 BC, utilizing electrical power from the torpedo fish. However, electrical treatments did not find a firm place in pain medicine until 1967, when spinal cord stimulation (SCS) was introduced by Shealy and associates.²¹

With SCS, the stimulating electrodes are placed in the epidural space, connected to the subcutaneous internal pulse generator (IPG) and the internal or external power source. A SCS screening trial is performed prior to permanent SCS implantation.

The initial SCS technique involved open intrathecal implantation of electrodes via laminotomy. With improvements in hardware, the procedure has become much simpler, and the benefit/risk ratio has improved. The alternative term for SCS is “dorsal column stimulation,” since SCS electrodes stimulate the dorsal columns of the spinal cord.

SCS – Mechanism of action

The Melzack and Wall theory proposes that stimulation of A-beta fibers modulates the dorsal horn “gate” and, therefore, reduces nociceptive input from the periphery. Recent studies suggest that other mechanisms may better explain SCS action. It has been demonstrated that intrathecal administration of the GABA_B agonist, baclofen, enhances the antinociceptive action of SCS in both animals and humans. Similar findings point to the possible role of adenosine as a mediator in SCS action. It appears that SCS may have a role in activating the descending inhibitory pathways originating in the periaqueductal gray (PAG). On the other hand, SCS has been shown to induce the release of serotonin and substance P, both known to be neurotransmitters involved in nociceptive processing.

The mechanism of SCS action in patients with peripheral ischemic pain may differ. SCS has been shown to suppress the sympathetic activity via α -adrenoreceptors and increase the release of calcitonin gene-related peptide (CGRP). In patients with myocardial ischemia, SCS mediates the redistribution of coronary blood flow from regions with normal perfusion to regions with impaired perfusion. Although the exact mechanism of SCS action is unclear, it appears very likely that various mechanisms may play a role in its effectiveness.²²

Indications for SCS treatment

Patients with lumbar and cervical radiculopathy who are not surgical candidates, and patients with failed back surgery syndrome (FBSS), are the best candidates

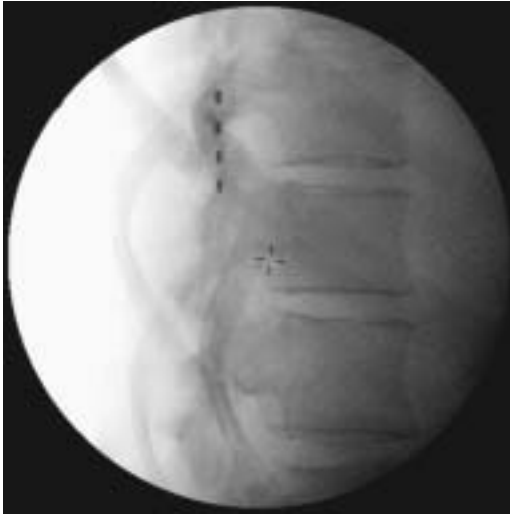
for SCS.²¹ Reported success rates in these conditions vary from 12% to 88%. Recently, Turner et al performed a systematic review of the literature related to SCS and FBSS and revealed that an average of 59% of patients had $\geq 50\%$ pain relief and improved functional status. Many studies suggest that patients with a radiating pattern to the leg appear to respond better to SCS than those with isolated axial LBP. Others support the use of SCS for the complex regional pain syndrome (CRPS), (previously called reflex sympathetic dystrophy [RSD]). A recent publication suggests that CRPS patients with sympathetically maintained pain respond significantly better to SCS than patients with sympathetically independent pain. The effectiveness of pain relief with SCS for CRPS varies from 50%-91%. Certain subgroups of patients with peripheral neuropathy may respond well to SCS:

- It appears that SCS may be an effective treatment for diabetic neuropathy, providing analgesia and potentially salvaging an affected limb. However, diabetics may have increased rates of infection with SCS implantation.
- Although a recent study showed excellent results with SCS in post-herpetic neuralgia patients, more studies are needed to fully support SCS efficacy for this condition.
- Myocardial ischemia and anginal pain refractory to pharmacologic and surgical interventions may respond well to SCS. Successfully treated patients have demonstrated increased exercise capacity, a reduction in anginal complaints, decreased use of short-acting nitrates, and improved quality of life. A fear of a potential increase in myocardial damage and cardiac arrhythmias does not seem to be justified.
- In patients with peripheral vascular disease, SCS may decrease pain, increase the peripheral blood flow, promote ulcer healing, and potentially contribute to limb salvage. Many European studies firmly support the role of SCS for peripheral ischemic pain.

Stimulation trial and permanent implant

Before proceeding with permanent SCS implantation, a SCS trial is warranted since it can positively predict good long-term outcome in 50%-70% of cases. The epidural space is identified by the loss of resistance technique. The SCS lead is inserted into the epidural space under continuous fluoroscopic guidance (Figure 3) and, once adequate lead position is obtained, a trial stimulation is performed with the goal of paresthesias providing a 70%-80% overlap with the patient's pain location. The lead contains 4-8 electrodes and various electrode combinations can be used to achieve optimal results. The typical trial time is 3-5 days, allow-

FIGURE 3: Spinal cord stimulator lead positioned in thoracic epidural space seen in lateral fluoroscopic view



ing the patient to adequately assess the effectiveness of SCS prior to a potential permanent implant. At the end of the trial, the percutaneous lead is removed.

A successful percutaneous trial is followed by permanent lead and IPG placement on a separate date. The permanent SCS hardware consists of an SCS lead, an extension cable, and a pulse generator power source (IPG). The entire procedure is performed under local anesthesia in the operating room. The lead is inserted in a similar fashion as in the trial and anchored to the fascia and then connected to the IPG, which is usually placed either in the abdominal or gluteal area. In certain cases, the SCS lead can be placed via open laminotomy, which allows for better effectiveness and a decreased chance of migration. For the first 6-8 weeks following permanent SCS implantation, patients should avoid extreme activity in order to prevent lead migration and allow epidural scar tissue formation. The scar tissue prevents undesirable migration of the electrodes.

Complications with SCS are rare and, in most cases, limited to equipment failure, infection, and subcutaneous hematoma. SCS and pacemakers can be combined in the same patient, but with caution because of potential interference between devices and inhibition of the cardiac pacemaker if used simultaneously. The SCS batteries have to be changed every 3-6 years, which requires a brief visit to the operating room.

INTRATHECAL MEDICATION DELIVERY SYSTEMS

Intrathecal drug delivery has gained popularity, since the discovery of opioid receptors in the spinal cord. While avoiding the side effects of systemically-

administered medications, the technique provides targeted delivery of medications to the intrathecal space via a surgically-implanted subcutaneous pump containing a reservoir for medication. The pump is easily refilled, the frequency depending on the infusion rate.

Recently, local anesthetics, clonidine, and baclofen, given alone or in combination with opioids, have been used for intrathecal delivery. Since numerous receptors involved in nociceptive transmission are located in the spinal cord, this approach appears promising.

Several, well-designed, outcome studies have demonstrated that intraspinal therapy provides an excellent therapeutic effect for nonmalignant and cancer pain. However, it should be reserved only for patients who have failed other, more conservative approaches for the treatment of pain, and used with caution. Before starting intrathecal treatment in a patient with chronic pain, the expectations and plans should be discussed in detail. Patients should undergo a trial infusion procedure before the pump is implanted in order to better assess the odds of a favorable outcome.

Several studies support the use of intrathecal medication delivery for chronic pain; however, the best candidates are patients who respond well to oral opioids, but who cannot tolerate the side effects (eg, sedation, constipation, nausea).²³

VERTEBROPLASTY

Osteoporotic compression fractures are a common disease in the elderly and in post-menopausal women who are particularly prone to bone loss. It is estimated that more than one-quarter of women >65 years will develop a vertebral fracture due to osteoporosis. Percutaneous vertebroplasty is a relatively new procedure consisting of percutaneously injecting polymethylmethacrylate cement into osteoporotic, fractured vertebral bodies. By stabilizing vertebral lesions, the injected cement produces analgesia in these patients. The major indications for vertebroplasty are osteoporotic vertebral compression fractures, vertebral angiomas, and osteoporotic vertebral tumors.

Vertebroplasty is an outpatient procedure, performed under fluoroscopic or CT guidance. The patient is placed in a prone position and, under local anesthesia, an 11-gauge bone marrow biopsy needle is directed using a transpedicular approach into the vertebral body. After confirming needle placement in the lateral fluoroscopic views and negative intravascular contrast spread, the cement is injected under continuous fluoroscopic guidance. Potential complications include leakage of cement into adjacent structures, with neural damage due to mechanical compression, and thermal necrosis. High technical expertise is needed in order to

appropriately perform this procedure. Outcome studies and clinical experience are supportive of vertebroplasty.²⁴

CONCLUSION

There has been very rapid growth in interventional pain management over the past decade. A significant portion of that growth has been due to newly developed minimally invasive treatments for LBP. The main reasons for seriously considering minimally invasive approaches for LBP are the:

- extremely favorable risk/benefit ratio of minimally invasive procedures
- possibility of avoiding surgical approaches and hospitalizations
- significant cost-savings these approaches have over surgical approaches.

Although there are no supporting studies as yet, clinical observations suggest that it may be safer to try these procedures first, before starting long-term opioid therapy for LBP. Finally, maintaining adequate body weight and performing back exercises on a regular basis may significantly improve the outcome of these procedures.

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