Percutaneous Epidural Adhesiolysis of Lumbar Spinal Stenosis

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Percutaneous epidural neuroplasty (PEN) represents an important part of the interventional repertoire for the treatment of low back pain which is refractory to conventional treatments such as epidural steroid injections (ESI). PEN has been done worldwide. The evidence surrounding epidural neuroplasty is still controversial, but, many studies support ambulatory PEN for failed back surgery syndrome, spinal stenosis and radicular pain refractory to less invasive procedures. The primary purpose of PEN is to deliver anesthetic, anti-inflammatory, and/or anti-adhesive drugs in addition to mechanical adhesiolysis. Hydrostatic and chemical adhesiolysis may contribute to the beneficial effect of adhesiolysis. Identifying the ideal patients and technique for PEN is important to maximize its effectiveness. The cumulative evidence shows that PEN is an effective treatment for spinal stenosis.

Key Words: Spinal pain; spinal stenosis; percutaneous adhesiolysis.

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INTRODUCTION

Lumbar spinal stenosis is a common degenerative disease. Spinal stenosis can be defined as a narrowing of the spinal canal by a combination of bone and soft tissues, which causes mechanical compression of spinal nerve roots¹⁰. The compression of these nerve roots can be asymptomatic, but it can also become symptomatic, resulting in weakness, reflex alterations, gait disturbances, bowel or bladder dysfunction, motor and sensory changes, radicular pain or atypical leg pain, and neurogenic claudication. As our population ages and the rate of spine surgery continues to rise, the use of various minimally invasive treatment has emerged as a popular treatment to treat spinal stenosis⁷. Percutaneous epidural neuroplasty (PEN) is the one of interventional techniques in the management of low back pain that was developed nearly a decade ago as part of a multidisciplinary approach. The review of PEN for spinal stenosis was undertaken utilizing literature reviews.

EVOLUTION OF TECHNIQUE

PEN is known as epidural neuroplasty and epidural adhesiolysis, is a minimally invasive technique for the treatment of axial spine or radicular pain when conservative therapy has failed⁵.

The technique typically involves accessing the epidural space via the sacral hiatus using a large gauge needle and inserting a catheter. The catheter is then advanced to the site of adhesions where epidurography is used to map out the adhesions, and adhesiolysis via the high-volume administration of saline (hydrostatic adhesiolysis) and medications (chemical adhesiolysis) is performed⁴. The original procedure required that the catheter remain in the epidural space for three days, with the injection of different medications on each of the days. The technique was subsequently modified to become an ambulatory procedure similar to a traditional ESI, but involving a catheter that is removed immediately following the injection of a combination of a steroid, local anesthetics, and sometimes hyaluronidase and hypertonic saline.

INDICATIONS AND CONTRAINDICATIONS

In a large retrospective analysis conducted in 115 patients who underwent PEN, the one variable that was most consistently associated with successful response was age >81 years⁹. A numeric rating score (NRS) <9 was also associated with a positive outcome. Paradoxically, patients seeking disability or worker's compensation were more likely to obtain a positive outcome,

while those with NRS pain scores >9 and in the age group between 41–50 years were more likely to experience a negative outcome. A poor outcome was more common in patients with previous surgery, spondylolisthesis, herniated disc, and lumbosacral and foraminal stenosis. An observational study performed in 66 patients with clinical spinal stenosis found no association between clinical outcome and the anatomical degree of stenosis.

PREOPERATIVE ASSESSMENT AND PLANNING

Physical examination

As with any patient, a thorough musculoskeletal and neurologic examination should be performed. In addition to standard dural tension provocative tests, a provocative test called ‘dural tug’ was generally recommended. To perform this test, the patient should be instructed to sit up with a straight leg, bend forward flexing the lumbar spine until their back pain starts to become evident, and the head and neck flexed rapidly forward. During this maneuver, the dura is stretched cephalad and if adhered to structures such as the posterior longitudinal ligament, the most heavily innervated spinal canal structure, the movement of the dura will elicit back pain that is localized to the pain generator. A positive dural tug maneuver has been observed to resolve after percutaneous neuroplasty.

Radiographic workup and preoperative imaging

MRI and computed tomography (CT) are diagnostic tools; sensitivity and specificity are 50% and 70%, respectively. CT myelography may also be helpful, although none of the aforementioned modalities can identify epidural fibrosis with 100% reliability. In contrast, epidurography is a technique used with considerable success and it is believed that epidural fibrosis is best diagnosed by performing an epidurogram. It can detect filling defects in good correlation with a patient's symptoms in real time. A combination of several of these techniques would undoubtedly increase the ability to identify epidural fibrosis.

Before the procedure, a complete blood count and a clean-catch urinalysis are obtained to check for any undiagnosed infections. An elevated white count and/or a positive urinalysis should prompt the physician to postpone the procedure and refer the patient to the primary care physician for further workup and treatment. In addition, history of bleeding, abnormalities a prothrombin time, partial thromboplastin time, and platelet function assay or bleeding time, are obtained to check for coagulation abnormalities. Any elevated value warrants further investigation and postponement of the procedure until those studies are complete.

Patient education

When PEN has been deemed an appropriate treatment modality, the risks and benefits of the procedure should be dis-

cussed with the patient and informed consent obtained. The benefits are pain relief, improved physical function, and possible reversal of neurologic symptoms. Risks include, but are not limited to, bruising, bleeding, infection, reaction to medications used (hyaluronidase, local anesthetic, corticosteroids, hypertonic saline), damage to nerves or blood vessels, no or little pain relief, bowel/bladder incontinence, worsening of pain, and paralysis. Patients with a history of urinary incontinence should have a urodynamic evaluation by a urologist before the procedure to document the preexisting urodynamic etiology and pathology.

TREATMENT OPTIONS

There is moderate evidence supporting the use of hypertonic saline in epidural lysis of adhesions, and weak positive evidence in favor of using hyaluronidase. Although the question has not been formally addressed in randomized studies, there is evidence that a significant portion of the benefit for epidural PEN can be attributed to the high volumes injected.

OPERATIVE TECHNIQUE

This procedure should be performed under strict sterile conditions in the operating room. Prophylactic antibiotics with broad neuraxial coverage may be given before the procedure. Patients will receive either ceftriaxone 1 g intravenously or Levaquin 500 mg orally in those allergic to penicillin. The same dose may be also given on day 2. An anesthesiologist or nurse anesthetist provides monitored anesthesia care.

The patient is placed in the prone position with a pillow placed under the abdomen to correct the lumbar lordosis and a pillow under the ankles for patient comfort. The patient is asked to put his or her toes together and heels apart. This relaxes the gluteal muscles and facilitates identification of the sacral hiatus. After sterile preparation and draping, the sacral hiatus is identified via palpation just caudal to the sacral cornu or with fluoroscopic guidance. A skin wheal is raised with local anesthetic slightly lateral and caudal to the sacral hiatus on the side opposite the documented radiculopathy. A distal subcutaneous approach theoretically provides some protection from meningitis, as a local skin infection would be much preferred over infection closer to the caudal epidural space. The skin is nicked with an 18-gauge cutting needle, and a 15-gauge Tuohy needle is inserted through the nick at a 45-degree angle and guided fluoroscopically or by palpation to the sacral hiatus (Fig. 1).

When the needle is through the hiatus, the angle of the needle is dropped to approximately 30 degrees and advanced. The back edge of the distal opening of the needle is designed to be a non-cutting surface that allows manipulation of the catheter in and out of the needle. A Tuohy needle has the back edge of the distal opening, which is a cutting surface and can more easily shear a catheter. A properly placed needle will be inside the caudal canal below the level of the S3 foramen on anteroposterior (AP)

Fig. 1. A : A 15-gauge Tuohy needle is inserted through the sacral hiatus. B : The catheter is navigated and advanced to the target level.

Fig. 2. A case of epidurogram using 3 mL of Omnipaque. Instead of normal tree pattern, asymmetric epidurogram is visualized due to possible microadhesions.

and later fluoroscopic images. A needle placed above the level of the S3 foramen could potentially puncture a low-lying dura. The needle tip should cross the midline of the sacrum toward the side of the radiculopathy².

An epidurogram is performed using 3 mL of a non-ionic, water-soluble contrast agent. Confirm a negative aspiration for blood or cerebrospinal fluid before any injection of the contrast or medication. Omnipaque and Isovue are the two agents most frequently used and are suitable for myelography. Do not use ionic, water-insoluble agents which are not indicated for myelography. Accidental subarachnoid injections can lead to serious untoward events such as seizure and possibly death³. Slowly inject the contrast agent and observe for filling defects. A normal epidurogram will have a “Christmas tree” pattern with

Fig. 3. A : A flexible catheter (Tun-L-XL, Epimed, TX, USA) with a bend on the distal tip through the needle. B : The bend is usually 2.5 cm from the tip of the catheter and at a 30-degree angle.

Fig. 4. A notch can be made to accelerate steering.

Fig. 5. An illustration of the final tip position in a case of foraminal stenosis. A target lesion is usually located at the ventral epidural space.

the central canal being the trunk and the outline of the nerve roots making up the branches (Fig. 2). An abnormal epidurogram will have areas where the contrast does not fill. These are the areas of presumed scarring and typically correspond to the patient’s radicular complaints. If vascular uptake is observed, the needle needs to be redirected¹.

After turning the distal opening of the needle ventral lateral, insert a flexible catheter (Tun-L-XL, Epimed, TX, USA) with a bend on the distal tip through the needle. The bend should be 2.5 cm from the tip of the catheter and at a 30-degree angle (Fig. 3A). The bend will enable the catheter to be steered to the target level. Under continuous AP fluoroscopic guidance, advance the tip of the catheter toward the ventro-lateral epidural space of the desired level (Fig. 3B). The catheter can be steered by gently twisting the catheter in a clockwise or counterclockwise direction. The steering can even easier if we make a notch (Fig. 4). Avoid “propelling” the tip (twisting the tip in circles) because this makes it more difficult to direct the catheter. Do not advance

Fig. 6. A : Routine epidurogram showed no contrast above the level of L5–S1. B : After hydrostatic (10 cc normal saline), mechanical, and chemical (1500-U hyaluronidase) adhesiolysis, the ventral epidural space was visualized by the final epidurogram.

the catheter up the middle of the sacrum because this makes guiding the catheter to the ventral-lateral epidural space more difficult. Ideal location of the tip of the catheter in the AP projection is in the foramen just below the midportion of the pedicle shadow. Check a lateral projection to confirm that the catheter tip is in the ventral epidural space (Fig. 5).

Under real-time fluoroscopy, inject 2 to 3 mL of additional contrast through the catheter in an attempt to outline the “scarred in” nerve root. If vascular uptake is noted, reposition the catheter and re-inject contrast. Preferably there should not be vascular runoff, but infrequently secondary to venous congestion, an epidural pattern is seen with a small amount of vascular spread. This is acceptable as long as the vascular uptake is venous in nature and not arterial. Extra caution should be taken when injecting the local anesthetic to prevent local anesthetic toxicity. Toxicity is volume and dose related and so far there has not been any reported complications from small volume venous spread. Any arterial spread of contrast always warrants repositioning of the catheter. The soft, spring-tipped catheters never be placed in intra-arterial placement. Inject 1500 U of hyaluronidase dissolved in 10 mL of preservative-free normal saline. A newer development is the use of hyaluronidase, which carries the advantage of a reportedly increased effectiveness at the body’s normal pH compared to bovine-recombinant hyaluronidase. This injection may cause some discomfort, so a slow injection is preferable. Observe for “opening up” (visualization) of the “scarred in” nerve root. A 3 mL test dose of a 10 mL local anesthetic/steroid solution is then given. Our institution used 4 mg of dexamethasone mixed with 9 mL of 0.2% ropivacaine. Ropivacaine is used instead of bupivacaine for two reasons : the former produces a preferential sensory versus a motor block, and it is less cardiotoxic than a racemic bupivacaine. Doses for other corticosteroids commonly used are 40 to 80 mg of methylprednisolone (Depo-Medrol), 25 to 50 mg of triamcinolone diacetate (Aristocort), 40 to 80 mg of triamcinolone acetonide (Kenalog), and 6 to 12 mg of betamethasone (Celestone Solu span). If, after 5 minutes, there is no evidence of intrathecal or intravascular

injection of medication, inject the remaining 7 mL of the solution. Remove the needle under continuous fluoroscopic guidance to ensure the catheter remains at the target level. Secure the catheter to the skin using nonabsorbable suture and coat the skin puncture site with antimicrobial ointment. Apply a sterile dressing and attach a 0.2 μ m filter to the end of the catheter. Affix the exposed portion of the catheter to the patient with tape and transport the patient to the recovery area.

CASE EXAMPLES

A 60-year-old male underwent percutaneous epidural adhesiolysis due to spinal stenosis at the level of L3–4. Routine epidurogram showed no contrast above the level of L5–S1 (Fig. 6A). After hydrostatic (10 cc normal saline), mechanical, and chemical (1500-U hyaluronidase) adhesiolysis, the ventral epidural space was visualized by the final epidurogram (Fig. 6B). A mixture of 0.2% Ropivacaine and 6mg betamethasone was instilled slowly. The patient’s radicular pain was improved dramatically.

PROBLEMS AND COMPLICATIONS

As for any procedural intervention, bleeding, infection, and nerve damage are some of the general complications associated with PEN. The added risks associated with entering the epidural space include cerebral spinal fluid leakage and subsequent post-dural puncture headache, and neurological sequelae resulting from a hematoma or compression from large volume injectate administration. Entering the epidural space at the sacrococcygeal ligament and advancing a catheter up towards the area of pathology should theoretically reduce the incidence of inadvertent dural puncture. Although this has yet to be formally examined, it is likely that the development and risk of serious neurological complications resulting from hematoma formation may be less with a fluoroscopically-guided caudal approach, as the entry point into the epidural space is more superficial;

the area is more compressible than in the lumbar and cervical spinal regions; and the nerve roots that innervate the lower extremities and most of the bowel and bladder are located more cephalad. One retrospective review of 250 patients who underwent epidural neuroplasty revealed a variety of different complications such as a bent needle tip (4.8%), torn catheters during withdrawal (1.2%), sheared catheter remnant (0.4%), intrathecal placement of catheter (4.4%), and epidural abscess (1.2%). In another large study, a prospective evaluation of 10000 epidural injections found that in the 839 patients who underwent adhesiolysis, the rates of intravascular injection (11.6%), transient nerve irritation (1.9%), and dural puncture (1.8%) were significantly higher than for conventional ESI. The differences are likely related to the volume administered, needle size, catheter insertion and manipulation, since patients who received caudal epidural injections without adhesiolysis experienced much lower complication rates : intravascular injection (3.1%), transient nerve irritation (0.0%), and dural puncture (0.0%).

PITFALLS & CAVEATS

Epidural adhesiolysis has evolved over the years as an important treatment option for patients with intractable cervical, thoracic, and low back and leg pain. Studies show that patients are able to experience significant pain relief and restoration of function. Manchikanti's studies show that the amount and duration of relief can be achieved by repeat procedures. Recent prospective randomized double-blind studies on failed back surgery and spinal stenosis show 75% and 80% improvement in visual analog scale scores and functional improvements at 12 months' follow-up. There have been no negative studies to date where the lysis target was the ventral-lateral epidural space. The evolution in the recognition of the site-specific importance of the catheter and medication delivery together with the fact that physicians

need to acquire the skills to be able to carry out the procedure led to the improved outcomes seen in recent prospective randomized studies. Lysis of adhesions via the caudal approach involves introducing a catheter through the sacral hiatus and advancing it to the affected nerve root in the ventral-lateral epidural space.

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REFERENCES

1. Anderson SR : A rationale for the treatment algorithm of failed back surgery syndrome. **Curr Rev Pain** 4 : 396-406, 2000
2. Cervellini P, Curri D, Volpin L, Bernardi L, Pinna V, Benedetti A : Computed tomography of epidural fibrosis after discectomy : a comparison between symptomatic and asymptomatic patients. **Neurosurgery** 23 : 710-713, 1988
3. Kuslich SD, Ulstrom CL, Michael CJ : The tissue origin of low back pain and sciatica : a report of pain response to tissue stimulation during operations on the lumbar spine using local anesthesia. **Orthop Clin North Am** 22 : 181-187, 1991
4. Lawrence RC, Helmick CG, Arnett FC, Deyo RA, Felson DT, Giannini EH, et al. : Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. **Arthritis Rheum** 41 : 778-799, 1998
5. Manchikanti L, Staats PS, Singh V, Shultz DM, Vilims BD, Jasper JE, et al. : Evidence-based practice guidelines for interventional techniques in the management of chronic spinal pain. **Pain Phys** 6 : 3-81, 2003
6. National Center for Health Statistics : National hospital discharge survey, Washington, DC, US Department of Health and Human Services, Centers for Disease Control and Prevention, Report no. PB92-500818, 1990
7. Pawl R : Arachnoiditis and epidural fibrosis : the relationship to chronic pain. **Curr Rev Pain** 2 : 93-99, 1998
8. Racz GB, Noe C, Heavner JE : Selective spinal injections for lower back pain. **Curr Rev Pain** 3 : 333-341, 1999
9. Straus BN : Chronic pain of spinal origin : the costs of intervention. **Spine** 27 : 2614-2619, 2002
10. Van Zundert J : Personal communication. 2005