







I am sure you are all aware of our upcoming annual meeting in Sydney. This year's gathering combines the strengths of ISIS and the Australian Faculty of Musculoskeletal Medicine, and should prove to be our best meeting yet. This year we have three distinct scientific sessions scheduled, concentrating on Whiplash, Shoulder Pain & Internal Disc Disruption, as well as our usual session reserved for the presentation of free papers. We are expecting meeting attendance to reach an all time high this year. There is still plenty of time to book. However, if circumstances do not permit attendance, do not fear. The meeting will be recorded in full audio and video, and will be available in the succeeding weeks.

### ***Credentialing***

We are currently working on our own credentialing package, but we need to know if it is something that members are interested in. The credential would not constitute board certification, but rather would be a document to demonstrate procedural knowledge & proficiency of a high enough standard to satisfy ISIS. Enclosed in the newsletter you will find a post-card asking for your opinions on the matter. Please, please, please take the time to fill it out and return it to us so that we may know the will of the majority.

### ***The Video***

The Lumbar Discography Instructional Video, prepared in conjunction with OEC, is in its final editing stages and should be ready for distribution in Sydney.

### ***The Atlas***

Work on the Injection Atlas is ongoing. The atlas will contain detailed procedural & technical information, equipment and instrumentation details, and fluoroscopic imaging guidelines, on the most common spinal injection procedures, (and some of the more obscure ones). Procedures will be divided by region; Lumbar, Thoracic and Cervical. Images will be used extensively throughout to further illustrate and clarify potentially ambiguous points. **BUT WE NEED YOUR HELP & INPUT.** The Atlas material can be accessed online at <http://www.spinaldiagnostics.com/spinaldx/contents.htm>. Access can be gained using your normal ISIS Username & Password. All feedback is hugely appreciated and will be acknowledged in the final manuscript. Dr. Conor O' Neill has graciously accepted the helm on this project, so all feedback can be directed to him at [coneill@spinaldiagnostics.com](mailto:coneill@spinaldiagnostics.com).

### ***Some Final Points***

On a personal note, I encourage members of ISIS to consider taking membership of other pertinent professional societies. (NASS, ISSLS etc.) I find that membership of such organizations benefit and enhance my practice greatly, by keeping me constantly appraised of the current state-of-the-art in our field. Complacency and stagnation are states to be avoided at all costs at any level of the medical profession. I would like to take this opportunity to thank Jordon Moncrief, the ISIS Chief Operating Officer, for the excellent, and often thankless, job she has

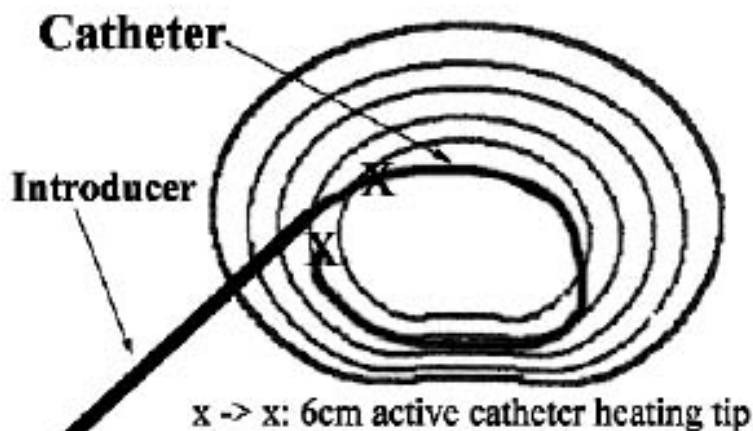




**Conclusions:** In the early stages of investigation, intradiscal electrothermal annuloplasty appears promising as a technique to reduce chronic pain of discogenic origin. Further study is warranted, both to compare efficacy against other intradiscal heating procedures and to assess the precise pathology most successfully treated by the procedure. The current study is ongoing, and the 12-month follow-up results will be presented as time allows.

**Fig 1: Typical catheter placement**

<sup>1</sup> The SPINECath catheter is manufactured & distributed by Oratec Interventions. Physicians requiring further information on equipment or procedure may contact Oratec Interventions at 3700 Haven Court, Menlo Park, CA 94025. (Tel (650) 369-9904) Please note, none of the authors hold any interest in this company.



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had intravenous access. Monitoring included ECG, non-invasive blood pressure and pulse oximeter. The skin was prepped and, under fluoroscopy, the C7, T1, T2, and T3 transverse processes were identified. Using second and third fingers of the non-dominant hand hooked around the medial edge of the sternocleidomastoid muscle, the underlying carotid sheath was pulled laterally. Initially a 25-gauge, 5cm long spinal needle was inserted at the level of C7 transverse process and aimed at the junction of the transverse process and body of T1 vertebra. Once bone contact was made at T1, the needle was redirected caudally in the parasagittal plane aiming at the junction of the transverse process and vertebral body of T2 vertebra. Care should be taken to avoid lateral placement due to the risk of pneumothorax. Following negative aspiration of blood and cerebrospinal fluid (CSF) (Figure 3), 0.5-1ml of a radio-opaque dye was injected. After biplanar confirmation of placement with the contrast material lying directly along the vertebral body just anterior to the thoracic foraminal opening. (3). A test dose of 1 ml of local anesthetic agent (2% lidocaine) was given. After waiting 2-3 minutes, if there were no signs of cerebral dysfunction (due to intravascular injection) or spinal anesthesia (intrathecal blockade), 3-5 ml of 0.5% plain bupivacaine was injected.

The same is done for the T3 sympathetic ganglion block by redirecting the needle caudally. The needle tip was positioned at the junction of the transverse process and vertebral body of T3 (Figures 4 and 5). The T3 was technically more difficult than the T2 sympathetic block, especially in the obese or the patient with a short neck. The temperature was monitored on both extremities and a successful sympathetic blockade was confirmed if there was an increase in the temperature of the ipsilateral side of the block of at least 5-6 C. Following a successful sympathetic block, the patient's pain was monitored for 24-48 hours following the procedure, using a Visual Analogue Scale (VAS) of 10. If there was more than 50% reduction in the severity of the pain on the VAS score, the patient was considered a candidate for radio frequency ablation (RFA) of the T2/T3 sympathetic ganglion for a longer duration of pain relief.

The RFA lesioning of the T2/T3 thoracic sympathetic chain was performed with a disposable SMK 145/20 gauge needle (SLUIJTER- MEHTA CANNULA by RADIONICS, INC., Burlington, MA 01803, USA). The needle was inserted in the manner described above. After the cannula position was confirmed by fluoroscopy and contrast material spread, electrical stimulation was then carried out. Sensory stimulation, described by the patient as deep aching pain in the back, chest and the medial aspect of the upper extremity, at frequencies of 50 Hz or 100 Hz at 0.4 volts or less, suggests that the thermal lesioning tip of the needle was close to the intercostal nerves, and no lesion was performed. Motor stimulation was performed with 2 Hz and intercostal fasciculation should be absent at 3 volts. After electrostimulation, verification that the cannula was in the correct position, 1-2 ml of 2% lidocaine was injected. After allowing 4-5 minutes, the eye was observed for signs of Horner's syndrome. If no pupillary changes occurred, lesioning at 60 C for 60 seconds was completed. Should Horner's syndrome develop after the thermal lesion, no further lesion is done. The pupillary changes (Horner's syndrome) is expected to resolve and disappear within 2-3 weeks. (1) If there were no pupillary changes, another RFA lesion was performed at 90 C for 60-90 seconds, the temperature of the upper extremity was observed, and if the temperature increased by 4-6 C no further lesioning was performed at this level. Horner's syndrome may follow the injection of the local anesthetic drugs which did not occur so far in our cases. In such cases, we recommend

that the procedure be deferred to another day to avoid confusion if the pupillary changes were due to the local anesthetic or the RFA effect.

The same technique was then done at the T3 sympathetic ganglion to produce a more complete sympathectomy.

All patients had chest x-ray after the procedure and were followed up for the first week to exclude any complications and to see their response to the block.

## **DISCUSSION**

The thoracic sympathetic ganglia and chain lies along the periosteum of the thoracic vertebral bodies on both sides in a much posterior position than the sympathetic ganglion in the lumbar area.

The sympathetic innervation for the upper extremity arises from the lateral horn of T2 to T7 - T9 segment of the spinal cord. (2, 3) The preganglionic fibers ascend in the sympathetic trunk on both sides of the spinal column to synapse with the postganglionic neurons in the inferior cervical and first thoracic ganglia. (2) In 80% of the population, these two ganglion are fused to form the stellate ganglion. (3)

The postganglionic fiber carries sympathetic flow to the upper extremities. However, the greatest number of these fibers pass through the second thoracic ganglion (T2), and hence T2 sympathetic ganglion should be the main target for sympathetic denervation. (1) Some of the postganglionic fibers that arise from the second and third thoracic sympathetic ganglion may bypass the first thoracic and inferior cervical sympathetic ganglion and pass directly to the upper extremity (the nerves of Kuntz). This is why it is recommended that both the T2 and T3 ganglion be blocked or lesioned (RFA) to have more complete sympathectomy. (2-4) This also explains the incomplete sympathectomy of the upper extremity following stellate ganglion block, as this will miss the nerve of Kuntz. (2-4)

It is important to avoid the T1 sympathetic ganglion, as blocking or RFA lesion here will interrupt the oculopupillary sympathetic pathway resulting in Horner's syndrome, and so the correct needle position at T2 and T3 is vital. (1-5) The T1 sympathetic ganglion is frequently affected in techniques directed against the stellate ganglion (RFA) and so leading to a Horner's syndrome.

The anterior approach offers the advantage of having the patient in the supine position. This is more comfortable to the patient, avoids the complication of the prone position and also makes it easier for the administration of sedatives/analgesic for conscious sedation and in managing complication should they arise(convulsion, cardiorespiratory arrest). Another advantage of this approach is that the thermal tip of the needle is parallel to the target the T2/T3 sympathetic ganglion (which is fusiform in shape). This can produce a better and wider lesion than the posterior approach. (6) This is because the current passes into the surrounding tissues along the length of the uninsulated portion of the needle. (6) The thermal lesion is oval along the axis of the bared part of the RFA needle and will be parallel to the sympathetic chain. In comparison to the classical posterior approach where the heated tip crosses the sympathetic chain and so produces a smaller lesion. (6,7)

This approach has the same potential complications as the classical posterior approach

for thoracic sympathectomy. (1, 5). These include pneumothorax, intravascular or intrathecal injection of the local anesthetic as the dural cuff of the intercostal nerves sometimes extends outside the spinal foramina. Careful aspiration before injecting any drug for blood and CSF and the injection of radio-opaque dye should be performed before diagnostic or therapeutic RFA blocks are performed. We also prefer to inject a test dose of local anesthetic (1-2 ml of 2% lidocaine) and observe the patient for signs of cerebral dysfunction (intravascular injection) and spinal anesthesia (intrathecal injection). All our patients had post procedure chest x-ray to exclude pneumothorax. If the RFA procedure was done, there is the risk of persistent Horner's syndrome and intercostal neuralgia. Some patients may complain of excessive dryness of the face and the hands. (8)

Contraindication for the procedure include coagulopathy and bleeding disorders, infection at the site of needle insertion and patient refusal.

More than 12 cases were performed using the above anterior approach using local anesthetic with no major sequel. There was only one case on pneumothorax (5%) which did not require any intervention and the patient was discharged home.

We have recently modified the technique using a curved RFA needle (C15ND-B) by RADIONICS, INC, Burlington MA, USA (Fig 6). This allowed us to steer the needle over the transverse processes of T1 and T2 vertebra, thus avoiding repeated insertion of needle. The blunt tip of the needle will deflect through tissue planes rather than transfixing them. (6) Since then we had no pneumothorax and patients required less sedation. This needle, however, need to be inserted through a 14 Gauge needle through the skin. The curved tip allowed multiple and wider radiofrequency lesions to be done by rotating the curved needle (360 degrees) without changing needle position.

Since pain and disability from CRPS Types I and II may not be all sympathetically maintained (which explains why some of our patients did not respond to the sympathetic block), it is important to include other therapeutic modalities, including physical therapy, medication and psychological approaches.

## **References**

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Figure 1: The white needle shows position of needle/RFA cannula. The black needle is inserted into sympathetic ganglion/chain.

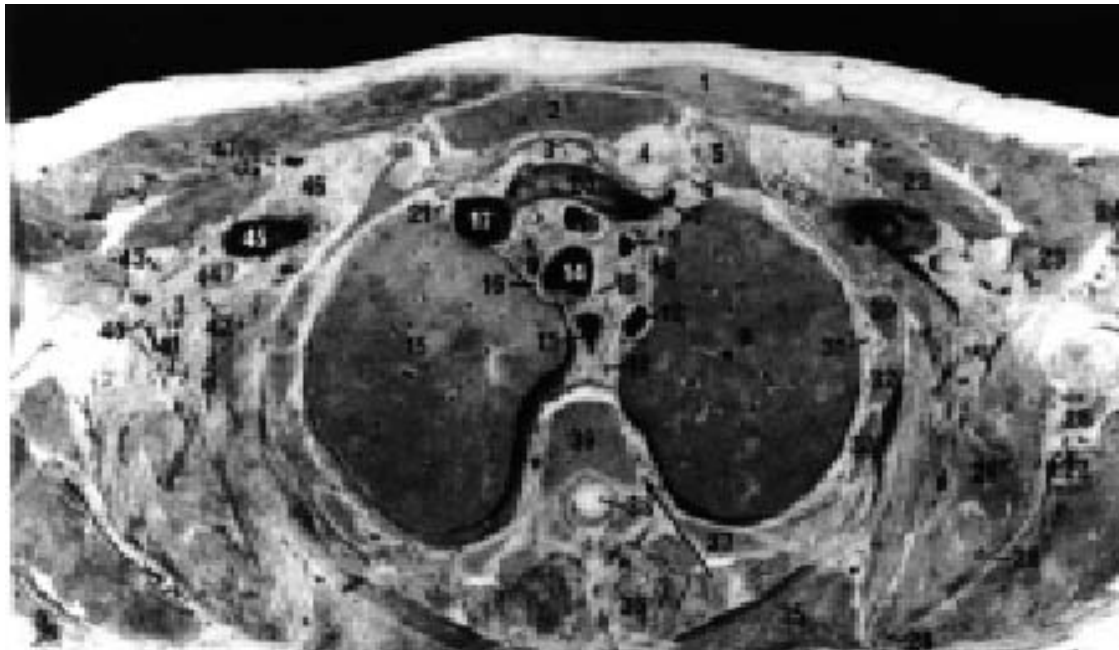


Figure 2: Section through thorax at the T3 level. Arrow is the site of the needle tip for sympathetic ganglion block.



Figure 3: Showing the needle tip at the junction of T2 vertebral body and transverse process. Note that the needle is always in the parasagittal plane.



Figure 4: Showing needle position form T3 sympathetic ganglion block.



Figure 5: Showing the spread of radio-opaque dye at the T3 level for sympathetic blockade. 1.5 - 2 ml of dye was injected (note the limited spread to T3-T4 level only).



Figure 6: A curved radiofrequency needle. Notice the curve at T2 transverse process. The heating tip is at level T3.















On a final note, medical procedures, by their very nature, contain a certain risk-to-benefit ratio that needs to be taken into consideration when deciding upon a responsible treatment modality, and/or prior to initiating interventional therapies. Procedures that are used primarily as a means of temporary chronic-pain control are certainly no exception. Interlaminar cervical epidural blocks may be categorized as a potentially high-risk procedure possessing a modest chance of returning a satisfactory therapeutic effect. Infrequent procedural complications are to be expected. Physician experience notwithstanding, it is my feeling that adherence to an established and accepted procedural standard of practice will serve to mitigate, or ideally, vanquish completely, the inherent risks involved in such procedures.

### **Guidelines**

Spinal cord injury is undoubtedly the major complication that can occur during, or following, a cervical epidural block. The possibility for both immediate and delayed onset injury exists. Cord damage occurs usually as a result of direct trauma to the cord by either contact with the needle, direct injection into the cord, or a combination of both. Delayed injury can occur due to compression of the spinal cord caused by bleeding or infection. Indirect injury of the cord could potentially occur by injecting a depo-steroid solution into the CSF. The incidence rate of both direct and indirect injury can be greatly lessened by observing to the following guidelines:

*1. Interlaminar cervical epidural blocks should not be performed at any level when the midline sagittal diameter is less than 8mm. If the midline sagittal diameter is between 8mm and 10mm, the procedure should be avoided if possible. If proceeding, extreme caution must be exercised.*

Rationale: The cervical epidural space is surrounded and cushioned by an extensive network of venous plexus. Consequently, needle entry into or through a vein is not uncommon. Post-block hematomas therefore can not be prevented and an already compromised canal diameter is placed at further risk from compromise by the possibility of epidural hematoma.

*2. Patients must not take aspirin or aspirin-based products for 7-10 days pre-procedure. Non-steroidal anti-inflammatory drugs (NSAIDs) must also be halted for 3-5 days prior to the block.*

*3. An interlaminar epidural block should not be performed at a level where a disk protrusion or spondylolisthetic narrows the midline spinal canal diameter. (Having typically been visualized by a pre-procedure MRI or CT myelography- See guideline #6 below)*

*4. A cervical epidural should rarely be performed above the level of C7-T1.*

Rationale: An examination of the midline sagittal T1 weighted MRI images, usually reveals 1 to 2 mm of fat which can be visualized in the dorsal epidural

space at the C7-T1 interspace. However it is rare that such fat is noted in the levels above. The epidural space at higher levels is therefore either very narrow or it is a potential space. Thus, at the moment when the epidural needle is on the verge of penetrating the ligamentum flavum, the needle's bevel may potentially press the ligamentum flavum against the dura, which in turn may become indented to press directly against the spinal cord. (This situation may further be aggravated by the existence of an anterior disc protrusion displacing the spinal cord posteriorly.) Consequently the injectionist experiences what amounts to a perceptual "absence" of epidural space and hence, the expected telltale "loss of resistance" sensation, indicating penetration into the epidural space, is not encountered. (Under normal circumstances, aspiration of CSF is the primary indication of sub-dural tap, and the procedure can be discontinued immediately, as per guideline #11, with no negative sequelae. However, due the atypical circumstance that finds the ligamentum flavum, the dura and the spinal cord pressed closely together, CSF may not be aspirated. ) Accordingly, believing the epidural space is yet to be encountered, the injectionist may initiate further advancement of the epidural needle, resulting in inadvertent spinal cord puncture. Needless to say, this represents a highly undesirable procedural outcome. Although 5 ml of solution injected at the C7-T1 interspace will often fill the entire space to the C2 level, if the structural pathology is at the C5-6 interspace or higher, one can perform a C7-T1 or a T1-T2 puncture and advance a catheter to the desired level.

*5. Fluoroscopy should be utilized to select & identify the level, the midline, and to help locate the depth.*

Rationale: As with guideline #4, this guideline is also apt to generate a polemic, and adherence to it will not it itself guarantee needle misplacement. However correctly utilized, fluoroscopic imaging is an invaluable tool for aiding in the prevention of inadvertent dural or cord punctures. The patient is placed in a prone position with the interspace visualized and pinpointed in the AP projection. Using a paramedian approach, with the epidural needle approximately 1cm from the midline and approximately 2 cm below the border of the lamina, (i.e. in the case of a C7-T1 puncture, the needle will be advanced over the lamina of T1), the needle is advanced to the edge of the lower lamina. Since the advancing needle is always over bone, unintentional advancement into the spinal canal is prevented. Once the needle contacts the lamina it is advanced cephalad and toward the midline until the resistance of the ligamentum flavum is felt. If the ligamentum flavum is not felt within 5mm then the needle is withdrawn again to the lamina to reestablish correct positioning and recheck depth. Entry into the epidural space is identified by a loss of resistance to fluid or a "hanging drop technique". Because of poor penetration through the shoulders, and/or rotational misalignments, one should not rely entirely on the lateral fluoroscopic image to identify a space that has a depth of less than 5mm.

*6. A recent MRI, or CT myelogram must be available for review prior to performing a cervical epidural. Failing this, a comprehensive radiological report of same is a minimal requirement.*

Rationale: If the patient's symptoms are severe enough to warrant a cervical

epidural injection then an evaluation of the structural pathology is justified and is required to enforce guideline #1 and guideline #3.

*7. An epidural needle of sufficient gauge to reliably feel the ligamentum flavum should be utilized.*

Rationale: The relative thickness of the ligamentum flavum in the cervical epidural space can vary, depending on the angle of needle entry. It can occasionally be relatively thin, consequently returning little resistance to the advancing needle. Although there are practitioners who advocate using a 25-gauge needle, the ability to "feel" the resistance of the ligamentum flavum becomes increasingly difficult with less than a 20-gauge needle.

*8. Non-ionic contrast should be injected prior to administering corticosteroids and local anesthetic.*

Rationale: If there is any resistance to the injection encountered, or if significant pain is evoked, the injection should be discontinued. The injection of nonionic contrast should be performed during real-time fluoroscopic monitoring. Contrast should remain in the epidural space post-injection which will, in effect, guideline out intravascular or subarachnoid injection. Furthermore, epidural spread has a characteristic pattern that is clearly different from subcutaneous, intravascular, or subarachnoid placement.

*9. Sedation can be administered but not so much that the patient becomes unaware or nonresponsive.*

Rationale: A sedating dose (e.g. 1 ml (.05 mg) Fentanyl, 1-2 mg Versed) is useful for anaesthetizing the skin and deeper tissues. The local anesthetic combined with the sedation helps prevent untoward jerking of the head during needle penetration of the ligamentum flavum. However, too much may attenuate a pain response which might indicate that the needle tip had contacted the dorsal column. Appropriate sedation, administered judiciously and incrementally, can render the patient relaxed enough to ensure the procedure is as comfortable as possible for them, while leaving them sufficiently aware to return potentially vital pain responses.

*10. Consider avoiding the uses of agents that have not been proven to be innocuous when injected intrathecally.*

Rationale: There are several preparations commonly used during epidural injection procedures that are potentially neurotoxic in nature and are a likely contributing factor to observe chronic arachnoiditis when inadvertently injected into the subarachnoid space. On the other hand, Celestone Soluspan has been shown in animals to be "relatively innocuous" when the clinical equivalent human dose of 12 mg is injected within the subarachnoid space.

*11. In the advent of an inadvertent dural puncture, the procedure should be abandoned immediately.*

Rationale: Any substance injected into the epidural space near a prior dural





since administration of sedative agents can usually overcome the problem of claustrophobia. However, at times general anesthesia is necessary.

A sagittal MRI view of the lumbar spine provides a general overview of multiple motion segments. On a T2 weighted image the CSF appears as a bright signal. The spinal cord is visualized and the nerve roots and vessels can be seen within the neuroforamen. The axial MRI view provides an image that reveals the relationship of the disc to the nerve roots and the thecal sac.

The MRI does not only provide information about the anatomical relationships within the lumbar spine, but it also provides information about the physiologic state of the soft tissue. Once a disc begins to "mature" the water content within the disc decreases. On a T2 weighted image this change will be seen as a low intensity signal (dark).

Annular tear, which can be detected with high quality MRI, can be a source of pain generation. Zones of high signal intensity can be found in the posterior annulus of a disc. These high intensity zones (HIZ) are best seen on fast spin echo T2 weighted MRI. Aprill and Bogduk (2) have studied these so-called HIZ discs with provocative discography. And CTdiscography was used to evaluate the internal morphology of these HIZ discs. Their work revealed that the HIZ's are annular tears and an 89% correlation between pain production and the presence of an HIZ was found.

MRI has been found to be more accurate in the diagnosing disc herniations than CT and CTmyelography (37). And in the same study it was noted that nerve root compression was sometimes demonstrated with myelography and CTmyelography and not seen with MRI. However, in general, the soft tissue etiology of the nerve root compression is better understood with MRI.

The persistence of sciatica or the recurrence of sciatica in the postoperative disc surgery patient can be a perplexing situation. The cause of the pain could be a recurrent disc herniation. Therefore, it is crucial that a distinction be made between a recurrent disc herniation and postoperative scar tissue. Gadolinium enhanced MRI has been found to be highly accurate when used for this purpose (18,31). On a T1 weighted gadolinium enhance MRI scar tissue appears as an area of high intensity (white).

Hypertrophic bony changes, such as osteoarthritic hypertrophic bone changes that is associated with zygapophysial joint degeneration can be seen with MRI. Although, according to Modic (27) "the distinction between hypertrophy of the ligamentum flavum and overgrowth is difficult to distinguish because of similar signal intensities." Therefore, it is the belief of some authors that CT is the study of choice for viewing osseous changes that result in spinal stenosis (15,27). However, other causes of spinal stenosis, such as intra or extradural tumors and synovial cysts are more accurately assessed with MRI (19,25,36).

MRI of the lumbar spine is exquisitely sensitive. Boden's prospective MRI study of asymptomatic patients emphasizes that point (4). Critics are concerned that the high degree of sensitivity associated with MRI can potentially lead to unnecessary

surgery. It must be remembered that MRI depicts only the anatomy of the lumbar spine. MRI does not have the capability to document the presence of pain with 100% confidence. Therefore provocative or analgesic spinal injection techniques such as discography, transforaminal selective epidural nerve root blocks or zygapophysial joint injections are frequently necessary to confirm or eliminate the sites of anatomic abnormality shown on MRI as sources of pain generation.

In today's world of cost consciousness and "cook book" medicine, guidelines for the appropriate use of lumbar MRI are offered. The North American Spine Society (NASS) has recommended that MRI is not needed until seven weeks after the onset of symptoms, if the pain is persistent. However, NASS also recommends that "in situations of major acute injury or symptoms of infection, or neoplasia or progressive neural dysfunction, MRI may be appropriate to the initial workup" (16).

### ***LUMBAR DISCOGRAPHY***

Lindholm is credited with the introduction of lumbar discography (23). Holts's work in the late 1960's cast lumbar discography as an unreliable test that had a false positive rate of 35% (17). In 1988, Simmons and Aprill (35) reviewed the work of Holt and they concluded that Dr. Holt based his lumbar discography data on outdated techniques. Walsh, in 1990 performed a prospective study of lumbar discography. The study included asymptomatic and symptomatic individuals. He concluded that the false positive rate of "properly performed lumbar discography approaches zero" (38). Although, lumbar discography still has critics who oppose its use (28,32,33). However, NASS has recently favorably endorsed lumbar discography (14).

Lumbar discography is a provocative diagnostic test with the purpose to determine if a suspected disc is a source of pain generation. A needle is placed in the centrum of the disc and a nonionic water soluble contrast media is injected into the disc. The injection results in a measurable increase in intradiscal pressure. Derby has related pain generation to the intradiscal pressure generated during the disc injection. His data suggest that discs which are the source of pain generation begin to "hurt" lower pressure thresholds (8,9).

The presence of nociceptors within the outer annulus of the lumbar disc has been described (5). Roberts et al, using immunohistologic techniques have also confirmed the presence of mechanoreceptors located in the peripheral annulus of the disc and the anterior longitudinal ligament (30). Type 3 mechanoreceptors have nociceptive functions and they can become sensitized by an inflammatory process. Aprill and Bogduk have suggested the HIZ seen with T2 weighted fast spin echo MRI is "nuclear material trapped between the lamellae of the annulus fibrosis, which has become inflamed and this accounts for the brighter signal" (2). Considering the data presented by Derby, Aprill, Bogduk and Roberts an explanation of why a disc, which is a source of pain generation is painful during disc stimulation. And why a disc which is not a source of pain generation is not painful during disc stimulation can be offered. The presence of annular tears in degenerative discs has been documented. Through these tears nuclear material

migrates to the outer annulus of the disc. The nuclear material is inflammatogenic and this results in sensitization of the Type 3 mechanoreceptors. The pressure threshold at which this receptors "fire" is lowered and consequently when the disc is tested by discography pain is measured at low pressure threshold. When discs that do not have annular tears are tested with pressure commonly pain is not stimulated even at pressure thresholds of 90 to 100 psi.

Recommended standards for lumbar discography technique and interpretation of the data collected have been published (1,6,7,14). Whenever possible, the discographic study should include a nonpainful control level. The nonpainful control level validates the patients' complaint of pain at other levels.

Comparison studies between CTdiscography and myelography (20,21,34) have found that CTdiscography is more accurate than myelography in demonstrating disc pathology. Comparing lumbar discography to MRI may be somewhat like comparing "apples to oranges." Both are radiologic imaging techniques, but unlike MRI, lumbar discography is a pain provocation test. It has been suggested that CTdiscography demonstrates annular tears better than MRI (29). However, with high quality MRI studies annular tears can be detected and demonstrated with amazing clarity. Lumbar discography should be considered as an adjuvant to MRI. That is to say, discography is best used to confirm or eliminate the possible sites of pain generation that are suggested with an MRI study.

Lumbar discography has been used in a wide range of clinical situations. Such as evaluation of persistent pain following lumbar disc surgery, far lateral disc herniations, painful disc levels in the scoliotic patient, evaluation prior to lumbar fusion and recurrent disc herniations. Specific indications for the use of lumbar discography have been set forth by the North American Spine Society (14). It is recommended that lumbar discography should be considered in a patient who has persistent low back or leg pain who has failed to improve with nonoperative or operative treatment, and other noninvasive imaging studies have failed to definitively explain the origin of the patient's persistent pain.

Potential complications of lumbar discography include infection, neural injury, hemorrhage, aural puncture and paralysis. However in the hands of experienced discographers, the incidence of such complications is rare (7,14). The risk of discitis is reduced with the use of stiletted needles, immaculate sterile technique and the use of either intravenous or intradiscal antibiotic administration.

### ***COMPUTER ASSISTED TOMOGRAPHY***

Reconstruction of rotating xray fanbeam projections into twodimensional images is the basis of CT image creation (3). The soft tissue imaging capabilities of CT allows for viewing of intervertebral discs, ligaments, muscle and vessels.

CT is considered to be superior to MRI for the viewing of cortical bone detail, although MRI is far superior to CT for evaluation of the bone marrow space. Lateral stenosis can be demonstrated with unique clarity when threedimensional reformatting of CT images is employed (15). At some centers, because of its lower cost CT has been considered to be the first choice imaging study for the lumbar

spine (15). Proponents of MRI counter that although CT is less expensive it yields less information and requires the use of ionizing radiation. Furthermore, visualization of intradural structures with CT requires injection of intrathecal contrast media.

An appropriate CT study of the lumbar motion segment should include the area from the inferior aspect of the pedicle above to the superior aspect of the pedicle below. This allows for visualization of the inferior aspect of the cranial vertebral body, the disc, the zygapophysial joints, the neuroforamens, the neural canal and the superior aspect of the caudal vertebral body (11).

Caution must be taken when viewing the L5S1 disc level. The posterior aspect of the L5S1 disc on CT is convex in the axial view and this can be misconstrued as a disc bulge or herniation. This occurs because of the lumbosacral angulation in relationship to the CT imaging angle at the L5S1 disc level. It has been suggested that this limitation can be overcome by using reformatted sagittal images (15).

CT is more accurate than myelography in evaluating disc herniations, according to Heitoff (15). Herniations are effectively demonstrated with CT, but distinguishing between contained versus noncontained herniations is best demonstrated with MRI. Annular tears are not visualized with CT, although degenerative changes such as loss of disc height, intradiscal vacuum effect, and calcification of the disc are demonstrated well with CT. Considering the clinical importance of annular tears, as suggested by Aprill and Bogduk the MRI is favored over CT if the suspected low back pain and referred leg pain is discogenic and not secondary to nerve root compression.

One particular strength of CT is its ability to visualize osseous disease. Pars interarticularis defects and hypertrophic bony overgrowth of the zygapophysial joints are well demonstrated with CT (11,15)

### ***LUMBAR MYLEOGRAPHY***

Myelography is an invasive procedure which requires the intrathecal injection of radiographic contrast media and ionizing radiation is used to create an image. The procedure is associated with potential complications such as postmyelographic spinal headaches and arachnoiditis.

The use of small gauge spinal needles, 25 and 26 gauge, reduces the incidence of spinal headaches. Spinal headaches can be treated conservatively with bed rest, oral analgesics and increased oral fluid intake. Administration of intravenous fluids containing caffeine sodium benzoate has been previously reported in the anesthesiology literature. Spinal headaches that do not resolve with time of conservative management can be treated with an "epidural blood patch."

Iophendylate (Pantopaque) contrast media which was used in the past for myelography has been associated with arachnoiditis. However, with the introduction of nonionic water soluble contrast media the incidence of arachnoiditis associated with myelography has decreased.

Some authors contend that CTmyelography is the best method to diagnosis arachnoiditis, although arachnoiditis can be demonstrated with MRI.

The nonfilling of a nerve root sheath seen with myelography indicates the presence of a compressive lesion within the neuroforamen. However, the nature of lesion cannot be defined with myelography alone. CT or MRI is needed to define the nature of the compressive lesion. Sagittal MRI images provide a view directly into the neuroforamen and thus lesions occupying this region are visualized.

Axial CT and MRI provide additional information about the patency of the neuroforamen. CT and MRI are noninvasive procedures whereas myelography is an invasive procedure. Critics of myelography suggest CT and MRI should replace myelography, since the effectiveness of CT and MRI in demonstrating disc herniations has been well established (15,21,37)

### ***SUMMARY***

The nonradiologist, nonsurgeon physician treating patients with back pain and leg pain should strive to improve their knowledge of the various available imaging tools. The indications for the use of the imaging tools should be clear in the mind of the treating physician, so that the most appropriate study is ordered.

MRI provides a detailed anatomical overview of the extradural and intradural structures of the lumbar spine. Information about the physiologic state of the disc is provided by MRI. Annular tears can be demonstrated and post gadolinium enhanced MRI can be used to detect recurrent disc herniations versus scar tissue in the postoperative patient. Inflammatory processes, infections, and spinal neoplastic lesions are well demonstrated with MRI. MRI is noninvasive and it does not require ionizing radiation. Quality MRI studies can as effective as CT, myelography and CTmyelography in demonstrating neuroforaminal compressive lesions.

CT is an effective imaging study for the lumbar spine. And it is often times less expensive than an MRI study. Osseous changes associated with trauma and degeneration can be effectively demonstrated with CT. However, it is inferior to MRI in displaying information in the sagittal and coronal planes, detecting early signs of disc degeneration, demonstrating annular tears and intradural pathology. CT is noninvasive, but it does require the use of ionizing radiation.

Lumbar discography is a provocative diagnostic imaging study of the intervertebral disc. CT, MRI, myelography and CTmyelography provide information about the anatomy of the lumbar spine. These studies are limited in correlating structural abnormalities with pain generation. Therefore, lumbar discography is necessary in determining the clinical significance of these anatomical changes detected by those studies. The presence of an HIZ in the posterior annulus of a disc has been shown to correlate well with pain generation. However, this is not a 100% correlation and thus lumbar discography is still needed.

The value of discography rests with the provocative nature of the test. To assume that a disc is painful merely because of its degenerative appearance on an MRI





Intradiscal neurolytics have been utilized in an attempt to coagulate the anular nociceptive fibers that render the disc painful. Phenol (e.g. 7%) and highly concentrated anesthetics (e.g. 10-15% lidocaine) have been injected. Safety concerns over epidural/subdural spread from extra-discal extravasation through complete anular tears have been appropriately raised.

As the grey rami communicans have been shown to provide the greatest source of discal innervation (3) there have been attempts to interrupt this neural connection by RF denervation techniques. Basic technique reports exist, (21) but no reports exist in established IDP.

Basic science rat data has shown that lower lumbar disc innervation is predominantly sympathetic and both multisegmental and bilateral (13). The predominance of sympathetic innervation appears to enter the spinal column via the L2 spinal nerve root/DRG level in rats (25). Some clinicians have assumed that human discal innervation is similar (14). Attempts to validate this assumption has been undertaken by assessing pain reduction following segmental L2 spinal nerve root blocks in presumed IDP (14). The preliminary results are intriguing but the methodology to support this assumption is flawed. Some of these methodologic limitations include lack of control injections, not assessing normal fluctuations in daily pain and utilizing physical examination along with MRI imaging of DDs as the criterion for "established" IDP rather than controlled discography. Despite early evidence for predominant L2 transmitted sympathetic innervation to the lower discs only in rats, some practitioners are attempting L2 DRG RF denervation for human IDP. No case reports/series exist in either presumed or established IDP for this intervention.

When all other interventions fail, some practitioners utilize implantable systems (e.g. intra-theal morphine and/or epidural stimulation) for pain control in chronic, multi-level, inoperable IDP. No reports exist regarding the effectiveness of these interventions for IDP versus other diagnoses such as chronic radiculopathy from epidural scar tissue.

Although limited, literature does exist on the use of intradiscal C/S and intradiscal RF anular denervation for IDP. Intradiscal C/S were first described in 1956 in patients with "pathologic lumbar discs" (7). Concordant pain was not assessed with disc stimulation yet 67% of patients had a "rapid remission of symptoms" and 60% had permanent relief at 8 months. Other positive open trial reports appeared in 1958, 1969 and 1975 (8,9,12). In 1980, another open trial reported only 33% of patients experiencing relief for at least 3 months and less than 30% with relief more than 6 months (29). A randomized, controlled trial of intradiscal C/S vs. marcaine was performed on one level IDP established by discography. This intradiscal C/S study (n=25) at 2 weeks post-injection showed there was no difference between groups using the VAS, pain grid drawing and the Oswestry questionnaire (24).

Patients with a high-intensity zone (HIZ) on T-2 weighted sagittal MRIs may represent a unique sub-set of intrinsic disc pathology. In 86% of those with this MRI abnormality, there was a painful, peripheral anular tear (2,18). More recently,

in those with a HIZ, Schellhas found at least a two-week therapeutic effect with intradiscal C/S in 14/21 (66%) patients in an open, non-controlled trial (17). Future study is needed to ascertain if indeed these patients respond better to intradiscal C/S over those with DDs or an annular tear without a corresponding HIZ on MRI. If intradiscal C/S is utilized, there is histologic evidence in rabbits that the polyethylene glycol contained within the depomedrol solution can cause degeneration and primary disc calcification (1). Celestone Soluspan currently does not contain polyethylene glycol and may be a safer substitute.

Intradiscal RF was first reported in 1995 as an attempt to perform annular denervation (27). Patients (n=39) with provocation discography established IDP were treated in a non-controlled fashion. Retrospective data revealed there was a 50% improvement in 70% of the unoperated and in 37% of the operated group at 8 weeks and at 16 months, 55% and 27% improvement respectively (24). Further open, non-published retrospective data has been presented by Sluijter (22). Using the criterion of "complete pain relief" following 1 cc of 2% intradiscal lidocaine, 25 unoperated and 24 operated patients underwent a central intradiscal lesion at 70 degrees celsius (C) for 90 seconds (s). On a 7 point scale, greater than 27% improvement was seen in 60% of the unoperated and 54% of the operated group with an average follow-up of 7.8 months.(22)

Salinger retrospectively reported on 29 patients with 1-3 level discogram positive IDP who underwent intradiscal RF. Three to four quadrant single lesions were performed at 90 degrees C for 4 minutes each. After a minimum follow-up of 9 months, those with single level IDP 11/18 (61%) were "much improved", 4/18 (22%) were "improved" and 3/18 (17%) were unchanged. The degree of positive results was less in those with 2 and 3 level IDP. (16)

Two prospective pilot studies exist on intradiscal radiofrequency lesioning. (4,28) Van Kleef treated 20 unoperated and 19 previously operated patients with percutaneous intradiscal radiofrequency thermocoagulation. All patients had failed physical therapy, medications and TENS treatment and had pain for at least 12 months. Those with clinical or CT/MRI evidence of a HNP were excluded as were those with spinal stenosis, previous spinal fusion or psychological problems as identified by the SCL-90. Those under 25 and older than 60 years of age were also excluded. All subjects underwent L3 and L4 medial branch blocks and L5 dorsal rami blocks; those with a "positive" block were excluded. If posterior column blocks were negative then the patient underwent L4-5 and L5-S1 discography using contrast and local anesthetic. 20 minute post disc injection pain relief was assessed using a four point "Likert-scale"; <30% relief "no relief", 30-50% relief "moderate relief", >50% relief "good relief" and 100% relief "pain free". Only patients with "good or pain free relief" went on to RF.

A 20g cannula with a 10mm exposed tip was placed in the center of the disc. A 90 second 70 degree lesion was made. First follow-up was 8 weeks post RF procedure. Long term results (>36 weeks) were collected by an independent party. In 10 patients MRI was performed before and 3-14 months post procedure.

21/39 (54%) patients reported an adequate reduction in pain (good to pain free on

the Likert scale) at 8 weeks follow-up. At long term follow-up (mean 16 months) this percentage fell to 41%. At 8 weeks and long term follow-up there was a significantly more number of non-operated patients that reported pain relief vs. those with previous discectomies. Success of the procedure could not be predicted retrospectively by discopathy on x-ray, pain during forward flexion or tip temperature following the lesion. Follow-up MRI in 7/10 showed no anatomic change in the disc. In 3 there was a slight decrease in signal intensity but this was observed in 1/3 at an adjacent untreated disc. (28)

Derby recently presented prospective results on intra-discal RF at the International Spinal Injection Society Meeting in 1997 (4). 21 consecutive patients undergoing intradiscal thermal modulation via radiofrequency lesioning were enrolled. The average age was 43 (range:24-60 years of age) and 5 patients had worker's compensation claims and 4 were involved in litigation. All had chronic low back pain without a radicular component. All had pain for at least 1 year, 5 months with the average duration 6 years, 6 months. All patients had failed multiple interventions including PT, medications, prolotherapy and epidural steroid injections. All underwent pressure controlled discography. Outcome tools included the Roland-Morris questionnaire, VAS, and an abbreviated NASS questionnaire. A 5 point satisfaction scale was also used. Treatment included a 20g Radionics Sluifster needle which was placed 5 mm across midline to the most symptomatic side. The needle was placed as far posterior as possible in the posterior annulus. The disc(s) was (were) heated at 80 degrees C for 4 minutes.

All 21 patients were contacted by a research assistant and completed the questionnaires. The follow-up interval was an average of 14 months (range: 9-18 months). There were no complications. The average number of discs lesioned based upon "positive" discography was 2.33 (range:1-5 levels). 17 (81%) of patients requested to have repeat burns performed on the same or adjacent discs because of incomplete pain relief. Prior to treatment the average VA pain scale was 7.9 (range:5-10) and the Roland-Morris index score was 15.5 (range:8-24). At follow-up, the mean VA pain score was 5.9 (range 3.5-8.5) and the Roland-Morris index score was 12.9 (range:3-24). On the five point satisfaction ordinal scale 14% of patients were much better, 52% were better, and 33% were the same. None were worse. 48% felt their overall activity level was improved and 57% felt the treatment met all their expectations. Prior to treatment 48% were unable to work and after treatment only 19% were not working (4).

Intradiscal RF research has begun to address the optimal needle position, optimal burn parameters, and safety to surrounding structures (10,26). In 27 cadaveric discs, the effects of 60-80 degree C lesions for 300s were evaluated. Macroscopic changes were evident in the nucleus without frank necrosis. Temperature increases in the tissues surrounding the disc was no more than 4 degrees C (26). Using RF parameters of 70 degrees C for 90s temperature rises at varying distances from the central RF needle tip was evaluated by Houpt (10). Temperature changes more than 11 mm from the needle tip were less than the 42 degrees C needed to induce early neuronal cell death (10).

In five patients Sluifster used a separate thermocouple to measure temperature

ahead of the electrode tip that was placed in the disc's center. The mean temperature in the disc outer annulus 14 mm ahead of the electrode tip was 43 degrees C when a 10 mm exposed tip was used for the intradiscal RF. (23)

In 1995, Windsor reported less encouraging results than Sluijter, Van Kleef, Salinger and Derby in an open trial of intradiscal RF in 15 discs (30). Furthermore, using a separate "passive temperature gauge" into the peripheral annulus in 4 patients undergoing intradiscal RF (using a 80 degrees C for 90s burn parameter), Windsor could only demonstrate a maximum temperature rise between 41-43 degrees C within 10s. This could be maintained for only 20-30s and then dropped by 1-2 degrees. Thus, it appeared using these RF parameters that not only did appreciable pain relief fail to occur but there was also an inadequate temperature rise in the innervated annulus to assure thermocoagulation of the local nerve endings (30).

Many questions remain regarding radiofrequency lesioning of the lumbar discs including, but not limited to, optimal needle positions, needle and tip size, burn parameters, pathoanatomy of the treatment, and efficacy of this procedure that will only be answered through future research.

A new percutaneous heating intervention is currently under investigation; "intradiscal electrothermal annuloplasty" via the use of a 30 cm Oratec Interventions SPINECath catheter with a 6 cm active tip. Derby (5) presented the results of the first 20 patients enrolled in a ongoing pilot study of this device. The catheter is inserted anteriorly into the annulus or nucleus via a 17g introducer. The active tip is advanced antero-lateral and is directed circuitously to return posterior, ideally achieving a full 360 degree penetration. Following placement electrothermal heat is generated at the active tip commencing at 65 degrees C and increasing to (typically) 80 degrees for a mean duration of 14 minutes. Pressure discography was used to select patients for the study.

Outcome at 6 months was assessed by comparison of baseline to follow-up questionnaires. A mean 2 point decrease on a 10 point visual analog pain scale was found. There was a 2.2 decrease in the Roland-Morris disability questionnaire. Using the 4 point NASS satisfaction index 73% of the sample was satisfied with their outcome and would repeat the procedure. 53% reported an improvement in general activity levels, 74% in sitting, 47% in standing, 46% in walking and 40% in sleeping. The study continues to enroll subjects. (5)

In conclusion, although there are many percutaneous needle procedures available for IDP there is inadequate research to completely endorse the role of any one or combination of these procedures. Substantial research is warranted so we may learn if any of these interventions offer the patient benefit over natural history, other non-invasive treatment options (e.g. functional restoration) or the many varieties of surgical fusion.

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this course. It is designed for physicians who have limited knowledge of spinal injection procedures. Instructors take into consideration the beginning nature of the participants and teach accordingly. Anatomy, imaging, precision technique, risk factors and complications are covered. There is no additional criteria required when registering for this course. The injections covered are: Lumbar; epidural, facet, selective nerve root blocks, and caudal.

### **Intermediate/Advanced Lumbar**

Members of the society who are currently practicing lumbar procedures, on patients, with a solid understanding of fluoroscopic anatomy may take this course. Anatomy, imaging, precision technique, risk factors, and complications are covered. Criteria required is that you are currently practicing lumbar injections under fluoroscopy or have been practicing injections for 2 years on patients without fluoroscopy. The injections covered are: Lumbar; facets, selective nerve root blocks, sympathetic, SJ joint.

### **Cervical/Thoracic**

Members of the society who are experienced in the practice of lumbar injections, who have been practicing on patients under fluoroscopy for no less than 2 years, and have the knowledge and skill level to advance to the cervical region with a clear and certain understanding of the increased risk to the patient, may then register for this course. Proof of 2 years or more of hands-on practice may be requested. Anatomy, imaging, precision technique, risk factors, and complications are covered. The injections covered are: Cervical; posterior column: facets, medial branch, neuraxial: interlaminar epidural, Selective nerve root block, and Thoracic; facets, epidural, SNRB.

### **Discography**

Members of the society who are experts in the field of lumbar and cervical spinal injections can register for this workshop. The criteria is as follows: (1) registrants must fill out the application form and (2) submit 5 procedure notes on facet injections, 5 on selective nerve root blocks, and 5 on sympathetic blocks mixed in both the lumbar and cervical regions. (3) A letter of recommendation from a physician attesting to your expertise in spinal diagnostic & therapeutic injections. (4) Answer all requested questions. Anatomy, imaging, precision technique, risk factors, and complications of Lumbar, Thoracic, and Cervical discography are covered.

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