

# EVOLUTION OF THE EPIDURAL AND THE IMPACT OF DR. RACZ

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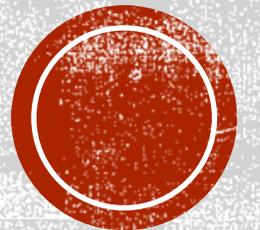
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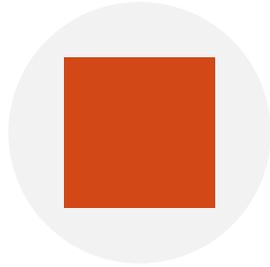


# **PRESIDENT OF THE WORLD INSTITUTE OF PAIN**

**Disclosures**



# OBJECTIVES



INVESTIGATE THE  
EVOLUTION OF THE  
EPIDURAL



REVIEW THE  
PATHOPHYSIOLOGY OF  
RADICULAR PAIN



EXPLORE INTERVENTIONAL  
TREATMENTS FOR  
RADICULAR PAIN



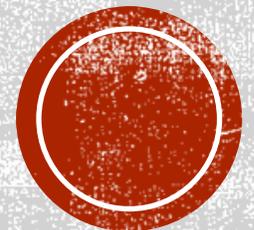
EXAMINE CURRENT  
EVIDENCE-BASED  
LITERATURE



Year	Country	Description
1885	USA	First spinal puncture by Corning
1895	Germany	Intrathecal infusion of cocaine by Bier
1901	France	First caudal epidural injections by Sicard and Cathelin
1925	Canada	Viner uses novocain to treat sciatica
1930	UK	Evans successfully treats 24/40 patients with procaine
1952	Italy	Robecchi and Capra use corticosteroids for the first time
1953	France	Lièvre et al. [21] publish a series of patients treated with epidural corticosteroids
1961	USA	Goebert et al.: first series in the USA
1960s–1970s		Uncontrolled studies
1970s–now		Randomized, controlled trials

Eur Neurol 2016;75:58–64

# TIMELINE OF THE EPIDURAL TREATMENT OF SCIATICA



# EVOLUTION: CORNING 1885

- The first direct spinal puncture in a living person.
- Injected a cocaine solution into the epidural space at the T11–T12 level of a man who was habituated to masturbation and suffered from ‘spinal weakness and seminal incontinence’.

Bicket MC, Chakravarthy K, Chang D, Cohen SP: Epidural steroid injections: an updated review on recent trends in safety and complications. *Pain Manag* 2015;5:129–146



# EVOLUTION: BIER 1895

- Successfully anesthetized the lower body of one of his residents by injecting a cocaine solution into the intrathecal space. Unfortunately, the procedure was complicated by severe headache due to intracranial hypotension lasting for more than 1 week

Bier A: Versuche über cocainisirung des rückenmarkes. Deutsche Zeitschrift für Chirurgie 1899;51:361–369.



# EVOLUTION: SICARD 1896



Started his research on the spine when he became an intern at the laboratory of the neurologists Fulgence Raymond (1844–1910) and Edouard Brissaud (1852– 1909) at the famous Hôpital de La Salpêtrière .



Passed a needle through the (first) dorsal sacral foramen to gain access to the sacral roots.



After his experiments with dogs, he performed similar injections in human cadavers to improve his skill and finally injected patients suffering from pain

Sicard MA: Les injections médicamenteuses extradurales par voie sacrococcygienne.  
C R Seances Soc Biol Fil 1901;53:396.



# EVOLUTION: SICARD 1901

- Presented the data of 9 of his patients during a weekly meeting of the Société de Biologie in Paris.
  - Two suffered from syphilitic myelopathy, 2 had low back pain and 4 had sciatica.
- The 2 patients with tabes only saw their fierce pains disappear for 12–20 h, but recovery has been maintained for 14 days in the 2 patients with low back pain as well as in 2 resistant cases of sciatica. The 2 other patients with sciatica have been relieved for 2–3 days after each new injection.



# EVOLUTION: CATHELIN 1901

- Cathelin also used the caudal approach with cocaine to anesthetize his patients, but unfortunately his results were not as positive as those by Sicard. Four patients that needed inguinal repair were anesthetized only partly. Cathelin suggested he should have increased the dosage.

Cathelin F: Une nouvelle voie d'injection rachidienne: méthode des injections épidurales par le procédé du canal sacre – applications à l'homme. *Compt Rend Soc de Biol* 1901;53: 452–453



# EVOLUTION: SICARD & FORESTIER 1921

- Made the first epidurogram by injecting contrast fluid in the epidural space, followed by examination of the subarachnoid space and myelography

Sicard JA, Forestier J: Méthode radiographique d'exploration de la cavité épurale par le Lipiodol.  
Rev Neurol 1921;2:



# EVOLUTION: VINER 1925

- Employed the caudal approach but used novocain instead of cocaine. He repeated the injections in patients with sciatica 3–4 times at weekly intervals with good outcome.

Viner N: Intractable sciatica. The sacral epidural injection; an effective method of giving relief.  
Can Med Assoc J 1925;15:630–634



# EVOLUTION: EVANS 1930

- Reported treating 40 patients with 'idiopathic sciatica' by caudal injection of normal saline and procaine hydrochloride.
- Sciatica was relieved completely in 24 patients and 'considerable benefit' occurred in 6 patients.
- He demonstrated that injection of **100 ml of fluid** into the epidural space at the base of the sacrum caused diffusion of the fluid throughout the spinal canal.

Evans W: Intracanal epidural injection in the treatment of sciatica. Lancet 1930;216:1225– 1228.

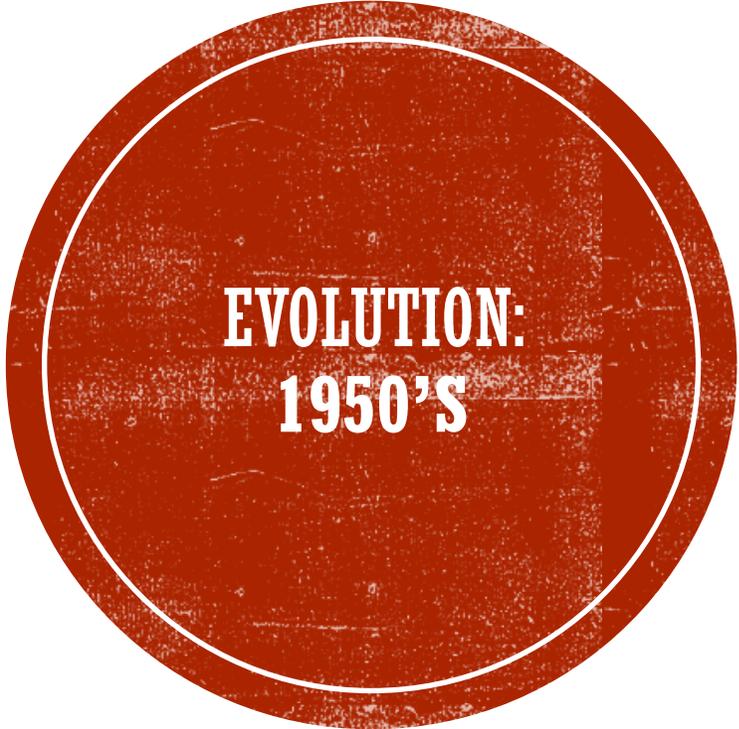


# EVOLUTION: 1920'S

- Animal research at the Mayo Clinic led to the discovery of **cortisone or 'compound E'** . Shortly after the World War II, the first patients with rheumatoid arthritis were treated. The results were spectacular, almost like an 'awakening', making corticosteroids the cornerstone of rheumatism treatment ever since.

The Epidural Treatment of Sciatica: Its Origin and Evolution. Eur Neurol 2016;75:58–64





**EVOLUTION:  
1950'S**

- **Hydrocortisone or 'compound F'**, a steroid with a longer lasting effect discovered.

# EVOLUTION: ROBECCHI AND CAPRA 1952

2 Italian rheumatologists from Torino, speculated that low back pain as well as sciatica were also caused by inflammation

Their first description was of a woman with sciatica, who reported successful pain relief after 'periradicular' infiltration with hydrocortisone of the first sacral nerve root

Robecchi P, Capra AL: L'idrocortisone (composto F), prime esperienze cliniche in campo reumatologico. Minerva Med 1952;2:1259- 1263.



# EVOLUTION: LIÈVRE 1953

- Treated 46 patients with sciatica with hydrocortisone.
  - 8 had a very good response, 15 good and 8 mediocre.

Lièvre JA, Bloch-Michel H, Pean G, et al: L'hydrocortisone en injection locale.  
Rev Rhum Mal Osteoartic 1953;20:310–311.



# EVOLUTION: GOEBERT 1960

- First to report the use of epidural corticosteroids against sciatica in the United States: 3 injections of procaine and hydrocortisone caused greater than 60% relief of symptoms in 58% of patients (n = 239).

Goebert HW Jr, Jallo SJ, Gardner WJ, et al: Sciatica: treatment with epidural injections of procaine and hydrocortisone. Cleve Clin Q 1960;27:191-197.



# EVOLUTION: 1970'S

- The first randomized controlled ESI studies.
- Yielded conflicting results.



# EVOLUTION: DILKE ET AL 1973



Investigated 100 consecutive patients with sciatica in a randomized blinded trial (epidural corticosteroids vs. cutaneous saline injections).



The results were labeled ‘striking’ – patients who received epidural corticosteroids experienced less pain than controls, needed surgery less often and returned back to work sooner.

Dilke TF, Burry HC, Grahame R: Extradural corticosteroid injection in management of lumbar nerve root compression. Br Med J 1973;2:635–637.



# EVOLUTION: SNOEK ET AL 1977

- Showed that 'extradural injection of methyl prednisolone (80 mg) is no more effective than a placebo injection in relieving chronic symptoms due to myelographically demonstrable lumbar disc herniation'.

Snoek W, Weber H, Jorgensen B: Double blind evaluation of extradural methyl prednisolone for herniated lumbar discs. *Acta Orthop Scand* 1977;48:635–641.



First author, year	n	Study design	Patients with pain relief, %*
Lièvre, 1953	20	Retrospective	25 at 3 weeks
Brown, 1960	20	Retrospective	100 at 52 weeks
Goebert, 1960	239	Retrospective	6 at 12–130 weeks
Gardner, 1961	113	Retrospective	83 at >12 weeks
Winnie, 1972	10	Prospective	100 at 2–104 weeks
Rosen, 1988	40	Retrospective	25 at 1–32 weeks
Power, 1992	16	Retrospective	6 at 1 week
Bowman, 1993	35	Retrospective	43 at 12 weeks

\* Definition of 'pain relief' = excellent + good + moderate + 'not severe'.

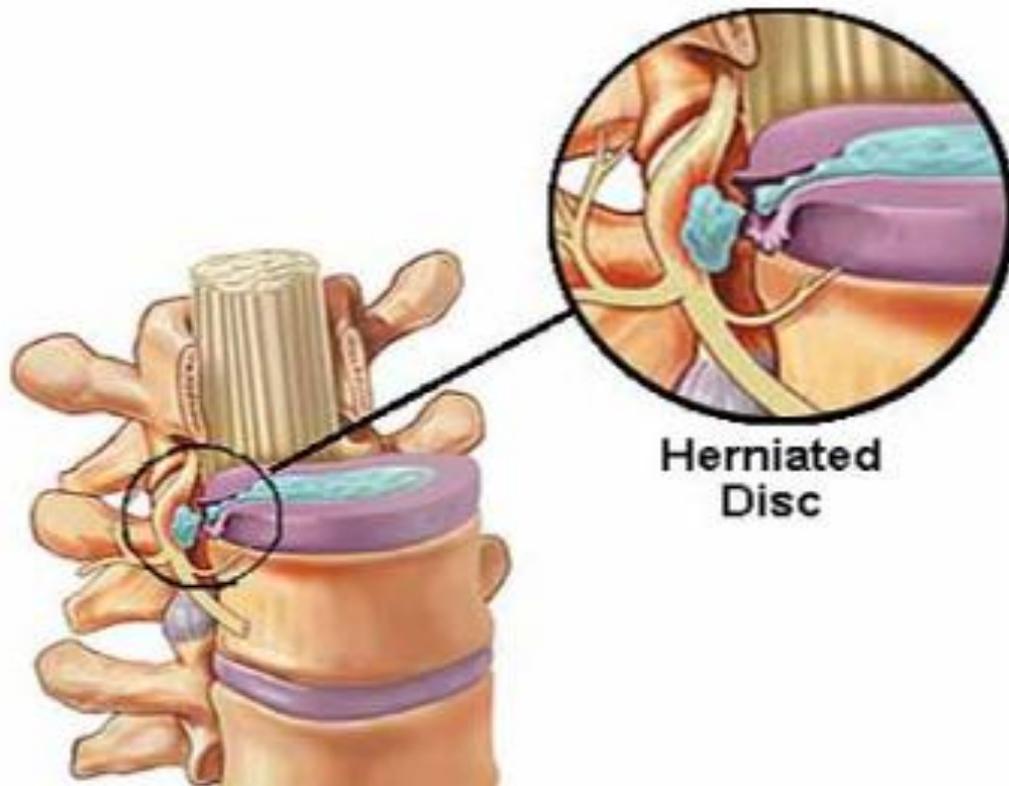
## THE MOST IMPORTANT UNCONTROLLED STUDIES



**WHY DO WE DO  
EPIDURALS?**



# ETIOLOGY OF RADICULAR PAIN



- Mixter WJ, Barr JS: *Rupture of the intervertebral disc with involvement of the spinal cord.* N Engl J Med 1934.
- Rupture of the intervertebral disc is the cause of symptoms.
- Disc rupture with herniation, and subsequent nerve impingement caused radicular pain.
- Surgical decompression is the preferred treatment.



# ETIOLOGY OF RADICULAR PAIN

- Hirsch C. *An attempt to diagnose the level of a disc lesion clinically by disc puncture. Acta Orthop Scand* 1948
  - Reproduced back pain with stimulation of disc annulus
  - Noted relief of sciatic pain following intradiscal injection of Novocain into the disc.
- Smythe J, Wright V. *Sciatica and the intervertebral disc. J Bone Joint Surg* 1958.
  - Attached nylon threads to potential pain generators
  - Ligamentum flavum, dura, nerve roots, and annulus
  - Traction on the threads and he noted
    - Annulus elicited back pain
    - Nerve-root stimulation caused sciatic pain

Hirsch C. An attempt to diagnose the level of a disc lesion clinically by disc puncture. *Acta Orthop Scand* 1948; 18: 131-140.

Smythe J, Wright V. Sciatica and the intervertebral disc. *J Bone Joint Surg* 1958; 40-A: 1401.



# ETIOLOGY OF RADICULAR PAIN

- Fernstrom U. *A discographical study of ruptured lumbar intervertebral discs*. Acta Chirurgica Scandinavica 1960.
  - Noted that a ruptured disc without herniation can have a clinical presentation similar to herniated disc.
- Goupille P, Jayson MIV, Valat JP: *The role of inflammation in disc herniation-associated radiculopathy*. Semin Arthritis Rheum , 1988.
  - Goupille noted by MRI:
    - Some patients with large herniations have no radicular symptoms,
    - No evidence of herniation with severe radiculopathy

Fernstrom U. A discographical study of ruptured lumbar intervertebral discs. Acta Chirurgica Scandinavica 1960; 258: 1-60.

Goupille et al: The role of inflammation in disc herniation-associated radiculopathy. Semin Arthritis Rheum 28:60–71, 1988.



# ETIOLOGY OF RADICULAR PAIN

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- Could not explain
  - Asymptomatic individuals with disc pro
  - Symptomatic patients with no disc prot

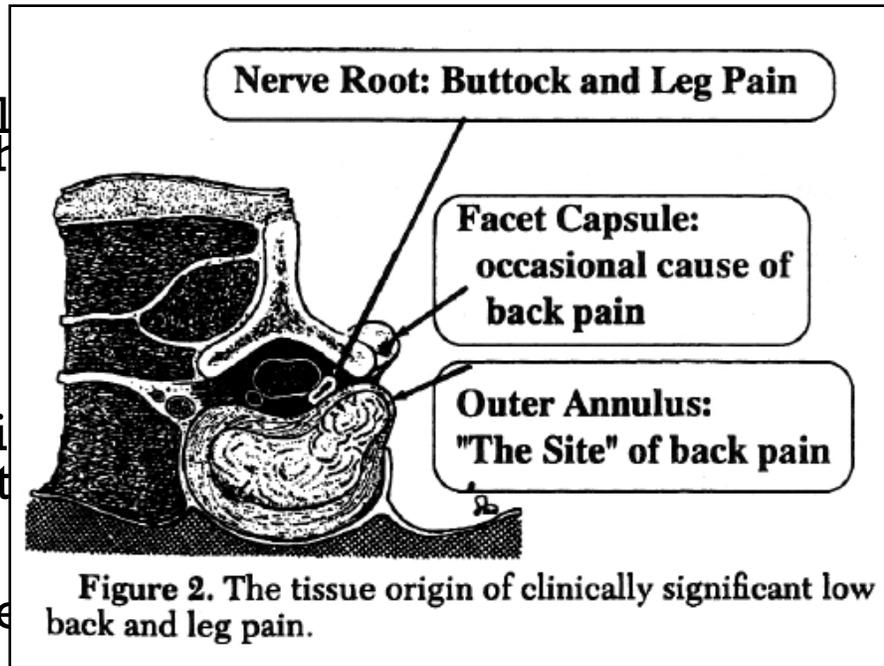


Table 3. Findings by Order of Pain Production

Always	Skin
	Compressed nerve root
Often	Outer annulus fibrosus
	Vertebral end plate
	Tissues in anterior epidural space, i.e., anterior dura and posterior longitudinal ligament
Rare	Supra- and interspinous ligament
	Facet capsule
	Muscle attachment at bone or neurovascular bundle
Never	Ligamentum flavum
	Lumbar fascia (except at site of vessels)
	Lamina bone
	Spinous process bone
	Facet synovium
	Uncompressed nerve root (unless great stress is applied)
	Uninflamed dura
	Facet cartilage

tica.



## BIOCHEMICAL ETIOLOGY OF RADICULAR PAIN

- McCarron et al. *The inflammatory effect of nucleus pulposus*. Spine 1987; 12: 760-764
- 8 dogs used, 4 experimental and 4 control groups.
  - Experimental group: Autogenous NP into the lumbar ES.
  - Control group: Sterile NS into the lumbar ES.
- Daily injections of the material over 5 to 7 days.
- Dogs were sacrificed at 5, 7, 14, or 21 days.
- Gross inspection and microscopic analysis:
  - Experimental group: Evidence of an inflammatory response
  - Control group: No inflammatory response noted.



# BIOCHEMICAL ETIOLOGY OF RADICULAR PAIN

- Saal et al. lumbar disc
- Human disc laminectomy
- All patients
- The PLA<sub>2</sub> activity in other tissues

<i>Human source of sample</i>	<i>PLA<sub>2</sub> specific activity (nmol/min/mg)</i>
PMN	3.2
Platelet	1.4
Sperm	28.0
Plasma	0.006
Synovial inflammatory effusion	12.1
Mucoid purulent ear effusion	0.3
Herniated lumbar disc	568.7

activity  
 underwent  
 activity in

- Human disc contain higher levels phospholipase A<sub>2</sub>
  - 20 to 100,000 x more than other human tissues.



# ETIOLOGY OF DISC HERNIATION

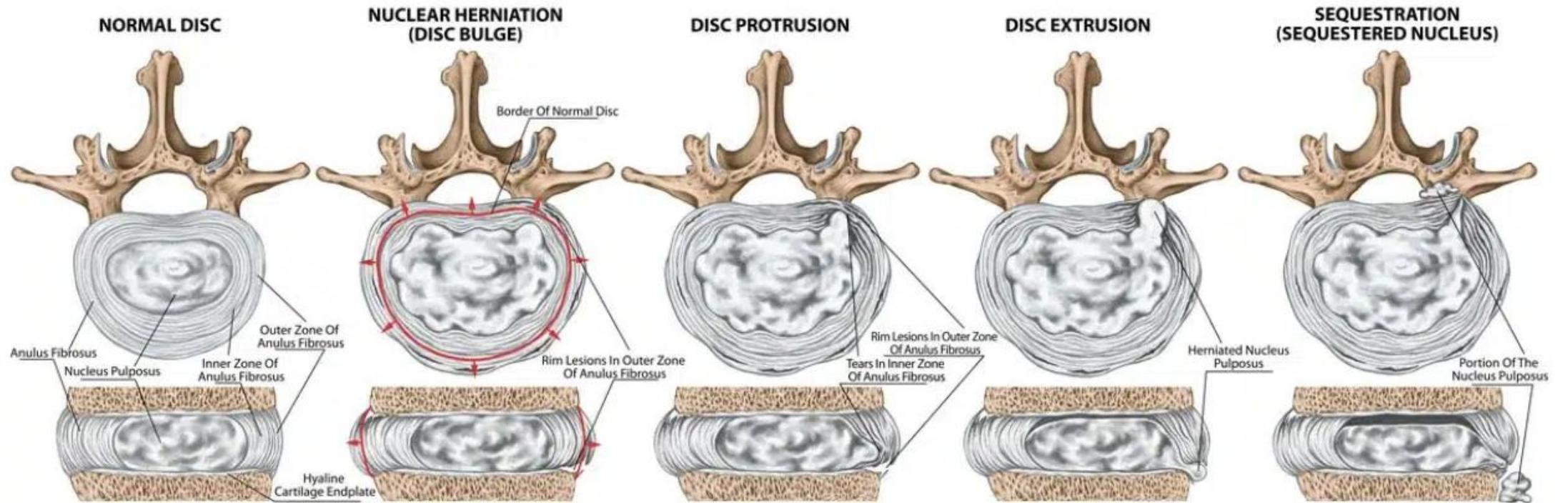
- Most common cause of disc herniation the degenerative process (as humans age, the nucleus pulposus becomes less hydrated and weakens and may lead to progressive disc herniation).
- The second most common cause of disc herniation is trauma.
- Other causes include connective tissue disorders and congenital disorders such as short pedicles.



# **PATHOPHYSIOLOGY OF DISC HERNIATION**

- **The pathophysiology of herniated discs is believed to be a combination of the mechanical compression of the nerve by the bulging nucleus pulposus and the local increase inflammatory chemokines.**
- **A tear can occur within the annulus fibrosus. The material of the nucleus pulposus can track through this tear and into the intervertebral or vertebral foramen to impinge neural structure.**
- **The changes consists of nuclear degeneration, nuclear displacement and stage of fibrosis.**





# ALGORITHMIC APPROACH TO ESI'S

- Documentation
  - The assessment as it relates to the complaint for that visit
  - Relevant medical history and physical examination
  - Results of pertinent tests/procedures
  - Signed and dated office visit record/operative report
  - Documentation to support the medical necessity of the procedure(s)

<https://asipp.org/an-algorithmic-approach-to-epidural-steroid-injections>



# ALGORITHMIC APPROACH TO ESI'S

- **Indications**
  - Pain duration of 4 weeks.
  - Inadequate improvement with 4 weeks of conservative management with documentation of duration and results of therapy.
  - Effectiveness should be documented as defined by 3 months of pain relief of  $\geq 50\%$ , in conjunction with conservative management.
  - Pain scale or functional assessment should be documented.

# ALGORITHMIC APPROACH TO ESI'S

- **Limitations**
  - Limitations include steroid dosages of 80 mg of triamcinolone, or 12 mg of betamethasone, or 15 mg of dexamethasone. Methylprednisolone is not allowed.
  - CT or fluoro is mandated except during pregnancy.
  - Imaging requires a minimum of 2 views with final needle position in contrast flow to be retained.



# ALGORITHMIC APPROACH TO ESI'S

- **Utilization**
  - Multiple procedures are not permitted.
  - Two unilateral or a bilateral transforaminal epidural injection may be performed. The maximum number of procedures is 4 per year per region.
  - ICD-10 codes are limited compared to previous policies as enclosed (It is crucial that the physician always includes a radiculopathy or radiculitis code.).



# BENEFIT OF EPIDURAL STEROID INJECTIONS

- Inhibition of PL A<sub>2</sub>
- Direct membrane action
- High doses shown to prevent reduction of NCV.
- Antinociceptive activity.
  - Blocks transmission of C-Fibers.

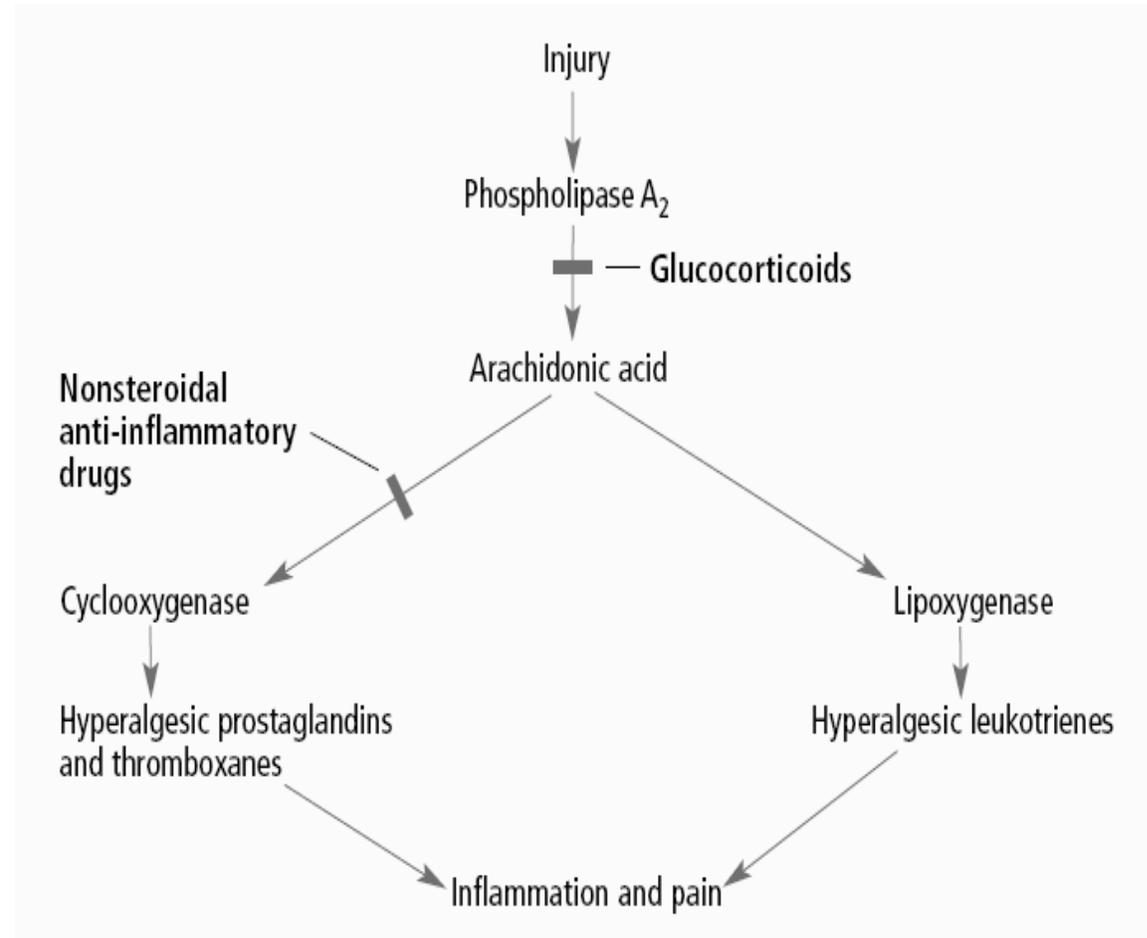


Table 23. Profile of commonly used epidural steroids.

Drug	Equivalent Dose	Epidural Dose	Anti-inflammatory Potency	Sodium Retention Capacity	Duration of Adrenal Suppression		
					IM	Single Epidural	Three Epidurals
Hydrocortisone	20 mg	NA	1	1	NA	NA	NA
Depomethylprednisolone (Depo-Medrol)	4 mg	40-80 mg	5	0.5	1-6 weeks	1-3 weeks	NA
Triamcinolone acetonide (Kenalog)	4 mg	40-80 mg	5	0	2-6 weeks	3-5 weeks	2-3 months
Betamethasone (Celestone Soluspan)	0.6 mg	6-12 mg	25	0	1-2 weeks	NA	NA

Table 24. Formulations of commonly used epidural steroids.

Amount of steroid	Depo-Medrol Methylprednisolone			Aristocort Triamcinolone Diacetate	Kenalog Triamcinolone Diacetate	Celestone Betamethasone
	20 mg/mL	40 mg/mL	80 mg/mL	40 mg/mL	40 mg/mL	6 mg/mL
Polyethylene glycol 3350	29.5	29.1	28.2	30	--	--
Polysorbate 80	1.97	1.94	1.88	2	0.4	--
Benzyl alcohol	6.9	6.8	6.59	--	--	3.4
Dibasic sodium phosphate	9.3	9.16	8.8	9	9	--
Edetate disodium	--	--	--	--	--	7.1
Edetate disodium	--	--	--	--	--	0.1
Benzalkonium chloride	--	--	--	--	--	0.2



## Approach

## Advantages

## Disadvantages

### Transforaminal

Provides highly targeted delivery of medication to a specific nerve root and the front part of the epidural space; often more effective for focal pain.

Higher risk of rare but serious complications, including nerve injury or inadvertent vascular injection, which can lead to spinal cord infarction.

### Interlaminar

Allows for a broader spread of the injectate, which is useful for widespread or central canal pain involving multiple levels; technically simpler than the transforaminal approach.

Less precise in targeting a single nerve root; higher potential for accidental puncture of the dura mater (the protective covering of the spinal cord).

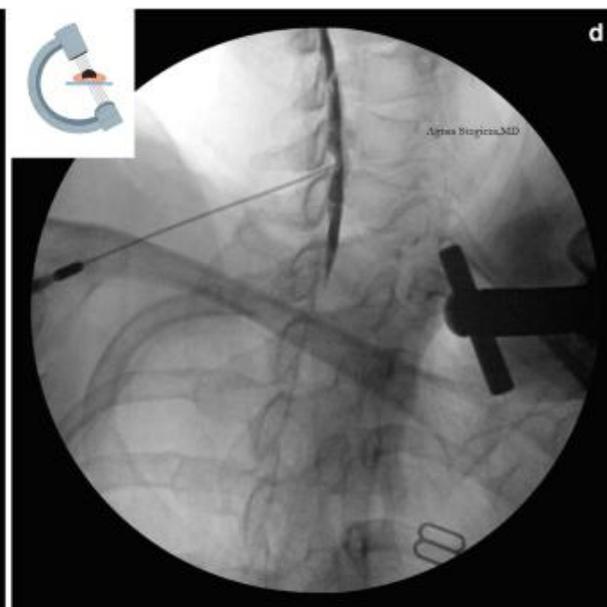
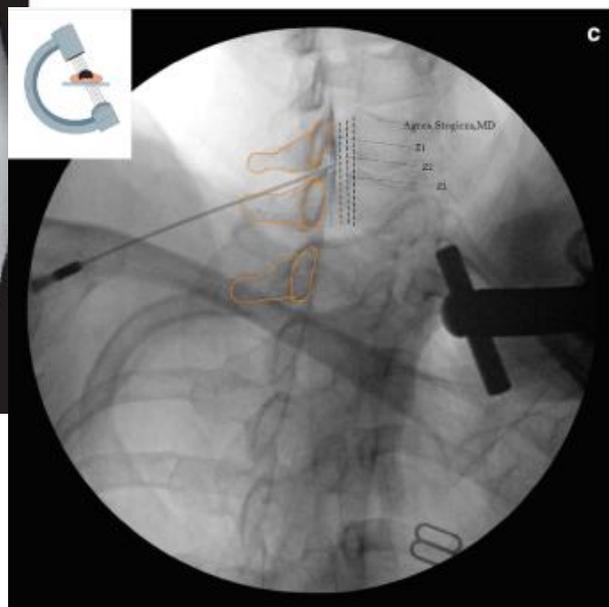
### Caudal

Safest trajectory, with a lower risk of dural puncture and nerve injury; preferred for patients with altered anatomy due to prior surgery or scar tissue.

Less targeted medication delivery, especially for pathology higher up in the spine; often requires a larger volume of injectate.

# ESI APPROACHES





# INTERLAMINAR



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DAVID SCHULTZ, M.D.  
TRANS LESI

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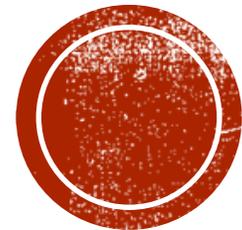
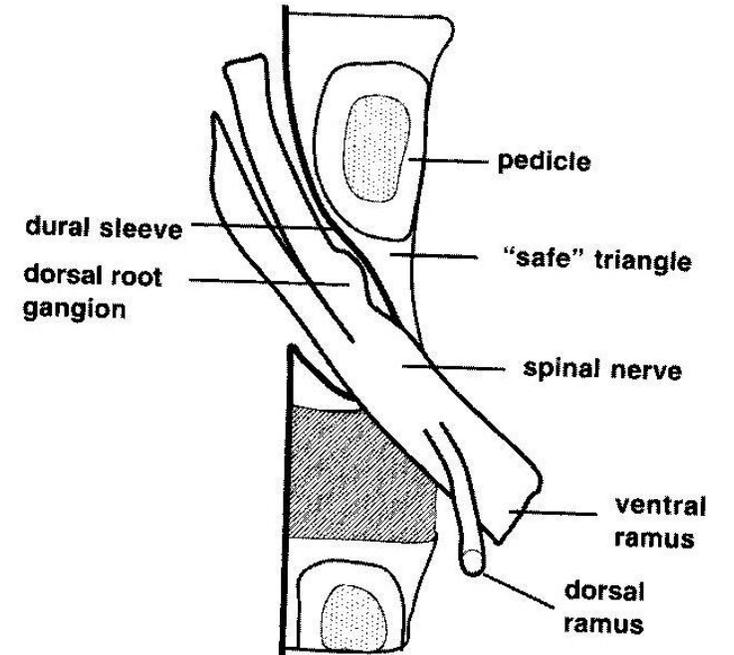
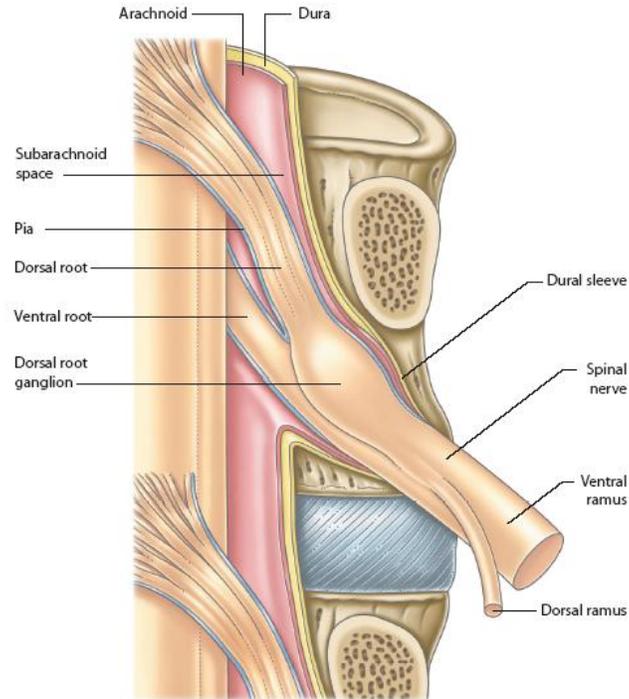
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# TRANSFORAMINAL (SUBPEDICULAR)



# BOGDUK'S SAFE TRIANGLE





# TRANSFORAMINAL (INFRANEURAL)

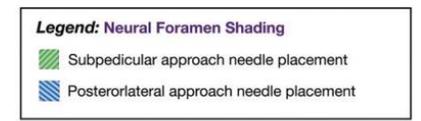
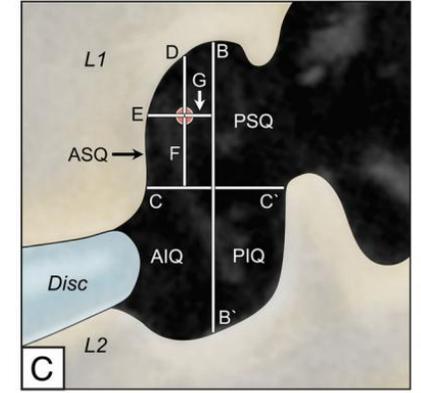
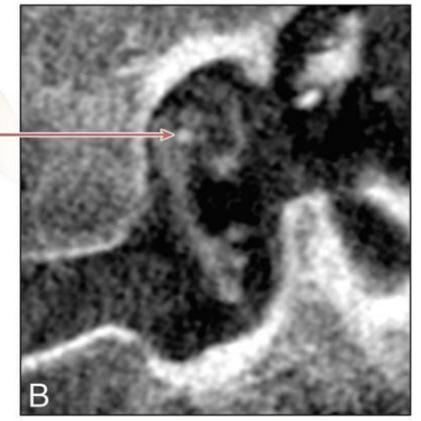
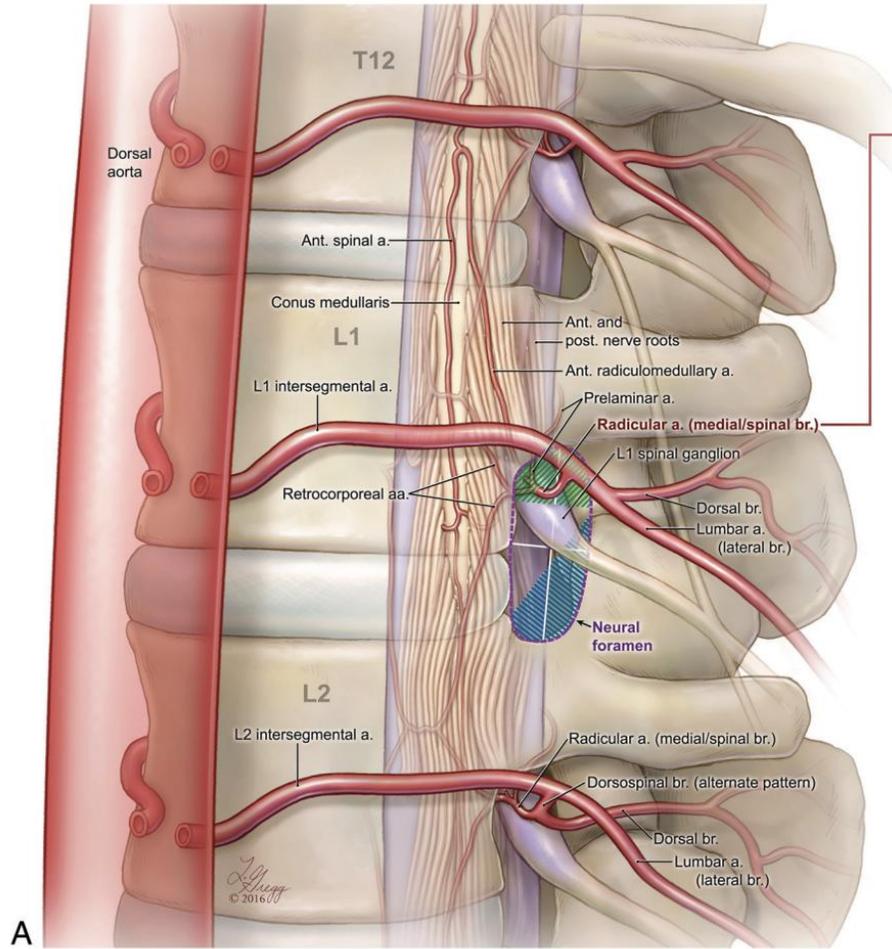
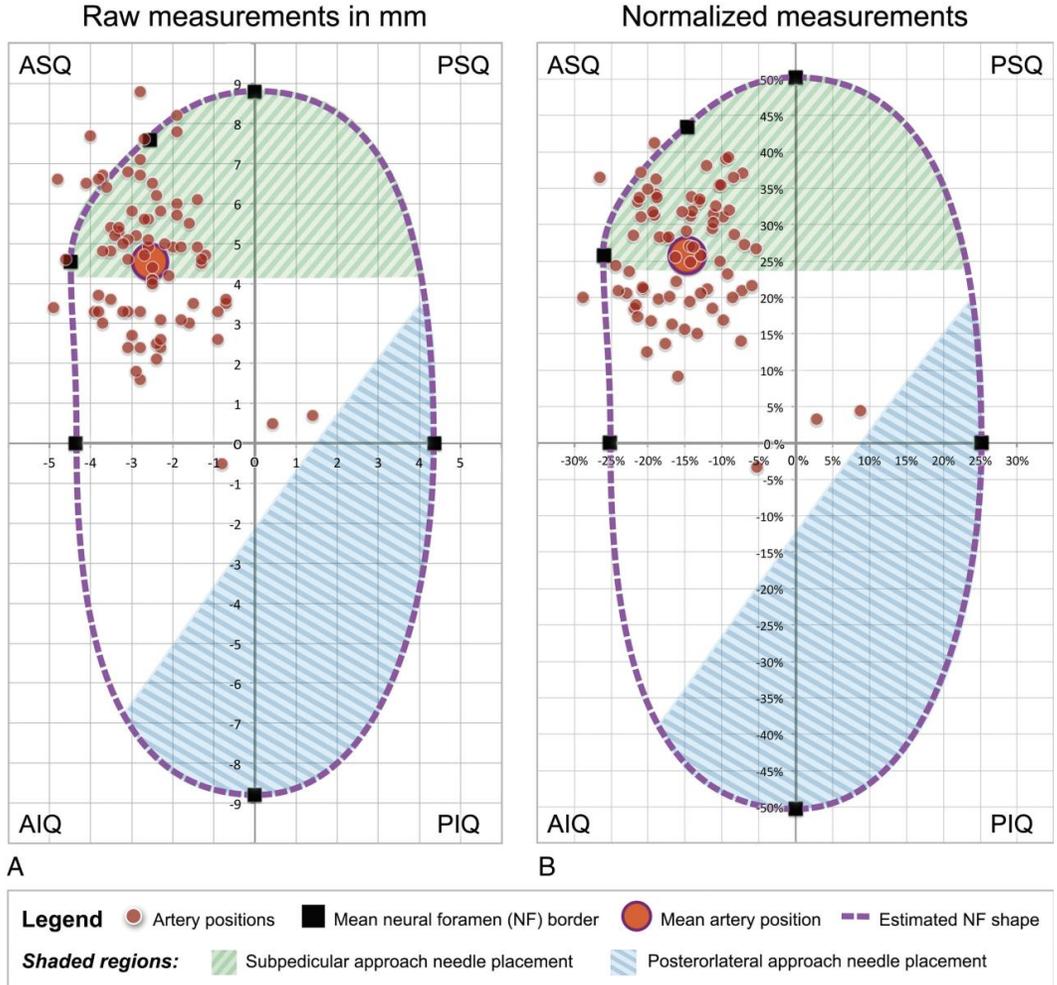




# SAFE OR UNSAFE TRIANGLE

*Kambin's triangle*





posterior spinal arteries

posterior radiculomedullary artery

radiculomedullary artery

anterior spinal artery

segmental artery

Anterior radiculomedullary artery

Posterior central arteries

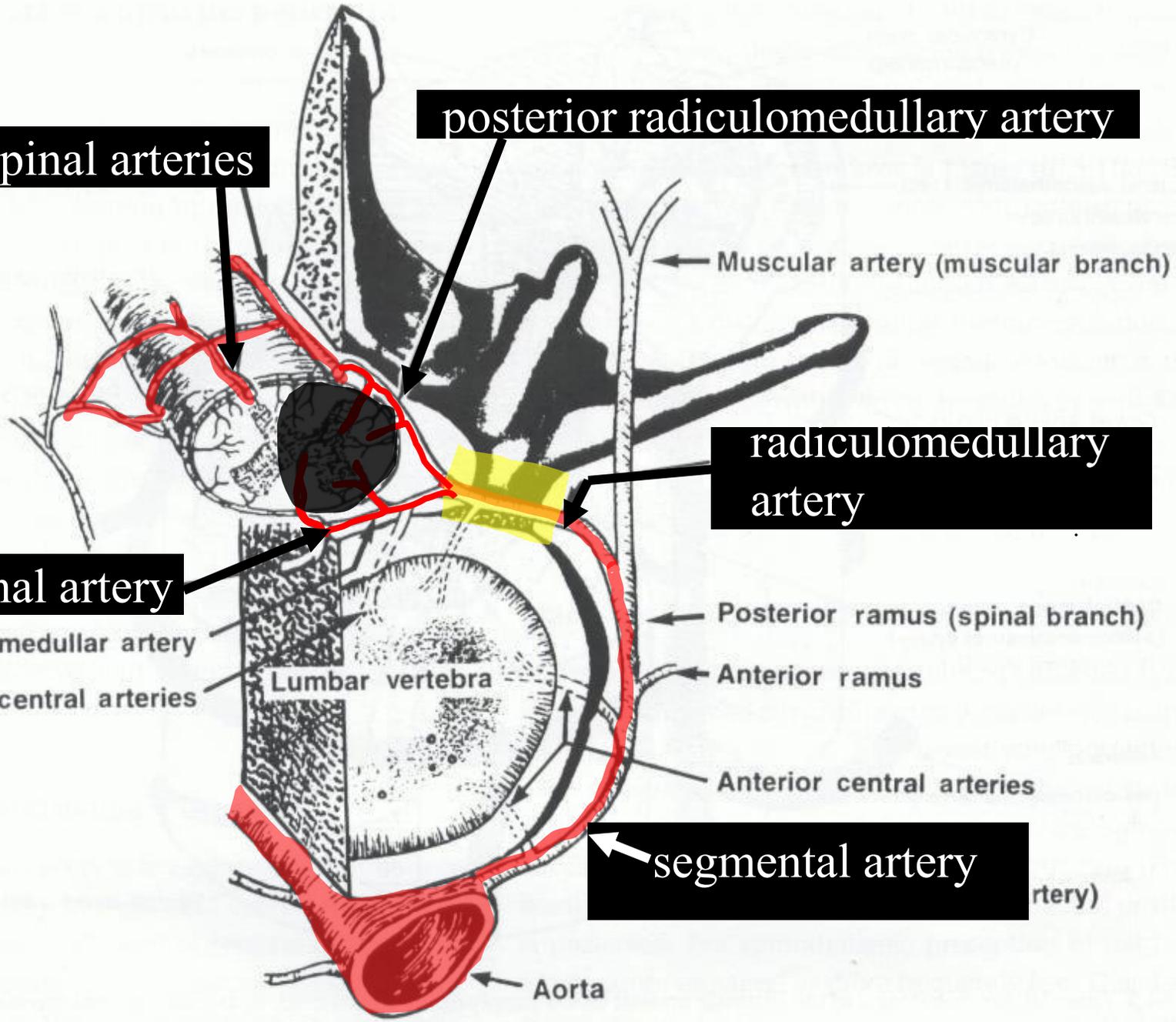
Lumbar vertebra

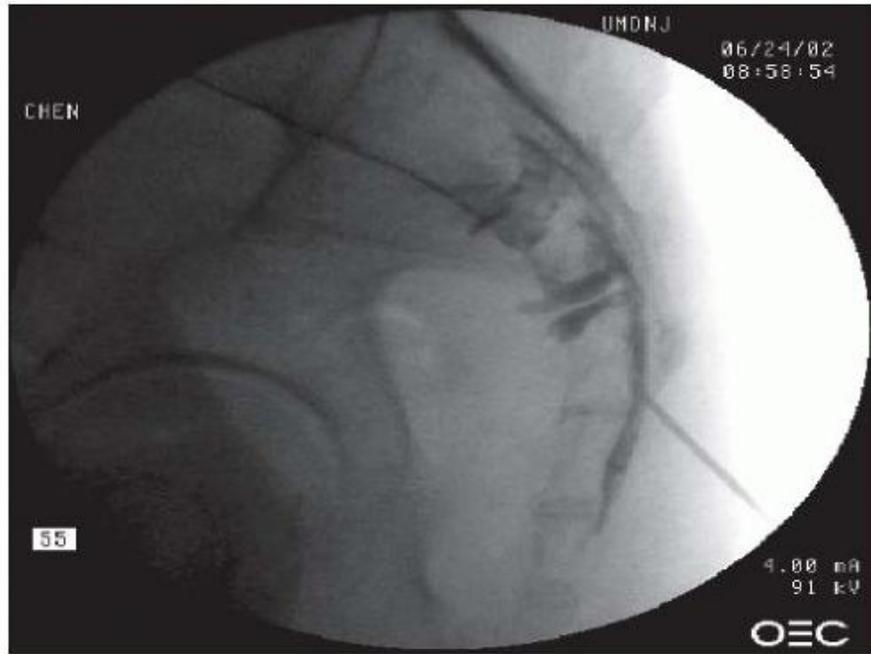
Posterior ramus (spinal branch)

Anterior ramus

Anterior central arteries

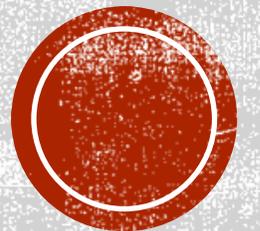
Aorta





# CAUDAL

<https://musculoskeletalkey.com/spinal-injection-procedures/>



GABOR RACZ  
MD, DABIPP, FIPP



JULY 6, 1937-JUNE 21, 2025



- Born in Budapest Hungary on July 6, 1937
- Granted entry into Semmelweis University Medical School in 1955
- November 27, 1956, he was forced to leave Hungary after learning that the Hungarian Secret Police wanted him for questioning
- As a former Hungarian medical student, he received a scholarship to attend the University of Liverpool School of Medicine. After learning English and passing his first-year exams, he matriculated in April 1957
- In 1962 Gabor received his Bachelor of Medicine and Bachelor of Surgery degrees.
- He worked in Liverpool until 1963 at the Royal Southern Hospital as a house surgeon and physician. That same year he and Enid moved to Syracuse, New York, where he began an anesthesiology residency at State University of New York Upstate Medical University.

- Completed his residency in 1966 and over the next 11 years worked as an associate attending anesthesiologist for the Veterans Administration hospital and UHS Chenango Memorial Hospital in Norwich, New York
- In 1977 Dr. Racz moved his family to Lubbock, Texas, to become the first chairman of Anesthesiology at Texas Tech University Health Sciences Center (TTUHSC)
- From 1978 through 2006, he was Director of Pain Services for the Department of Anesthesiology.
- In the 1980's he created a 6-month fellowship in the management of chronic pain. In 1993, the fellowship evolved into a 12-month American College of Graduate Medical Education-accredited program which to this date has trained over 130 fellows in the management of chronic pain.
- The major accomplishment of his career was the development of the Racz catheter in the early 1980's. The catheter was specifically designed to be the central tool for treating epidural adhesions after surgery and its use evolved into the Racz procedure in 1989.



# ABBREVIATED HISTORY OF EPIDURAL ADHESIOLYSIS

Catheter directed technique for cancer-related pain developed using a new epidural catheter made of spiral stainless-steel coils coated with fluoropolymers. JAMA 1982;248(5):579-81.

1979–1980

Catheter targeted to ventral-lateral epidural space

Early 1980's

1981–1982

Based on Hitchcock's studies, hypertonic saline added to the epidural infusions

Mid 1980's

Hyaluronidase added to the lysis protocol



# Intractable Pain Therapy Using a New Epidural Catheter

Gabor B. Racz, MD; Magdy Sabonghy, MD; Jonas Gintautas, MD, PhD; William M. Kline

• Conventional epidural catheters used in performing neurolytic blocks create frequent problems such as kinking, misplacement, and questionable localization of the catheter. We present a study of a new epidural catheter for injection of phenol in patients with severe pain problems. In four of five cases complete pain relief was obtained for several months. The design of this catheter provides improved localization of the injection site.  
(*JAMA* 1982;248:579-581)

INTRATHECAL injections of phenol for the control of cancer pain was introduced in 1955.<sup>1</sup> Possible complications using this technique include spread of the neurolytic agent to larger areas than desired, meningitis, arachnoiditis, muscular weakness, bladder weakness, urinary incontinence, headache, bowel incontinence, paresthesias, and thrombosis of spinal arteries causing extensive necrosis of the spinal cord.<sup>2,3</sup>

Epidural injection of phenol using conventional catheters does not appear to have major complications. However, determination of the exact location of the tip of the catheter during injection and kinking of the catheter remain as major problems.<sup>4,6</sup> One method for verification of correct placement of a Teflon-type epidural

fluoropolymers (Fig 1) has been successfully used by our group for anesthesia or analgesia purposes with more than 100 patients. Recently we began using the catheter in pain therapy.

### Materials and Methods

Five patients described herein were seen in our pain center with chronic, intractable thoracic pain. All patients were hospitalized. Three patients had invasive carcinoma of the lung, one patient had posttraumatic brachial plexus injury and shoulder pain, and one patient had chronic postherpetic neuralgia. Informed consent was obtained. The procedure was conducted in the pain center, which is equipped with ECG monitor and life support systems. Vital signs of the patients were monitored, an intravenous route was established, and sedation was used as

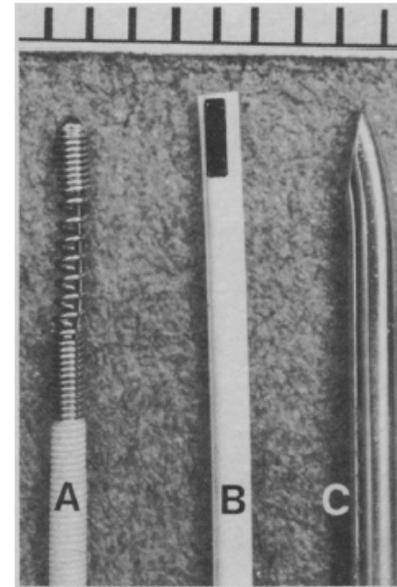


Fig 1.—Comparison of sizes: A, epidural catheter. Tip of catheter and extended spiral stainless steel coils of injection area are displayed. Longitudinal supportive metal core is inside the catheter. White surface is a coat of fluoropolymers. B, 18-gauge Hustead tip epidural needle. Scale: 1 mm between black bars on top of photograph.

# EVOLUTION LYSIS OF ADHESIONS

- Racz GB, Sabonghy M, Gintautas J, Kline WM: Intractable pain therapy using a new type of epidural catheter. *JAMA* 248:579-580, 1982.
- Racz GB: Technical advance: A new epidural catheter. *Persistent Pain-Modern Methods of Treatment (VS)*, S Lipton and J Miles (eds): London, Grune and Stratton 267-273, 1985.
- Racz GB, Haynesworth RF, Lipton S: Experiences with an improved epidural catheter. *The Pain Clinic*, 1985.
- Racz GB, Holubec JT: Lysis of adhesions in the epidural space. In Racz GB (ed): *Techniques of Neurolysis*. Boston, Kluwer Academic Publishers 57-72, 1989.
- Racz GB, Heavner JE, Singleton W, Carline M: Hypertonic saline and corticosteroid injected epidurally for pain control. In Racz GB (ed): *Techniques of Neurolysis*. Boston, Kluwer Academic Publishers 73-86, 1989.
- Racz GB, Kline WA: Technical advance: New epidural adapter and epidural needle. In Racz GB (ed): *Techniques of Neurolysis*. Boston, Kluwer Academic Publishers, 95-98, 1989.
- Racz GB, Holubec J, Heavner JE: Lysis of adhesions in the epidural space. *La Revista Italiana Per La Clinica Del Delore*, June: 19-30, 1990.
- Racz GB, Heavner JE, Diede JH: Epidural approach for lysis of epidural adhesions. In Waldman SD and Winnie AP (eds): *The Interventional Pain Management Text*, Philadelphia, WB Saunders Co. 1996.
- Racz GB, Heavner JE, Raj PP: Epidural neuroplasty. *Seminars in Anesthesia* 16:4 302-312 1997.
- Racz GB, Heavner JE, Raj PP: Nonsurgical management of spinal radiculopathy by the use of lysis of adhesions. In Aronoff GM, ed.: *Evaluation and Treatment of Chronic Pain*, Third Edition, 1997.
- Racz GB, Heavner JE and Raj PP: Percutaneous epidural neuroplasty: Prospective One-Year Follow-Up. *Pain Digest* 9:97-102, 1999.
- Heavner JE, Racz GB, Raj PP: Percutaneous epidural neuroplasty: Prospective Evaluation of 0.9% NaCl Versus 10% NaCl With or Without Hyaluronidase. *Regional Anesthesia and Pain Medicine* May-June 24(3): 202-207, 1999.
- Anderson SR, Racz GB, Heavner J: Evolution of epidural lysis of adhesions. *Pain Physician* 3:262-270, 2000.
- Racz GB, Heavner JE, Trescot A. Percutaneous Lysis of Epidural Adhesions-Evidence for Safety and Efficacy. *Pain Practice*. 8: 277-286, 2008.
- TNTC



# WHAT IS EPIDURAL ADHESIOLYSIS?

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A technique involving site-specific catheter placement and injections intended to “open up” the perineural space.

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The injectates are designed to free the nerve root from restrictions and reduce painful nerve roots inflammation.

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A steerable soft-tip catheter is guided to the targeted nerve root where medication is administered.

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These catheters are introduced via a specially designed, shear-resistant, epidural needles.



# BENEFITS OF A DIRECTED CATHETER

- Breakdown of epidural adhesions
  - Epidural fibrosis may account for as much as 20% to 36% of all cases of failed back surgery syndrome
    - Epter R, Helm S, Hayek S. Systematic Review of Percutaneous Adhesiolysis and Management of Chronic Low Back Pain in Post Lumbar Surgery Syndrome. Pain Physician 2009; 12:361-378.
- Directed steroid placement
- Electrical stimulation of the selected nerve root
- Avoidance of injectate related spinal cord compression

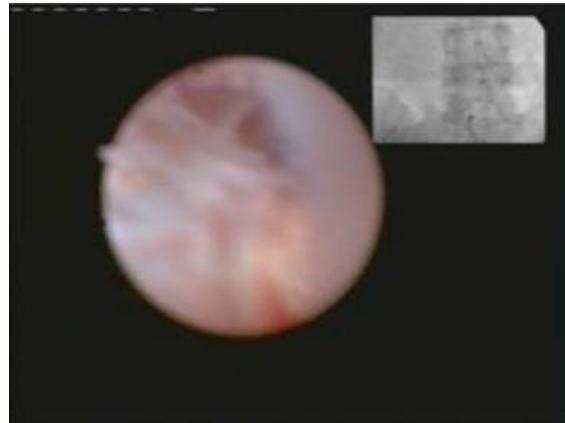




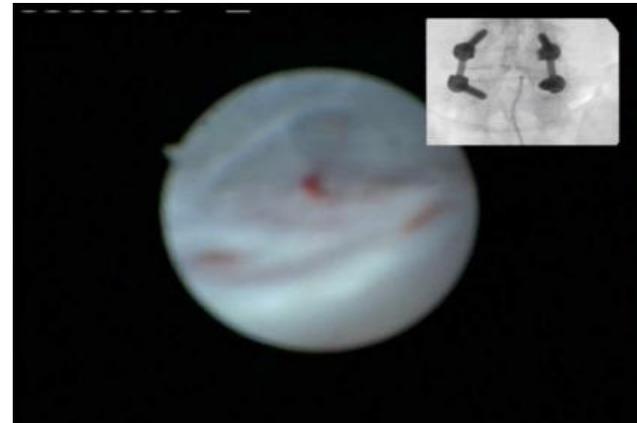
**Grade 1 fibrosis**



**Grade 2 fibrosis**



**Grade 3 fibrosis**



**Grade 4 fibrosis**



# “CLASSIC” LYSIS PROTOCOL

- Needle placed with paramedian approach
- Epidurogram with 10 ml non-ionic, water-soluble contrast
- Catheter inserted ventral-lateral epidural space to target level
- Contrast 1-3 ml
- 150-300 units Hylanex in 10 ml PFNS
- Contrast 1-3 ml
- 10 ml local anesthetic/steroid
  
- 10 ml hypertonic saline (10%) infusion

} May repeat  
times 2



- **Contrast**
  - Non-ionic, water-soluble (Iohexol-240, Isovue-M)
  - DO NOT USE ionic, non-water-soluble contrast including: Hypaque<sup>®</sup>, Renagrafin/Urografen<sup>®</sup>, or Conray<sup>®</sup>
- **Steroids**
  - Particulate (Non-soluble) vs. non-particulate (Soluble)
- **Local Anesthetic**
  - 0.25% bupivacaine, 0.2% ropivacaine
- **Hyaluronidase**
  - Human recombinant: 150-300 units
  - Ovine, Bovine, Porcine: 1500 units
- **Hypertonic saline (10%)**



# HYALURONIDASE

- Mechanism of action
  - More correctly termed hyaluronoglucosaminidase
  - Liquifies the interstitial barrier between cells by cleaving  $\beta$ -1,4 glycosidic bonds
  - Improves the diffusion of injected substances within most connective tissue planes except for collagenous barriers.

Watson D. Hyaluronidase. *Br J Anaesth* 1993;71:422-425





- Mechanism of action
  - In the lysis procedure, it presumably breaks down the ground substance in the epidural scar tissue to “free up” the nerve root and to better allow deposition of local anesthetic/steroid/hypertonic saline to the target level

# Hyaluronidase decreases neutrophils infiltration to the inflammatory site

Marcio Fronza<sup>1,2</sup> · Cornélia Muhr<sup>3</sup> · Denise Sayuri Calheiros da Silveira<sup>1</sup> · Carlos Artério Sorgi<sup>1</sup> · Stephen Fernandes de Paula Rodrigues<sup>4</sup> · Sandra Helena Poliselli Farsky<sup>4</sup> · Francisco Wanderley Garcia Paula-Silva<sup>1</sup> · Irmgard Merfort<sup>3</sup> · Lúcia Helena Faccioli<sup>1</sup>

Received: 27 September 2015 / Revised: 10 December 2015 / Accepted: 24 February 2016 / Published online: 4 March 2016  
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## Abstract

**Objective** To evaluate the in vivo anti-inflammatory potential of bovine hyaluronidase (HYAL) using two different models of acute inflammation.

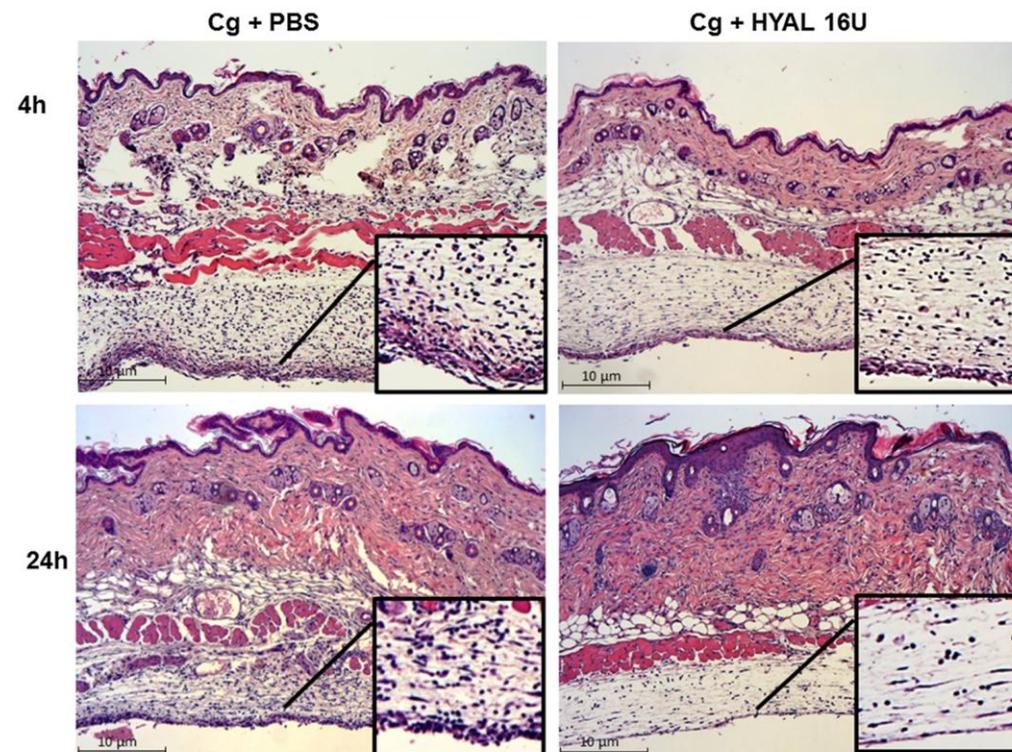
**Methods** Air pouches were produced in the dorsal subcutaneous of mice and injected with phosphate saline solution or HYAL. The antiinflammatory action of HYAL was evaluated in carrageenan (Cg)-inflamed air pouches. After 4 and 24 h the cellular influx, protein exudation, cytokines and lipid mediators were evaluated. The action of HYAL on the rolling and adhesion of leukocytes was investigated in the LPS-stimulated mesenteric microcirculation by intravital microscopic.

**Results** Treatment with HYAL reduced the cellular influx and protein exudation in non-inflamed and inflamed air pouches. HYAL treatment of Cg-inflamed air pouch reduced the production of tumor necrosis factor-alpha

(TNF- $\alpha$ ), interleukin-8 (IL-8), leukotriene B<sub>4</sub> (LTB<sub>4</sub>) and LTC<sub>4</sub>, whereas prostaglandins E<sub>2</sub> (PGE<sub>2</sub>) and D<sub>2</sub> (PGD<sub>2</sub>) concentrations were unchanged. Histological analyses showed that HYAL administration diminished cell infiltration in the air-pouch lining. In LPS-stimulated mesenteric microcirculation, HYAL usage decreased rolling and adhesion of leukocytes, but did not affect the blood vessels diameters.

**Conclusion** The results demonstrate that HYAL inhibited cellular recruitment, edema formation and pro-inflammatory mediators production, resulting in decreased adherence of leukocytes to blood vessels and tissue infiltration. Our data suggest that HYAL may be considered an effective candidate to ameliorate acute inflammation.

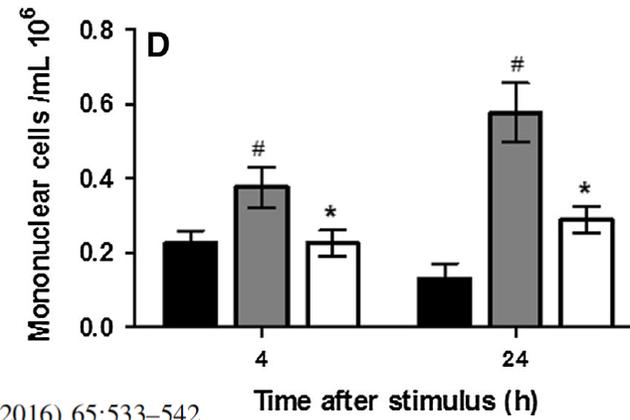
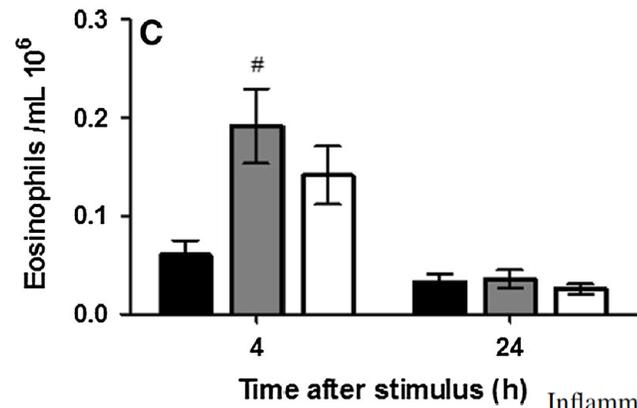
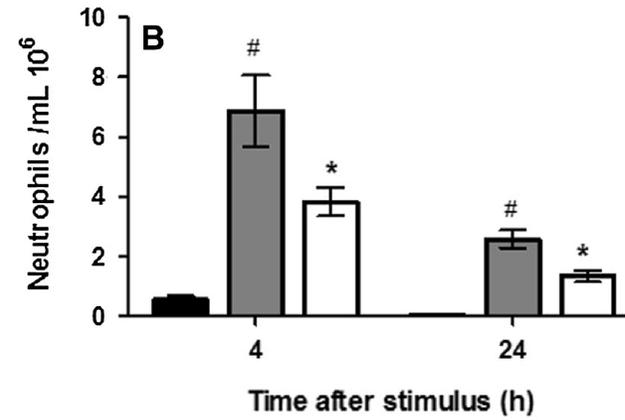
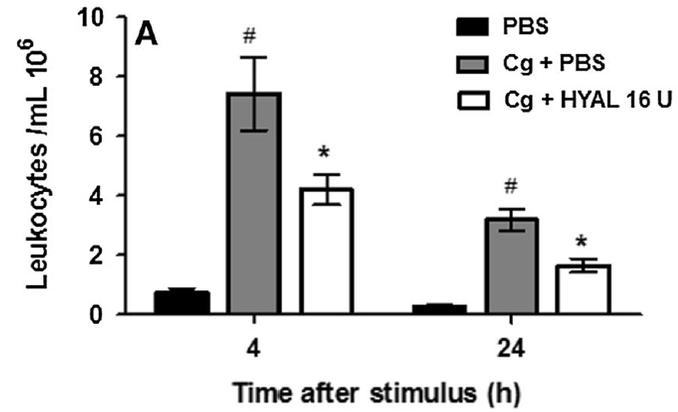
**Keywords** Air pouch · Cytokines · Lipid mediators · Intravital microscopy · Leukocyte-endothelial interactions · Neutrophil influx · Carrageenan · LPS



**Fig. 5** Hyaluronidase (HYAL) affects cellular recruitment in the inflamed air-pouch lining tissue. Pouches were inoculated with Cg (1 % concentration) and 1 h later treated with HYAL (Cg + HYAL 16 U/0.5 mL/pouch) or phosphate buffered saline (PBS) (Cg + PBS/0.5 mL/pouch). Paraffin-air pouch membrane sections were stained

with hematoxylin and eosin to evaluate the inflammatory infiltrate response by image analysis. The inserts depicted from the skin-tissue linings surrounding the pouch cavity ( $\times 400$  original magnification) shows the infiltrating cells. The sections were photographed at  $\times 100$





Inflamm. Res. (2016) 65:533–542



# HYALURONIDASE

- Currently available hyaluronidase preparations
  - Hylenex<sup>®</sup>
    - Human recombinant hyaluronidase
    - Produced by genetically engineered Chinese hamster ovary cells
  - Vitrase<sup>®</sup>
    - Ovine hyaluronidase
  - Amphidase<sup>®</sup>
    - Purified bovine testicular hyaluronidase
  - Compounded hyaluronidase formulations



# CORTICOSTEROIDS

- Mechanism of action
  - Reduce inflammation either by inhibiting the synthesis or release of a number of pro-inflammatory substances or by causing a reversible local anesthetic effect
  - Others
    - Membrane stabilization
    - Inhibition of neural peptide synthesis or action
    - Blockade of phospholipase A2 activity
    - Prolonged suppression of ongoing neuronal discharge
    - Suppression of sensitization of dorsal horn neurons



# HYPERTONIC SALINE

- Possible mechanisms of action when injected in the epidural space for analgesia
  - Evidence from studies on cats and monkeys that hypertonic saline has a local anesthetic-like effect on intact dorsal rootlets
    - The chloride ion seems to play a major role in the persistent C-fiber blockade
    - Choline chloride just as effective as sodium chloride

Jewett D, King JS. Conduction blockade of monkey dorsal rootlets by water and hypertonic saline solutions. *Exp Neurol* 1971;33:225-237.

King JS, Jewett D, Sundberg H. Differential blockade of cat dorsal root C-fibers by various chloride solutions. *J Neurosurg* 1972;36:569-583.



- Possible mechanisms of action when injected in the epidural space for analgesia
  - Reduction of cell swelling (edema) by causing water to migrate out of cells
    - Osmotically induced water shift
      - Decreased swelling → less pressure on nerve

Racz G, Heavner J, Singleton W, Carline M. Hypertonic saline and corticosteroid injected epidurally for pain control. In Raj P (ed): *Techniques of Neurolysis*. Boston, Kulwer Academic Publishers, 1989, pp 73-86.

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# HYPERTONIC SALINE



# An Evaluation of Medications Commonly Used for Epidural Neurolysis Procedures in a Human Fibroblast Cell Culture Model

*Christof Birkenmaier, MD, Julia Redeker, Birte Sievers, PhD, Carolin Melcher, MD, Volkmar Jansson, MD, and Susanne Mayer-Wagner, MD, PhD*

**Background and Objectives:** Epidural injections are popular therapies for sciatica and low back pain. Local anesthetics and corticosteroids are commonly used for most injections techniques, but some treatments use a specific combination of several agents. The epidural lysis of adhesions procedure (Racz) uses a combination of bupivacaine, hyaluronidase, a corticosteroid, and hypertonic saline. Because severe complications, some with permanent neurologic deficits, have been observed, we considered the possibility that individual agents or a combination thereof might be capable of damaging or destroying cells in primarily the epidural tissues.

**Methods:** We used monolayer cell cultures of human fibroblasts in Dulbecco modified Eagle medium to study these pharmacological agents alone or in combination. Cell viability and proliferation were assessed by Trypan blue staining, cell counts, and the WST-1 assay. Time and concentration series were performed.

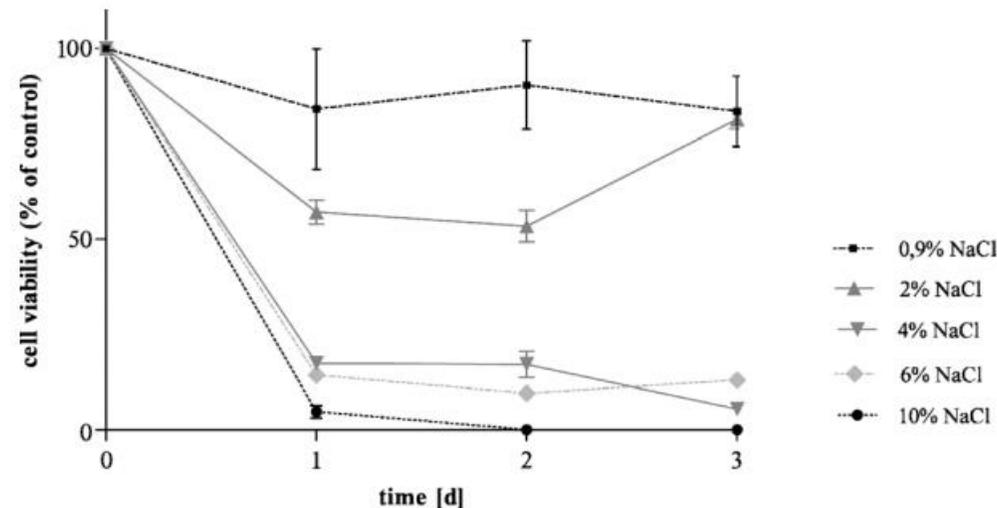
**Results:** With the corticosteroid, we observed the previously described proliferation-retarding effects. Hyaluronidase was not found to have a relevant effect on fibroblast proliferation. Bupivacaine and hypertonic saline were found to have a time- and concentration-dependent effect on cell viability and proliferation. Both were found to be toxic at concentrations well below the ones used clinically.

**Conclusions:** We identified a potential for harm caused by commonly used pharmacological agents when applied epidurally. Animal studies will have to show whether the same can be observed in living tissues.



# An Evaluation of Medications Commonly Used for Epidural Neurolysis Procedures in a Human Fibroblast Cell Culture Model

*Christof Birkenmaier, MD, Julia Redeker, Birte Sievers, PhD, Carolin Melcher, MD, Volkmar Jansson, MD, and Susanne Mayer-Wagner, MD, PhD*

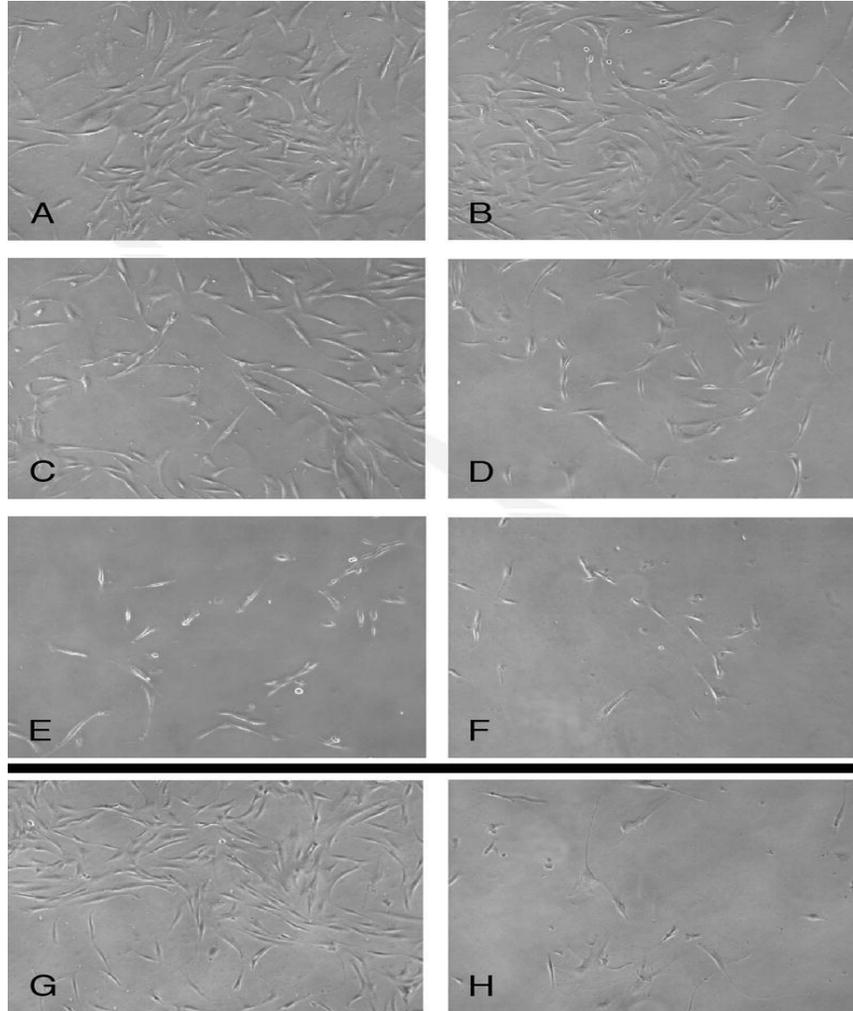


**FIGURE 3.** Effects of 1 hr of incubation with DMEM containing different NaCl concentrations on human fibroblasts. Cell counts were performed with a hemocytometer on days 1, 2, and 3. The graph shows cell numbers normalized to the control group during a 3-day period. There was a reduction in cell viability with increasing NaCl concentrations.



# MONOLAYER OF CULTURED HUMAN FIBROBLAST IN NAACL AND DMEM

## 1 HOUR INCUBATION AND 3 DAYS OF INCUBATION TO VARIOUS PERCENTAGES



- A. Control-DMEM
- B. 0.9% NaCl-DMEM
- C. 2% NaCl-DMEM
- D. 4% NaCl-DMEM
- E. 6% NaCl-DMEM
- F. 10% NaCl-DMEM

**Below black line represents 3 days incubation and 24 hour exposure:**

- G. Control-DMEM
- H. 0.9% NaCl-DMEM

DMEM-Dulbecco's Modified Eagle Medium  
(cell culture medium)



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Sex: F  
Site: UNIVERSITY MEDICAL CENTER

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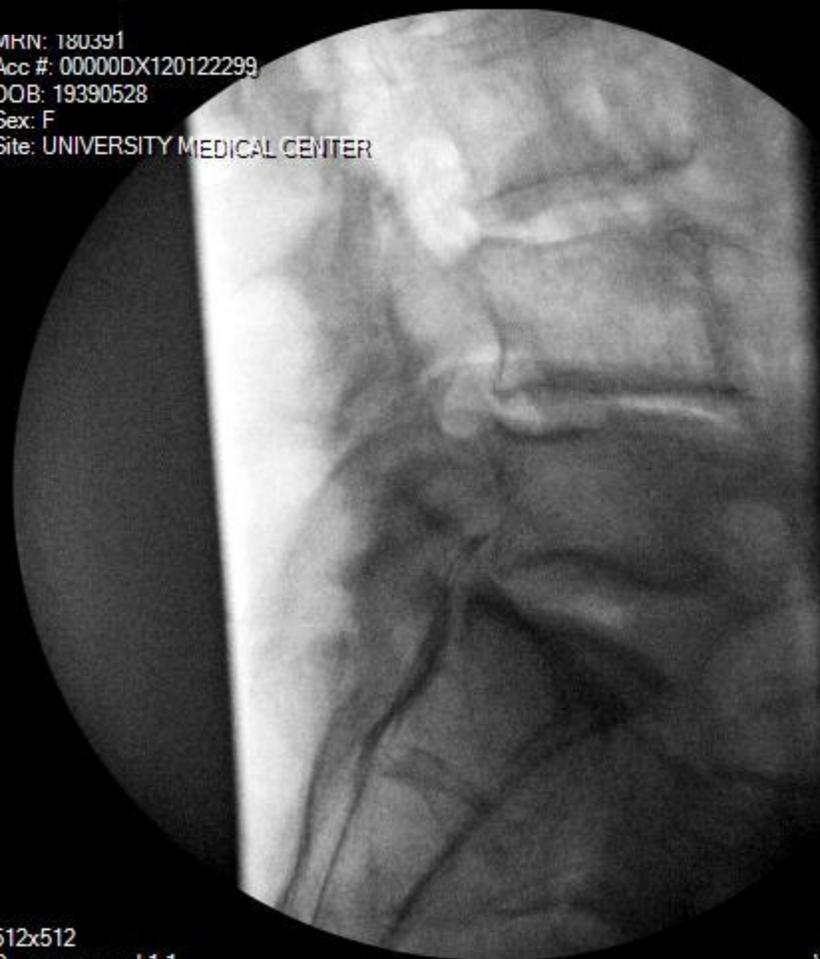


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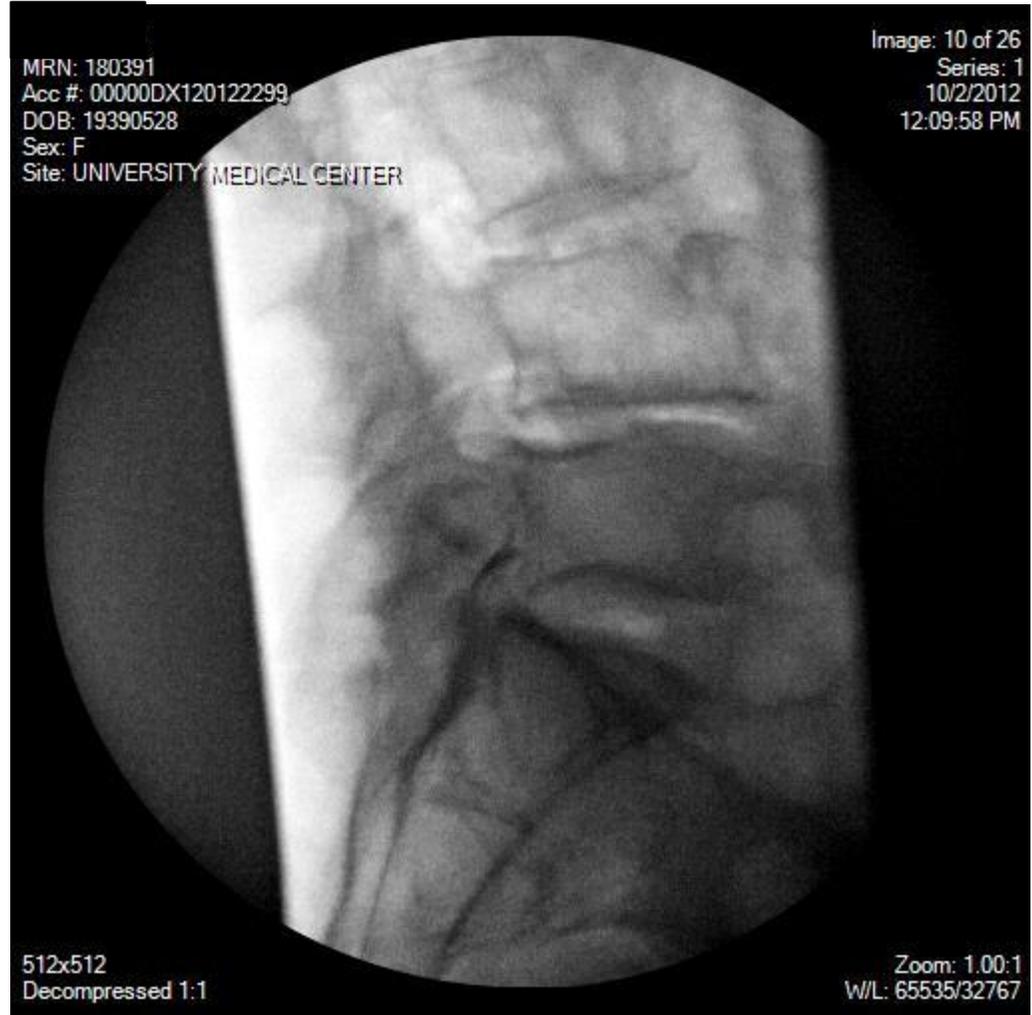
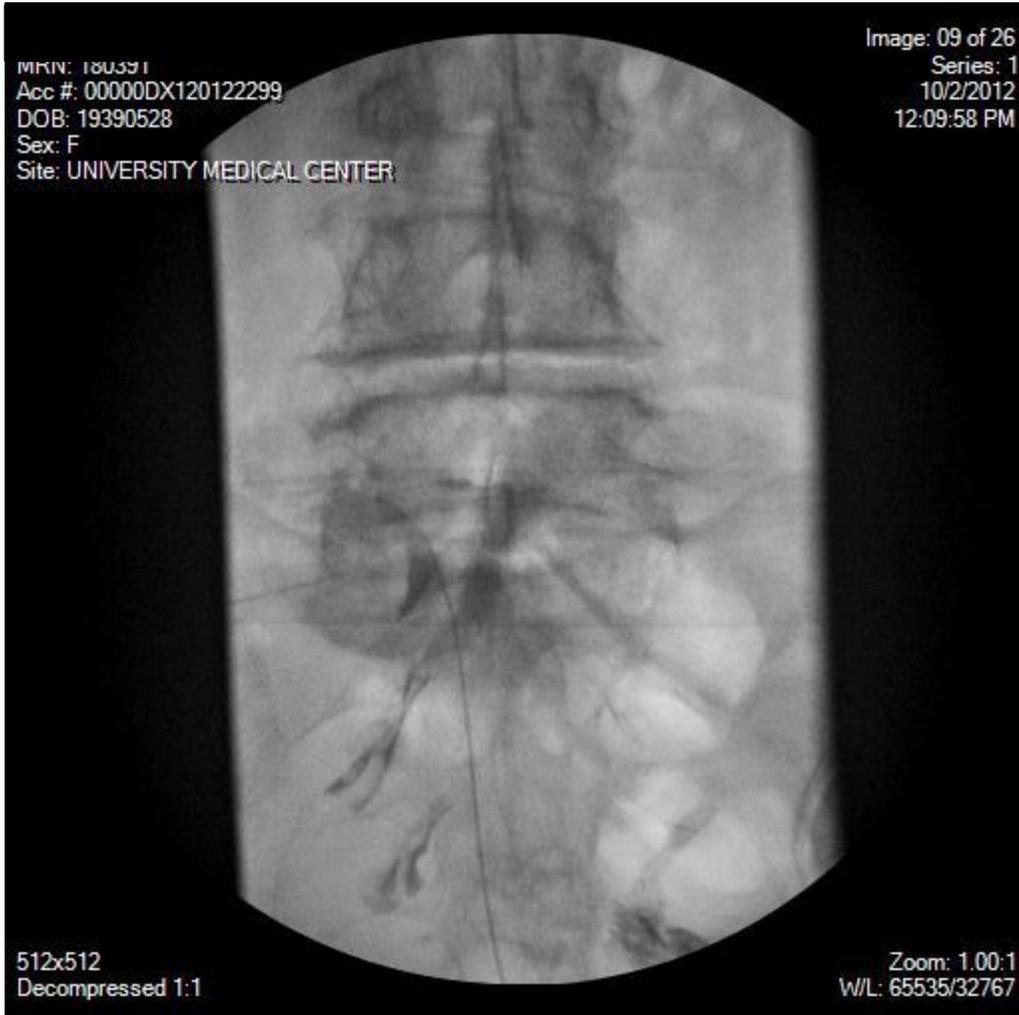
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# COMPLICATIONS OF ESI'S

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Intravascular  
trauma or  
injection

Neural  
trauma or  
injection

Subarchnoid,  
subdural  
injection

Bleeding

Infection

Steroid side  
effects

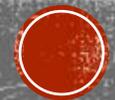
Allergy

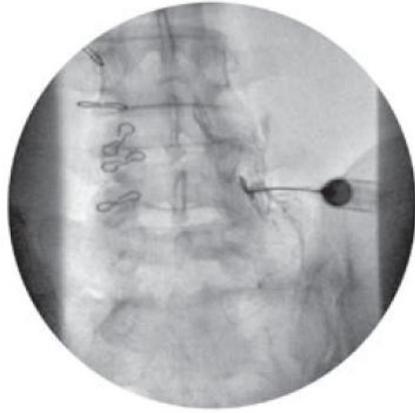
Pain

# COMPLICATIONS RELATED TO LYSIS OF EPIDURAL ADHESIONS

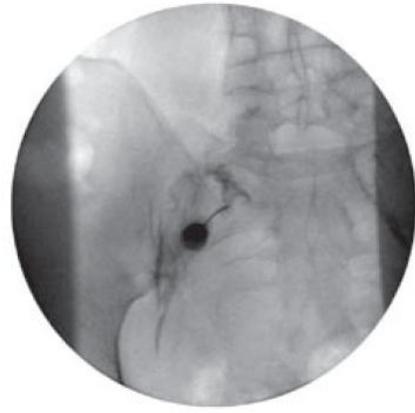
- Allergic Reactions
- Headache
- Iatrogenic Cushingoid Syndrome
- Macular Hemorrhage
- Somatosensory and Somatomotor Dysfunction
- Bowel, Bladder, Sexual dysfunction
- Infection
- Pain at epidural entry site
- Local anesthetic toxicity – CNS, cardiovascular
- Catheter shearing
- Subdural or intrathecal spread of medication







A. L5 intravascular.

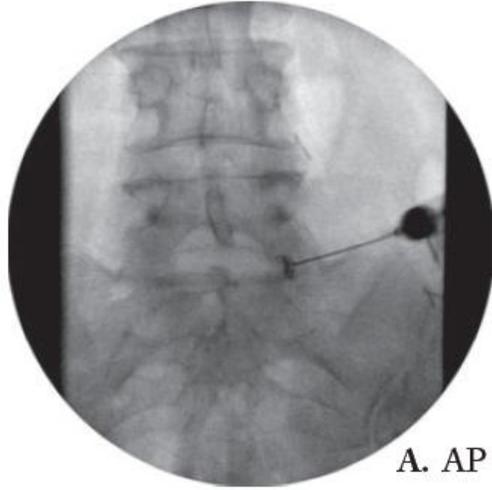


B. S1 Intravascular.

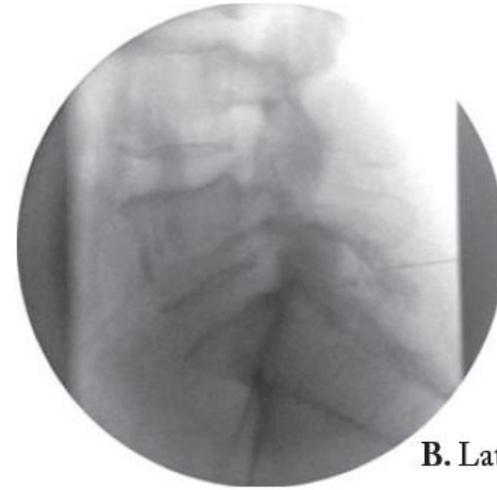
# INTRAVASCULAR PLACEMENT AT L5, S1



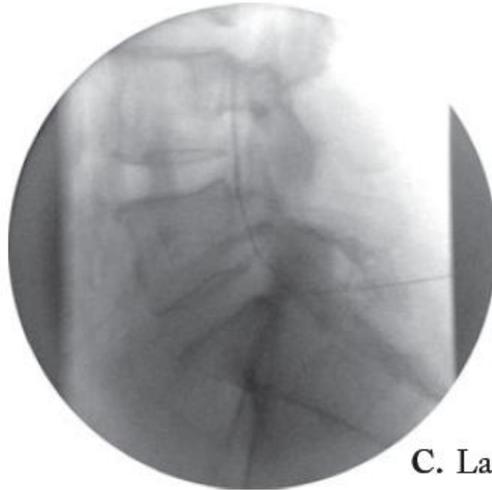
# SUBDURAL PLACEMENT WITH L5 TRANSFORAMINAL



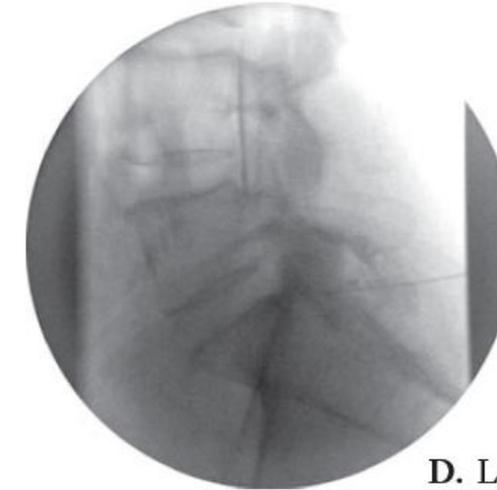
A. AP view



B. Lateral view



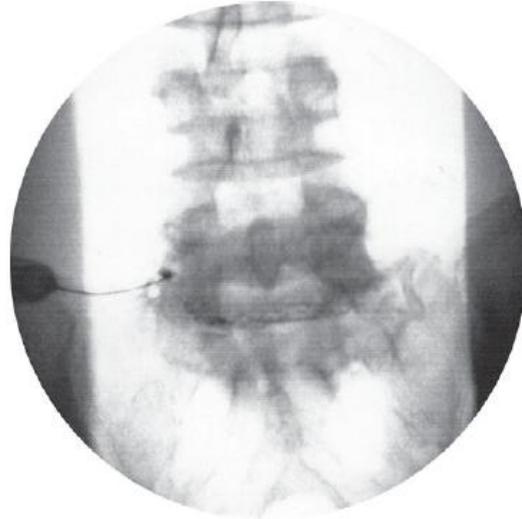
C. Lateral view with contrast



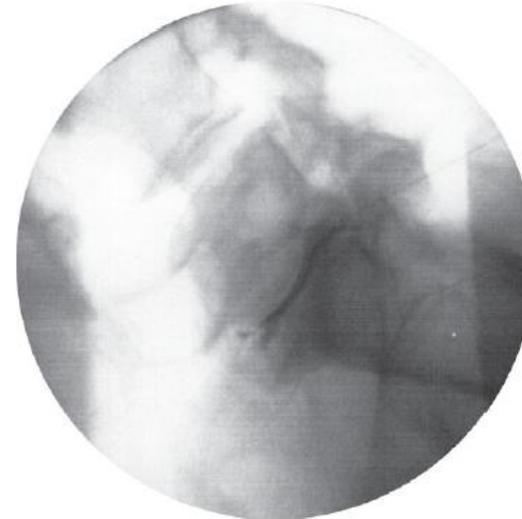
D. Lateral view with contrast



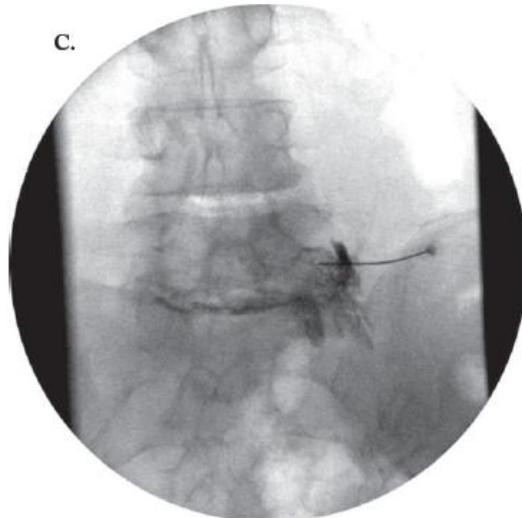
# INTRADISCAL CONTRAST PATTERN



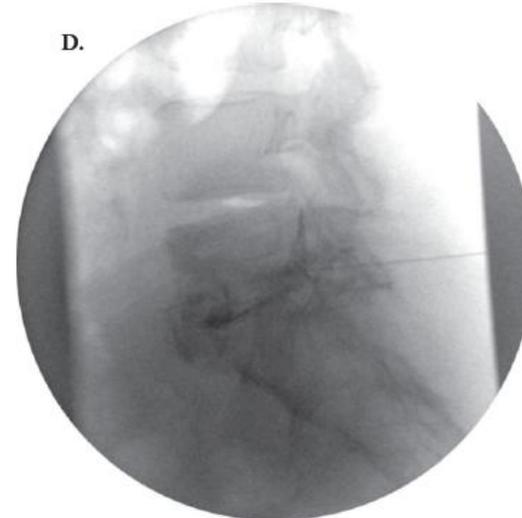
A. AP view



B. Lateral view



C. AP view



D. Lateral view



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GE\_HEALTHCARE

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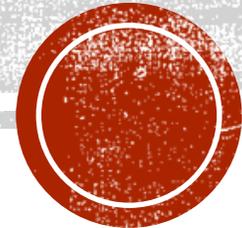
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- Disc herniation/cervical radiculitis (evidence – Level I with strong recommendation)
- Cervical spinal stenosis (evidence – Level II with moderate to strong recommendation)
- Post cervical surgery syndrome (evidence – Level II to I with moderate to strong recommendation)
- Axial or discogenic pain without facet joint pathology or disc herniation (evidence – Level II with moderate to strong recommendation)

# CERVICAL ESI LEVELS OF EVIDENCE

Pain Physician 2021; 24:S27-  
S208 ISSN 2150-1149



# THORACIC ESI LEVELS OF EVIDENCE

- Level 2 Evidence



# LUMBAR ESI LEVELS OF EVIDENCE

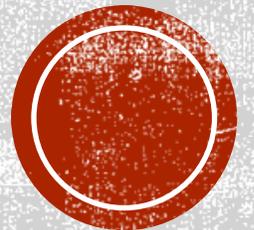
- Disc herniation/lumbar radiculitis: (evidence – Level I with strong recommendation for caudal, interlaminar, and transforaminal)
- Lumbar spinal stenosis: (evidence – Level II for caudal with moderate to strong recommendation, Level II for lumbar interlaminar with moderate to strong recommendation and Level IV to III with moderate recommendation for lumbar transforaminal)
- Post-lumbar surgery syndrome: (evidence – Level II for caudal with moderate to strong recommendation)
- Axial or discogenic low back pain without facet joint or sacroiliac joint pain or disc herniation: (evidence – Level II for caudal and lumbar interlaminar with moderate to strong recommendation)



- Post-surgery syndrome (evidence – Level I with strong recommendation).
- Central spinal stenosis (evidence – Level II with moderate to strong recommendation)
- Disc herniation/radiculitis/severe degenerative disc disease (evidence – Level II with moderate to strong recommendation)

# **PERCUTANEOUS LYSIS OF ADHESIONS LEVELS OF EVIDENCE**

Pain Physician 2021; 24:S27-S208 ISSN 2150-1149





# WIP

13<sup>TH</sup> WORLD CONGRESS

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## SEPTEMBER 19-21, 2026

