



Indications for Spine Interventional Procedures

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OBJECTIVES

- Review basic spine anatomy and common occurring spine pathology through case presentation scenarios.
- Introduce most commonly used spine interventional procedures.
- Review appropriate evidence-based guidelines for each spine interventional procedure.



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DISCLOSURES

Nothing to disclose.

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Levels of Evidence in Clinical Studies

- **Level I:** High quality randomized trial or prospective study; testing of previously developed diagnostic criteria on consecutive patients; sensible costs and alternatives; values obtained from many studies with multiway sensitivity analyses; systematic review of Level I RCTs and Level I studies.
- **Level II:** Lesser quality RCT; prospective comparative study; retrospective study; untreated controls from an RCT; lesser quality prospective study; development of diagnostic criteria on consecutive patients; sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses; systematic review of Level II studies or Level I studies with inconsistent results.
- **Level III:** Case control study (therapeutic and prognostic studies); retrospective comparative study; study of nonconsecutive patients without consistently applied reference "gold" standard; analyses based on limited alternatives and costs and poor estimates; systematic review of Level III studies.
- **Level IV:** Case series; case control study (diagnostic studies); poor reference standard; analyses with no sensitivity analyses.
- **Level V:** Expert Opinion

Levels of Evidence For Primary Research Question, adopted by the North American Spine Society January 2005

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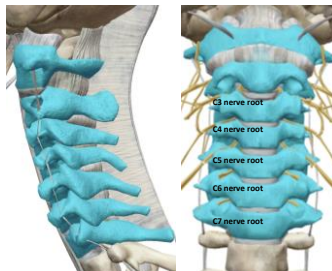


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7 Cervical Vertebra

- C1-C2 (Atlas/Axis): anterior arch and transverse ligament of C1 articulates with the odontoid process/dens of C2
- C3-C7 typical cervical vertebra
- Intervertebral disc b/w two adjacent vertebral bodies
- Facet joints (aka-apophyseal or zygapophyseal)—formed by the articulation of adjacent articular processes.
- 8 Cervical nerve roots exiting above the named vertebral body.

CERVICAL SPINE



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COMMON CLINICAL SCENARIO

- 65 yo female with complaints of neck pain, bilateral trapezius/shoulder pain with associated headache for the last several months
- Refractory to traditional treatment (i.e. OTC meds, physical therapy, massage; +/- sumatriptan, topamax)
- X-rays/MRI reveal multi-level cervical spondylosis with mild/moderate central canal stenosis.
- Referral for further evaluation/treatment
- **Co-morbidities:** overweight (BMI~29); high cholesterol; IBS
- **Past surgical hx:** regular screening colonoscopy with polyp removal (benign)
- **Social hx:** married; 3 grown children; lives independently; independent with all ADLs.



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COMMON CLINICAL SCENARIO

PE:

Gen: 65 yo female in NAD; A&O; good historian; accompanied by husband

MSK: limited cervical ROM in all planes; painful extension/bilateral rotation; some improvement with flexion; painful to palpation bilateral cervical paraspinals/trapezius.

Neuro:

Str: age appropriate strength and muscle tone

Sensation: intact to pinprick bilaterally all dermatomes

DTR: globally decreased reflexes (1/4) bicep, brachioradialis and tricep

Pathologic reflexes: down going Babinski, no clonus

Special tests:

Lhermitte's: negative

Spurlings: increased neck/trapezius pain but no true radicular arm pain

Hoffman's: negative



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COMMON CLINICAL SCENARIO

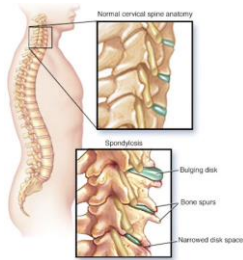
• Differential diagnosis:

- **Cervical facet arthropathy/spondylosis**-multi-level involvement; imaging shows involvement in the upper cervical spine; patient complaining of HA.
- **Cervical disc degeneration**-multi-level involvement
- **Cervical spinal stenosis**-no signs of myelopathy on physical examination; multi-level involvement; no specific radicular pattern.
- **Myofascial pain**-tenderness on examination.

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Cervical Spondylosis

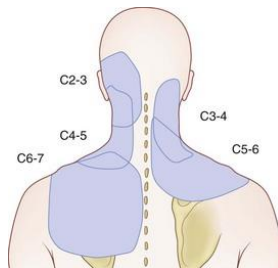
- Prevalence of chronic, recurrent neck pain is approximately 15% of the adult general population.
- Controlled studies show 36-67% of these patients have cervical facet/zygapophysial pain (aka—**Cervical spondylosis**).¹
 - false-positive results in 27% to 63% of the patients with a **single diagnostic block**.
- General degenerative condition of the cervical spine.
- Effects both the intervertebral discs as well as articulating facet joints
- Common cause of other conditions—i.e. cervical radiculopathy, cervical spinal stenosis.



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Cervical Spondylosis

- Common pain referral pattern for cervical spondylosis is the neck, trapezius, parascapular region and shoulders.
- Significant overlap in pain distribution of the **intervertebral discs and facet joints**.
- Distribution of pain provides some general guidance as to what level(s) is/are involved.
- Treatment differs for spondylosis affecting discs vs facet joints.

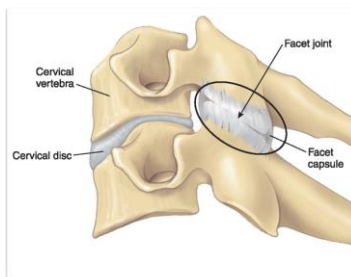


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Cervical facet anatomy



- Cervical facet joint anatomy
- Articular cartilage on the surface of the superior and inferior articular process
- Synovial capsule
- Hinged joint
- Allows for flexion, side to side rotation of the head/neck



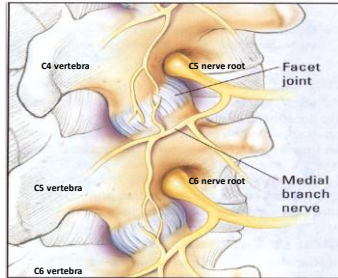
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Cervical facet innervation



• Cervical medial branch blocks.

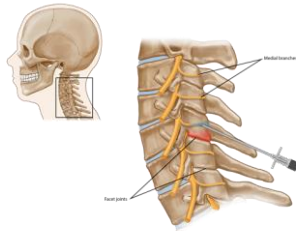
- Anatomy of cervical facet (zygapophyseal) joint innervation.
- Variable course along the articular pillar at each level.
- Each joint is innervated by two branches



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Cervical medial branch blocks

- Due to overlapping pain distribution it can be difficult to determine the underlying etiology of symptoms (i.e. cervical disc pathology vs facet degeneration vs central stenosis).
- Role of interventional procedures for diagnostic purposes
- **Comparative local anesthetic blocks** are used for diagnostic purposes. ²
 - Bupivacaine and Lidocaine



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Cervical Radiofrequency Ablation

- 3 step process
- 2 **concordant**, diagnostic blocks (phase 1-0.75% marcaine; phase 2-4% lidocaine)
- >80% relief of typical symptoms
- Ideally we look for longer relief with phase 1 compared to phase 2.
- Indication:
 - Cervical facet spondylosis
 - Safe and effective for those patients with disabling neck pain that fails to respond to other conservative measures. ³



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Common clinical scenario (cont'd)

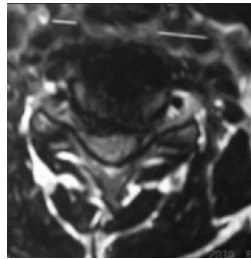
- Patient presents to clinic **8 month post RFA** reporting "different pain" in neck and right arm for the last 6 weeks.
- Feels like her previous pain in neck/shoulders has improved since RFA.
- Intermittent radiation of the pain into her right arm with activity...especially overhead activity.
- Experiencing a sense of "fatigue in my right arm" with increased activity.
- Denies balance difficulty, weakness; unchanged bowel/bladder function (some urge incontinence).



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Common clinical scenario (cont'd)

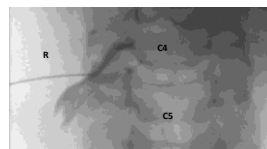
- PE
- MSK: increased neck/right shoulder and arm pain with neck flexion.
- Shoulder ROM intact; slight increased pain with Hawkins maneuver on the right.
- Neuro:
 - Str: 4-/5 right shoulder abduction; 4+ right bicep; otherwise 5/5
 - Sensation: slightly decreased pinprick sensation right deltoid
 - DTR: absent right bicep; 1/4 globally otherwise in upper extremities
 - Lhermitte's: + for neck/arm pain
 - Spurling's: + for shoulder/arm pain
 - Pathologic reflexes: negative for cord involvement.



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Cervical epidural steroid injection

- Two procedures to consider for this patient—
- Cervical interlaminar approach
 - Less specific; covers more ground; less risk.
 - Highest level we can access is C6-7 due to proximity to the cord.
- Cervical transforaminal approach
 - More specific; usually only covers the single nerve root/disc; more risk: vertebral artery is close by—stroke risk.



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Cervical epidural steroid injection

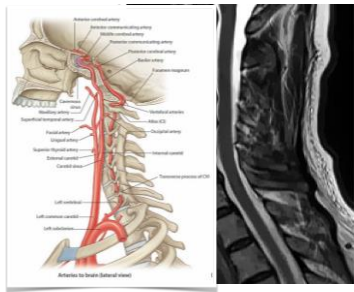
- **Indications—**
 - Level II evidence for axial/discogenic pain in cervical region
 - Level II evidence for cervical spinal stenosis with interlaminar approach and Level 3 evidence to support the use of cervical epidural steroid injection for radicular arm pain and cervical spinal stenosis respectively.
 - Level II evidence for post cervical surgery syndrome with interlaminar approach.
 - More rigorous designed clinical outcome studies are needed for both interlaminar and especially transforaminal approach.
- **Risk factors** to be aware of:
 - Spinal epidural hematoma—paralysis
 - Infection
 - Allergy to medications injected
 - Brain stem/Circle of Willis embolic CVA with transforaminal approach—due to proximity of vertebral artery.

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Cervical epidural steroid injection

- Right C4-5 TFESI
- Minimal pathology below C4-5
- Pain pattern follows the C5 nerve root
- Patient will fill out 2 wk pain diagram to document % improvement following the procedure.



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Thoracic pain

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- Similar potential etiologies for pain
 - **Thoracic spondylosis**—34-48% of patients with chronic mid/upper back pain. ⁸
 - **Thoracic disc bulging**—> thoracic neuritis/radiculitis.
 - Level II-III evidence for interlaminar epidural approach. ⁴
 - **Thoracic spinal stenosis**—have to be aware of cord compression/myelopathy
 - The level of evidence was classified as good, fair, or limited (or poor) based on the quality of evidence developed by the U.S. Preventive Services Task Force (USPSTF)
 - Fair to limited evidence for inter laminar approach. ⁹



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Thoracic spine procedures/indications

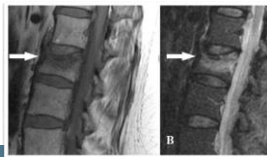
- **Thoracic facet spondylosis**—performed for diagnostic and therapeutic medial branch blocks (MBB)/intra-articular (IAF) facet injections.
- 2018 study showed therapeutic benefit with the use of 0.5mL of 0.5% bupivacaine and 0.25mL of 10mg dexamethasone.
- 1, 3 and 6 months post-op f/u: 65% of patients reported statistically significant pain relief in the IA group and 40% of patients in the MBB group reported ongoing relief. ⁶
- limited evidence for radiofrequency neurotomy of thoracic medial branches. ^{7,8}



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Thoracolumbar vertebral compression fracture

- Estimated 1.5 million thoracolumbar vertebral compression fractures (VCF)/year in U.S. ¹⁰
- ~\$750 million annually in medical expense
- 25% are post-menopausal women.
- Prevalence increases with age to 40% by age 80.
 - 10.7/1000 women
 - 5.7/1000 men
- Irrespective of bone density, having 1 or more VCFs leads to a 5-fold increase in the patient's risk of developing another vertebral fracture



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Thoracolumbar vertebral compression fracture

- Common presenting symptom just back pain
 - Acute or insidious; moderate to severe; variability.
- ~30% of osteoporotic compression fractures occur while the patient is in bed. ¹⁰
- Patients with moderate osteoporosis can fracture their spine with a “ground level” fall.
- Patients under 55 y/o with VCF, malignancy should be considered.

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Thoracolumbar vertebral compression fracture

• Risk factors: 10

Modifiable	Nonmodifiable
Alcohol consumption	Advanced age
Tobacco use	Female sex
Osteoporosis	Caucasian race
Estrogen deficiency	Dementia
Early menopause	Susceptibility to falling
Bilateral salpingo-oophorectomy	History of fractures in adulthood
Premenopausal amenorrhea for more than one year	History of fractures in a first-degree relative
Frailty	
Impaired eyesight	
Insufficient physical activity	
Low body weight	
Dietary calcium deficiency	
Vitamin D deficiency	

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Thoracolumbar vertebral compression fracture

• Classification:

• Three types

- Wedge—most common; ~50%
- Biconcave—17%
- Crush—13%
- Complex—the other 20%



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Thoracolumbar vertebral compression fracture

• Imaging:

- X-ray: most readily available; cost effective; timely; can measure kyphotic angle to compare with future imaging for fracture progression.
 - Limitation: cannot detect ligamentous injury
- CT: helpful when plain films are inconclusive; best modality for complex fractures.
- MRI: helpful to evaluate cord and ligaments; if worried about malignancy and/or infection

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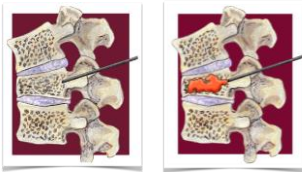
Thoracolumbar vertebral compression fracture

- Treatment:
 - Non-invasive: Relative rest, medication mgmt and bracing
 - Too much "rest" can increase risk for thromboembolism.
 - TLSO-can be modified by orthotist but still can struggle with patient compliance.
- Interventional:
 - Vertebroplasty vs Kyphoplasty



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Thoracolumbar vertebral compression fracture



Vertebroplasty:

- Augmentation of the vertebral body by injection of polymethylmethacrylate (PMMA)
- Helpful in reducing the need for pain medications
- Short-term studies show 75-100% of patients achieve at least moderate relief of back pain.
- Most effective if performed within 6 mos of fracture.

Contraindications:

- infection of the vertebral body, coagulopathy, bone fragment retropulsion, and allergy to any of the substances used during the procedure (i.e. PMMA and or contrast).

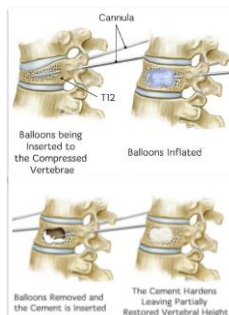
Potential complications:

- Leakage of cement into the spinal canal
- Radiculopathy and/or cord compression
- Wide range depending on which study you review—3-75%

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Thoracolumbar vertebral compression fracture

- **Balloon Kyphoplasty (BKP):**
 - Involves placement of inflatable balloon tamp within vertebral body.
 - Balloon filled with contrast agent to confirm position under fluoroscopy.
 - Balloon is removed and the cavity is filled with PMMA.
 - Improved outcomes when compared to non-interventional care as well as standard vertebroplasty.
- Similar contraindications
- Less risk of extravasation of cement into the canal
- Potential for restoration of vertebral architecture
 - 50-70% vertebral body height restoration
 - 6-10% improvement in segmental kyphotic angle
 - Decreased kyphosis will therefore place less compressive load on adjacent vertebral bodies.



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Thoracolumbar vertebral compression fracture

- In a 2009 study published in the New England Journal of Medicine Buchbinder et al found that vertebroplasty offered no benefit to patients with fresh and painful VCFs.
- 78 patients had post-op MRI to confirm that VCF's had been treated.
 - Patients in both the control and treatment arm experienced similar pain reduction as well as improvements in physical functioning, quality of life measures and perceived recovery.
- NOTE: no similar study has been published in terms of kyphoplasty



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Low back pain

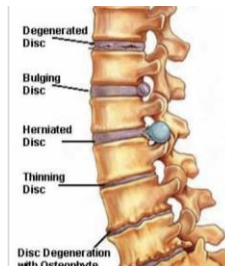
- Demographics and most likely etiologies:
 - Children/adolescents
 - Muscle strain/ligament sprain
 - **Stress fracture (i.e. spondylolysis w/wo spondylolisthesis)**—should be high on differential in young athletes. Early detection is key!!
 - Disc bulging
 - Tumor/infection—night time pain
 - Scoliosis
 - Scheuermann's kyphosis
 - Sickle cell disease
- **NOTE:** children with complaints of back pain are more likely to have psychosocial difficulties, conduct problems or somatic disorder
- Adulthood
 - Lumbar Spondylosis—(i.e. facet arthropathy, disc degeneration, etc.)
 - Lumbar disc herniation/bulging
 - Lumbar canal stenosis
 - Lumbar compression fracture
 - Tumor/infection



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Lumbar Spondylosis

- **Lumbar spondylosis**
 - Present in 27-37% of asymptomatic individuals.
 - In U.S. over 80% of those over 40 years old have radiographic evidence of lumbar spondylosis.
 - Prevalence increases with age
 - No validated correlation between radiographic presence of lumbar spondylosis and the presence of low back pain
 - Studies show clear correlation between the presence of lumbar spondylosis and BMI, activity level or gender on severity.

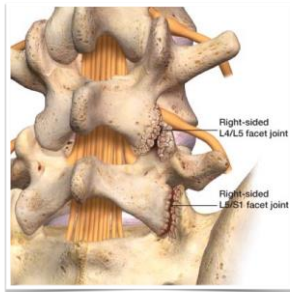


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Lumbar facet arthropathy



- 1st diagnostic step is phased medial branch blocks
- Currently our best way of differentiating b/w facetogenic and discogenic pain
- Similar meds as discussed previously
 - Bupivacaine and Lidocaine
 - Strictly diagnostic—No Steroid
 - Looking for concordant response

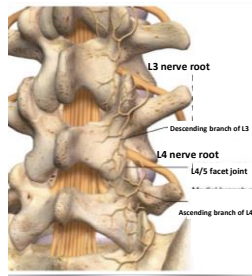


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Lumbar facet arthropathy



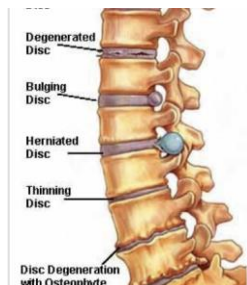
- 2 branches for each lumbar facet joint
- Superior and inferior branch
- Example: L4-5 facet joint is innervated by the inferior descending branch of the L3 nerve root and the superior ascending branch of the L4 nerve root...therefore numbering is different in the lumbar spine vs cervical
- To effectively denervate the L4-5 facet joint—we perform a “L3, L4 medial branch block”
- If concordant response is noted then it is appropriate to offer radiofrequency ablation as more long term treatment.



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Lumbar disc bulging/herniation

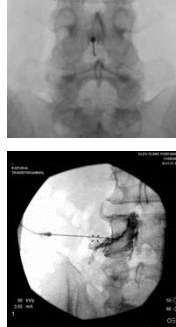
- There is level II evidence supporting the use of caudal, lumbar interlaminar and transforaminal epidural steroid injections for lumbar disc bulging.
- No significant difference among the approaches.



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Lumbar disc bulging/herniation

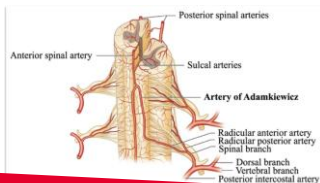
- **Interlaminar approach:**
 - Midline approach
 - Not targeting a specific nerve root
 - Covers more area vs transforaminal approach
 - Not used for diagnostic purposes.
- **Transforaminal approach:**
 - More specific to one nerve root level.
 - Can see extension of contrast medium to the adjacent level above.
 - More technical procedure—smaller window; have to maneuver around facet joints and avoid nerve root
 - No more than (2) levels can be performed in one setting
- **Complications:**
 - Spinal headache—if inject into the dural space
 - Lay horizontal, force fluid, caffeine bolus, Tylenol; if greater than 24-48 hours may need blood patch; if fever contact MD.
 - Spinal cord infarction—Artery of Adamkiewicz



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Artery of Adamkiewicz

- Left sided 80% of the time.
- 70% of the time at the level of the 9th-12th intercostal artery.
- Variable course—can be seen as low as L2
- Anastomosis with anterior spinal artery
- Anterior spinal artery supplies blood supply to the spinal cord from T8-Conus medullaris.
- E.M. Lyders and P.P. Morris. "A Case of Spinal Cord Infarction Following Lumbar Transforaminal Epidural Steroid Injection: MR Imaging and Angiographic Findings". American Journal of Neuroradiology October 2009, 30 (9) 1691-1693
- 55 yo female developed spinal cord infarction after undergoing **right** L2-3 transforaminal epidural steroid injection.



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Lumbar spinal stenosis

- Can present w/wo neurogenic claudication
- + "shopping cart sign"
- Back pain with bilateral leg pain; "legs fatigue easy"; "legs feel heavy".
- usually caused by a combination of: disc bulging, osteophyte formation, facet hypertrophy, ligamentum flavum hypertrophy



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Lumbar spinal stenosis

- Level III evidence for lumbar epidural steroid injection in the setting of spinal stenosis. ⁴
- **Clinical scenario:**
 - 75 yo male with a chief complaint of low back and bilateral leg "pain"—been present for "years" just getting worse of late.
 - Pain is more heaviness that prevents him from walking longer distances or enjoying his regular golf league.
 - Isn't getting out as much because he's had a couple instances where he couldn't find a place to sit down to alleviate his symptoms.
 - Didn't go to Iowa State Fair with family
- MRI with multi-level disc degeneration, facet arthropathy, central and foramina spinal stenosis.
- **Physical therapy:** helped—"my legs feel stronger...but I still can't walk."
- **Meds:** Gabapentin 300/3, Tylenol or Advil... "doc tells me not to use Advil because of my heart", has Tramadol 50/2 for breakthrough pain—"helps some...takes the edge off"



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Lumbar spinal stenosis

- Surgical consultation: pathology is too wide spread to consider surgery—referred to PM&R/Interventional Pain Dept.
- PE:
- Gen: 75 yo male in NAD; antalgic gait.
- Neuro: intact strength except for slight foot drop bilaterally; sensation intact; absent reflexes-bilateral patella, achilles.
- Pain seems to travel more in the L5 dermatome bilaterally—fits PE findings
- All three approaches are available to us:
 - **Interlaminar L5-S1**—should get medication to extend up to L3-4 disc level.
 - **Bilateral L5-S1 TFESI**—more specific to his pain pattern of L5. Will likely extend up to the L4-5 disc space which appears to be the source of the L5 impingement.
 - **Caudal epidural**—more of a shot gun approach...but a good option if other options prove difficult to access.



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Lumbar spinal stenosis

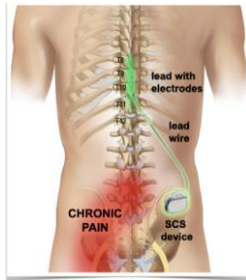
- Initially went with bilateral L5-S1 TFESI and patient reported excellent relief of his back and leg symptoms for 2 wks...then "just about like I was before injection".
- Repeat epidural was offered to see if more long term relief
 - Fortunately he received good relief with second set of bilateral L5-S1 TFESI reporting "80% better" that held up for "most of the golf season"
 - Started to wear off after 4 months with patient reporting 50% better and wondering "when should I get another shot?"
- Medicare guidelines recommend no more than 3 epidural steroid injections in a 6 month period with no more than 6 in a 12 month period.
 - We try to limit our patients to 3-4 every 12 months
 - Have to consider risk/benefit ratio as well as bone health of patient (more of a concern in female population).
 - Also have to consider if patient is receiving other steroid based injections (i.e. shoulder, knee, hip, etc.

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Neuromodulation



- Clinical scenario cont'd:
 - 2 years later... now 77 yo patient returns to clinic having failed to see good sustained (i.e. >3 months) with most recent injections.
 - "Doc...what's the next step?"
 - At this point he's exhausted most of the appropriate conservative options.
 - Do we adjust meds?
 - Add SNRI—may lead to cognitive delay
 - Can't take NSAID's...already on Gabapentin...could increase dose...Opioids...not a great option???
 - Neuromodulation**—(i.e. Spinal Cord Stimulation)
 - Been around for over 40 years.
 - New technology has shown better results in capturing low back and leg pain
 - Previously only good for leg symptoms



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Neuromodulation



- Gate theory of pain**—first proposed by Melzack and Wall in 1965.
- Shealy et al first to implant a dorsal column stimulator for pain in 1967.
- Shimoga, 1971, first to publish analgesic benefit from spinal cord stimulation.
- Appropriate for **non-mechanical back pain**
- Mechanism of action:** in neuropathic pain is unknown...however, research suggests the target is at the level of the dorsal horn.
 - Decreases the hyper excitability of the ascending "signaling" pathway by increasing GABA and serotonin levels in the meantime decreasing excitatory neurotransmitters (e.g. glutamate and aspartate).
- New high frequency devices are much better tolerated as the patient no longer feels the "stimulation".
- MRI compatibility is increasing among many of the most common manufacturers.



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Neuromodulation

- Indications:** FDA approved for failed back surgery syndrome (FBSS), chronic pain, intractable angina and Complex Regional Pain Syndrome (CRPS)
- Contraindications:** Coagulation disorder, anti-coagulant therapy, systematic or local infection, pre-surgical imaging shows difficult access or concerns with psychological evaluation.
- Process:**
 - Before trial often times a formal neuropsych evaluation is performed in order to assess if patient is appropriate candidate for an implantable device.
 - Because these devices are often used in the setting of chronic pain we need to address any underlying psychological aspects of the patient's pain.
 - 1 wk trial implantation
 - Work with device rep to adjust settings as appropriate.
 - Return to office to discuss response—if good response in trial then proceed with permanent implant.
- Risks:**
 - Infection, dural tear, spinal cord injury, paralysis, lead migration, CSF leak with spinal headache.
- Benefits:**
 - Avoid use of long term medications; good alternative for non-surgical patients.

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CONCLUSION

Summary:

- Spine pain is a common condition that affects millions of Americans yearly.
- Associated with significant medical costs, lost work hours and productivity.
- Debilitating condition for many patients that affects their ability to perform basic ADL's.
- Can be difficult to "fix".
- Interventional Pain Mgmt options exist for the majority of patients and/or conditions.
- As with most treatment approaches we need continuing research data to support and improve what we have to offer patients.



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Thank You!
Questions?

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Sources

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