

## ADVANCES IN SPINAL SURGERY

From Cedars-Sinai Medical Center Institute for Spinal Disorders' Sixth Annual Symposium on Current Concepts in Spinal Disorders 2007

**DIAGNOSTIC, PROGNOSTIC, AND THERAPEUTIC NERVE BLOCKS**—Howard L. Rosner, MD, Medical Director, Cedars-Sinai Pain Center, Los Angeles, CA

**Purpose of injections:** elucidate pain generator; predict treatment outcomes; reduce pain; understand purpose before injection

**Components of pain:** neuropathic; radicular; somatic; axial; all overlap; multiple sources of pain make diagnosis difficult

**Anatomic pain generators in spine:** anterior compartment (eg, vertebral body; endplates; intervertebral discs; sympathetic chains); middle compartment (spinal cord; nerve roots; central canal; foramina); posterior compartment (z-joint; supporting ligaments and musculature)

**Diagnostic procedures:** nerve blocks intended to determine pain generator, eg, cervical radicular vs z-joint problems; *be specific*—about diagnostic procedure being ordered; *types of diagnostic procedures*—medial branch nerve block; selective nerve root block; discography; hardware injections; sympathetic chain blocks; each assists in removing one component of pain; *involve patient*—in assessment of diagnosis immediately after procedure; *injection*—local anesthetic most important component (higher concentrations often used)

**Prognostic procedures:** allow surgeon or patient to predict results of more definitive procedure; *be specific*—tell patient and injector purpose of procedure; *types of procedures*—medial branch block to determine whether fusion or medial branch rhizotomy appropriate; selective nerve root blocks; trigeminal ganglion block (gives patient idea of how half-numb face would feel after trigeminal rhizotomy); *injection*—very small doses of local anesthetic

**Therapeutic procedures:** to relieve pain (either temporary or curative); *be specific*—about purpose of procedure; *types of procedures*—intra-articular facet joint injections for inflammation; combine selective nerve root blocks for radicular pain with therapeutic epidural injections; sympathetic chain blocks; *injection*—steroid; botulinum toxin; alcohol; phenol; low concentration of local anesthetic

**UPDATE ON SPINAL CORD STIMULATION**—Christopher J. Zarebinski, MD, Director, Acute Pain Services, Cedars-Sinai Pain Center, Los Angeles, CA

**Possible mechanism of action:** 1) allodynic animals have lower extracellular levels of  $\gamma$ -aminobutyric acid (GABA); spinal cord stimulation may involve increased dorsal horn inhibitory action of GABA; intrathecal baclofen (GABA agonist) produces augmentation of spinal cord stimulation; 2) intrathecal adenosine receptor agonists also potentiate spinal cord stimulation; 3) suppression of sympathetic activity via

$\alpha$ -adrenal receptors; calcitonin-gene-related peptide induces vasodilation, which may explain redistribution of coronary blood flow from regions of normal perfusion to areas of impaired myocardial perfusion

**Anatomy:** paresthesias tend to diminish with thickening of dorsal cerebrospinal fluid (CSF) layer

**Terminology:** *cathode*—negative charge; increases sodium permeability; *anode*—positive charge; shapes field

**Indications for spinal cord stimulation:** neuropathic pain with unilateral monoradicular distribution (most likely to respond; radicular pain responds better than axial pain); peripheral vascular disease (ankle brachial pressure index useful marker for following patients); phantom limb pain; stump pain; complex regional pain syndromes; ischemic heart disease

**Outcome findings:** reduced pain; decreased analgesic use (40%-80%); enhanced activities of daily living (60% improvement); return to work (25% of patients); decrease in effectiveness over time (in 20%-40% of patients)

Cost-effectiveness: paid for itself in  $\approx 2$  yr when effective

**Devices:** new rechargeable implantable pulse generator (IPG); has longer life than primary cell IPG; 3-ft programming range; neuronavigation (new software programs); *main competitors*—Advanced Neuromodulation Systems (ANS); Medtronic; Precision device from Advanced Bionics (volume and weight  $\approx 50\%$  lower); *spacing of leads*—6 mm standard spacing; leads with 4-mm and 1.5-mm spacing now available; narrower lead spacing produces deeper paresthesia; wide spacing produces shallow stimulation; *single-lead guarded array*—cathode surrounded by anodes allows more focused direction of energy; may lead to

### Educational Objectives

The goal of this program is to enable orthopaedists to implement recent advances in spinal surgery. After hearing and assimilating this program, the surgeon will be better able to:

1. Identify components of disc pain and anatomic generators of spinal pain.
2. Select diagnostic, prognostic, and therapeutic procedures for lumbar disc pain.
3. Recognize indications for spinal cord stimulation.
4. Explain how functional anesthetic discography differs from provocative discography.
5. Incorporate new approaches for disc repair focusing on the center of the disc, including potential use of growth factors and gene therapies.

more effectiveness for axial pain; *under development*—magnetic resonance imaging (MRI)-compatible hardware; antimicrobial coating; smaller batteries

**DISCOGRAPHY ISSUES AND PERSPECTIVES**—Avrom Gart, MD, Director of Physical Medicine and Rehabilitation, Cedars-Sinai Institute for Spinal Disorders, Los Angeles, CA

**Introduction:** since discography depends on patient and person performing test, results can vary; provocative discography provides diagnostic tool to help assess discs as potential pain generators in patients with neck, middle, and lower back pain; needle placed inside disc to provoke pain; patient then asked whether pain same as customary pain (concordance); correlation between annular disruption and concordance based on level of annular disruption (*eg*, concordance lower with grade-1 annular disruption than full-thickness annular fissure that leaks); *compared to MRI*—substances leaking out of disc onto nerve root can cause radiculopathy and denervation without frank compression of disc

**Principles of discography:** *measures pressure*—opening, distending, and closing pressures; pressure when patient first feels pain; *needle placement*—extrapedicular approach with 22- or 25-gauge needle (use smallest needle to minimize damage to nerve roots and disc); *control necessary*—study invalid without control (negative) disc; report showing multiple levels of pain indicates need for psychologic assessment; *patient's role*—must be fully awake and cooperative; deep local anesthesia often preferable

**Aspects of discography:** *manometry*—standard for measuring lumbar intradiscal pressure; not used in cervical and thoracic regions; important not to overpressurize or use large volume; *discography report*—should identify positive and negative levels, opening pressure, and control level; positive results followed with computed tomography (CT; for more detailed anatomic analysis); *causes of false positives*—injecting contrast too quickly, causing pressure spike; psychosocial distress; *surgical outcomes*—no significant difference between discography and MRI

**FUNCTIONAL ANESTHETIC DISCOGRAPHY**—Harvinder S. Sandhu, MD, Associate Professor of Orthopaedic Surgery, Weill Cornell Medical College, and Director, Spine and Scoliosis Fellowship, Hospital for Special Surgery, New York, NY

**Current diagnostic tools:** most degenerative disc disease asymptomatic; goal to diagnose few symptomatic discs; based today on x-rays, CT, MRI, and discography; MRI, CT, and x-ray can image degenerated disc but not identify pain

**Discography:** best tool for diagnosing painful degenerated disc; *inherently flawed*—depends on subjective component; requires reliable, discerning, and honest patient (patient asked whether pain from discography same as usual pain); unable to distinguish multiple causes for pain, *eg*, sacroiliac pain and disc pain; data reveal almost 30% rate of misdiagnosis (often false

positives); trial results demonstrate good surgery, but pain often unresolved

**Functional anesthetic discography:** rather than provoking pain, diagnosis made by relieving pain; rather than lying down, patient stands and performs activities during test; provides access to disc over extended period; patient able to reproduce postural pain, *eg*, swinging golf club; dual-lumen catheter with on-off switch anchored in disc space; differentiates disc pain from other sources of pain; gives patient idea of potential pain relief

**DISC REPAIR**—Alexander R. Vaccaro, MD, Professor of Neurosurgery and Orthopaedic Surgery, Thomas Jefferson University School of Medicine, and Co-Director, Regional Spinal Cord Injury Center of Delaware Valley, Philadelphia, PA

**Introduction:** “nothing costs more than a failed open spinal procedure”; 90% of costs in spine surgery expended on 5% to 20% of patients with poor outcomes

**Recent focus on disc:** attempt to understand nucleus pulposus and outer lining; *center of disc*—contains few cells; rich in proteoglycans; has poor nutrition (no blood vasculature permeates disc in adults); notochordal cells present until 10 yr of age replaced by nucleus pulposus cells and phenotypic chondrocyte-like cells; *outer portion of disc*—fibroblasts form annulus fibrosus; thought to be source of much pain innervation; *lack of nutrition*—makes disc immune privileged; may lead to degeneration of disc over time; purpose of few cells in disc to make matrix and give it water-binding capacity

**Causes of degeneration:** genetics primary cause; nutrition unable to penetrate center of disc (oxygen low; glucose levels decline); cigarette smoking (smoking cessation relieves 20% of pain); certain activities, *eg*, riding in truck for long periods

**Treatment goals:** to develop ability to inject agent into disc before instability develops; bone morphogenic protein (BMP)-7 currently being injected into disc on investigative basis; BMP-7 intended to increase water binding capacity and restore mechanical properties; aim to promote synthesis and negate catabolism within disc

**Therapeutic options being investigated:** include protein therapies (*eg*, BMP), gene therapies, and cell therapies; gene therapy seeks to have body produce own proteins by replacing gene with therapeutic gene (would increase production of metabolites and growth factors); speaker's laboratory investigating transformation of mesenchymal stem cells into nucleus pulposus cells

**GROWTH FACTORS**—Dr. Vaccaro

**Current status:** *growth differentiation factor (GDF)-5*—originally called BMP-14 when released by DePugh (name changed because term BMP patented); presently called *radotermin* by World Health Organization; *transforming growth factor-beta (TGF- $\beta$ ) super-family*—all BMPs included; BMPs expressed in early limb development; induces differentiation of

cartilage, bone, tendon, and ligament; recombinant production through bacterial fermentation; 9 BMPs now identified

**Commercial products:** 2 studies looking at acute tibial fracture and nonunion, and interbody fusion with GDF-5; Helos brand name for GDF-5 with collagen and hydroxyapatite coating now available to surgeons; different companies have own carriers; BMP-2 available in noncompressible carrier; *optimal carrier*—noncompressible, 3-dimensional, with appropriate porosity and interconnectivity; would allow

slow elution of growth factor over time; under investigation; *current problem*—BMP “goes places it shouldn’t go”; *eg*, BMP permeated intertransverse ligament, causing ossification and significant disability

**Speaker’s study:** using BMP-2 in transforaminal interbody fusion; hopes to avoid problem of substance eluting over time into epidural space; *results*—interbody space heals predictably; posterolateral heals poorly; response improves with increasing dose; with 1-mg dose, success rate ≈80% in posterolateral gutter; performed better than allograft-to-bone

### Suggested Reading

**Boas RA:** Nerve blocks in the diagnosis of low back pain. *Neurosurg Clin N Am* 2:807, 1991; **Burkus JK et al:** Influence of rhBMP-2 on the healing patterns associated with allograft interbody constructs in comparison with autograft. *Spine* 31:775, 2006; **Burkus JK et al:** Use of rhBMP-2 in combination with structural cortical allografts: clinical and radiographic outcomes in anterior lumbar spinal surgery. *J Bone Joint Surg Am* 87:1205, 2005; **Collins HR:** An evaluation of cervical and lumbar discography. *Clin Orthop Relat Res*:133, 1975; **Foletti A et al:** Neurostimulation technology for the treatment of chronic pain: a focus on spinal cord stimulation. *Expert Rev Med Devices* 4:201, 2007; **Haque R et al:** Spinal nerve root stimulation. *Neurosurg Focus* 21:E4, 2006; **Hidaka C et al:** Gene therapy for spinal applications. *Orthop Clin North Am* 33:439, 2002; **Huang RC et al:** The current status of lumbar total disc replacement. *Orthop Clin North Am* 35:33, 2004; **Jonsson B et al:** Symptoms and signs in degeneration of the lumbar spine. A prospective, consecutive study of 300 operated patients. *J Bone Joint Surg Br* 75:381, 1993; **Khan SN et al:** Bone morphogenetic proteins: relevance in spine surgery. *Orthop Clin North Am* 33:447, 2002; **Lee AW et al:** Spinal cord stimulation: indications and outcomes. *Neurosurg Focus* 21:E3, 2006; **Mink JH et al:** Spinal imaging and intervention: 1998. *Phys Med Rehabil Clin N Am* 9:343, 1998; **Sandhu HS et al:** BMPs and gene therapy for

spinal fusion: summary statement. *Spine* 28:S85, 2003; **Sandhu HS et al:** Recombinant human bone morphogenetic protein-2: use in spinal fusion applications. *J Bone Joint Surg Am* 85, 2003; **Sandhu HS:** Bone morphogenetic proteins and spinal surgery. *Spine* 28:S64, 2003; **Suzuki A et al:** A biodegradable delivery system for antibiotics and recombinant human bone morphogenetic protein-2: A potential treatment for infected bone defects. *J Orthop Res* 24:327, 2006.

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#### Estimated time to complete the educational process:

Review Educational Objectives on page 1	5 minutes
Take pretest	10 minutes
Listen to audio program	60 minutes
Review written summary and suggested readings	35 minutes
Take posttest	10 minutes

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On a Test and Evaluation form, complete Pretest section *before* listening and Posttest section *after* listening.

1. Which of the following is the most important component of the diagnostic nerve block injection?
 

(A) Steroid	(C) Local anesthetic
(B) Botulinum toxin	(D) Alcohol
  
2. While higher concentrations of local anesthetic are often used for \_\_\_\_\_ nerve blocks, a low concentration of local anesthetic is indicated for \_\_\_\_\_ procedures.
 

(A) Diagnostic; therapeutic	(B) Therapeutic; diagnostic
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3. The best response to spinal cord stimulation can be expected in the patient with:
 

(A) Phantom limb pain	(C) Peripheral vascular disease
(B) Stump pain	(D) Unilateral monoradicular neuropathic pain
  
4. In spinal cord stimulation, wide lead spacing produces shallow stimulation, while narrower lead spacing produces deeper paresthesia.
 

(A) True	(B) False
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5. Discography measures which of the following?
 

(A) Opening and closing pressures	(C) Pressure at which patient first feels pain
(B) Distending pressure	(D) A, B, and C
  
6. Disadvantages of discography include which of the following?
  1. Dependence on subjective component
  2. Inability to distinguish multiple causes of pain
  3. Requirement for reliable, discerning, and honest patient
  4. High rate of false-positive diagnoses
  5. Pain during procedure

(A) 1,3,4	(B) 2,5	(C) 2,4,5	(D) 1,2,3,4,5
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7. In functional anesthetic discography, the diagnosis is made by relieving pain, rather than by provoking pain.
 

(A) True	(B) False
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8. Identify the *incorrect* statement about intervertebral discs.
 

(A) Center of disc rich in proteoglycans but contains few cells
(B) Nucleus pulposus has rich vasculature
(C) Discs are immune privileged
(D) Anulus fibrosus thought to be source of pain innervation
  
9. Which of the following is the primary cause of disc degeneration?
 

(A) Poor nutrition in disc
(B) Cigarette smoking
(C) Certain activities, <i>eg.</i> riding in truck for long periods
(D) Genetics
  
10. Which of the following avenues for promoting synthesis within a degenerated disc is now commercially available to the surgeon?
 

(A) Anticatabolic factors	(C) Growth factors
(B) Limb mineralization factors	(D) Transcription factors

Answers to Audio-Digest Orthopaedics Volume 30, Issue 04: 1-C, 2-D, 3-D, 4-A, 5-D, 6-C, 7-A, 8-B, 9-D, 10-B