Spinal Injections for Pain Management

Image-guided spinal injection is commonly performed in symptomatic patients to decrease pain severity, confirm the pain generator, and delay or avoid surgery. This article focuses on the radiologist as spine interventionist and addresses the following four topics relevant to the radiologist who performs corticosteroid injections for pain management: (a) the rationale behind corticosteroid injection, (b) the interaction with patients, (c) the role of imaging in procedural selection and planning, and (d) the pearls and pitfalls of fluoroscopically guided injections. Factors that contribute to the success of a pain management service include communication skills and risk mitigation. A critical factor is the correlation of clinical symptoms with magnetic resonance (MR) imaging findings. Radiologists can leverage their training in MR image interpretation to distinguish active pain generators in the spine from incidental abnormalities. Knowledge of fluoroscopic anatomy and patterns of contrast material flow guide the planning and execution of safe and effective needle placement.

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Online supplemental material is available for this article.
In 1930, epidural anesthetic injection was described in the treatment of sciatica (1). Epidural steroid injection (ESI) was first performed in the 1950s, it evolved as a therapeutic option during the 1960s, and it became a cornerstone in the management of low back pain and sciatica in the 1970s (2–6). During these decades, needle placement and injection site depended on palpated landmarks and loss-of-resistance techniques. In the 1980s and 1990s, radiologists and anesthesiologists began to use fluoroscopy to determine the accuracy of caudal and interlaminar needle placement, and they used epidurography to understand patterns of injectate flow. They found needle misplacements in 25%–38% of blind procedures performed by experienced injectionists (7–9). Epidurography was necessary to confirm injectate location and to exclude intravascular or intrathecal administration (10–13).

Computed tomography (CT) and magnetic resonance (MR) imaging spurred growth in intervention by revolutionizing the noninvasive diagnosis of pain generators (14,15). When spinal stenosis, disk herniation, and facet arthropathy correlated with symptoms, they were targeted for therapeutic interventions. When the correlation was uncertain, they were targeted for a systematic series of diagnostic interventions. ESIs shifted from caudal routes performed blindly to lumbar and cervical routes directed at the imaging abnormalities and presumed pain sources (16). As fluoroscopic techniques evolved, facet injection, nerve root block (NRB), and discography were added to lumbar and cervical ESIs (17).

During the 1980s and 1990s, utilization data showed dramatic volume growth as spinal interventions gained widespread acceptance (18,19). Lumbar ESI rates for spinal stenosis increased 300% within 2 decades (from 1994 to 2011) (20–23). By 2010, more than 2.2 million lumbar ESIs were performed yearly in Medicare patients (21). Facet injections surged 147% from 1993 to 1999 and increased another 300% from 1998 to 2006 (23–26). Medicare payments for spinal injections expanded 629% from 1994 to 2001 (23). Before 2000, anesthesiologists performed the majority of injections (20). By 2007, procedures were performed by anesthesiologists (49%), physiatrists (25%), family practitioners (12%), orthopedists (6%), and radiologists (3%) (27). Within the pain management domain, a small percentage of providers performed a disproportionately high percentage of spinal inter-ventions (22,23,26,27).

Overuse led to the scrutiny of therapeutic outcomes and the publication of contradictory articles that defended or criticized injections depending on the interests of the authors (16,26,28–38). Epidemiologists tended to focus on long-term outcomes and surgical end points. Injectionists focused on short-term outcomes, accepting the fact that interventions could modulate but not cure the underlying cause of symptoms. Research studies remain difficult to compare due to disparate symptoms (back pain vs radiculopathy), diagnoses (spinal stenosis vs disk herniation), injection types (interlaminar vs transforaminal), procedural techniques (blind injection vs fluoroscopic guidance), patient demographics, pharmaceutical agents, and drug doses (7,30,32–34,39–41).

Corticosteroid Properties

Corticosteroids are powerful anti-inflammatory medications. The rationale for administration is the suppression of inflammation implicated in the pathogenesis of radiculopathy and axial pain (42). Inflammation as a generic physiologic response can be triggered by numerous stimuli. In disk herniation and spondylolisthesis, radiculopathy results from both chemical and mechanical irritants (43–45). Phospholipase A2 and other enzymes are released into the epidural space by disk material and annular tear. These inflammatory mediators recruit macrophages that secrete cytokines and catalyze the inflammatory cascade; they produce prostanoids and leukotrienes that sustain the inflammatory cycle (46). Mechanical nerve root stretching, tethering, and compression provoke...
Interaction with Patients

Structured interactions promote trust and build patient-physician relationships that can last for years in individuals who suffer from chronic neck or back pain and who return for periodic injections. In my practice, these interactions are important because patients relay their positive and negative experiences to referring physicians. These interactions also create rewarding opportunities for radiologists to counsel patients and affect clinical decision making. Patients actively seek the perspective of nonsurgeons. Radiologists should understand the treatment options and lifestyle modifications that help patients stay active.

During procedural visits, I engage patients at four junctures to obtain or convey information. These purposeful interactions can be categorized as the interview, the blow-by-blow, the teachable moment, and the discharge.

In April 2014, the Food and Drug Administration (FDA) posted a safety announcement requiring manufacturers to add a warning in package inserts about adverse neurologic events (59). In that same posting, the FDA stated: “Injecting corticosteroids into the epidural space of the spine has been a widespread practice for many decades; however, the effectiveness and safety of the drugs for this use have not been established, and FDA has not approved corticosteroids for such use.” Several professional societies responded to this FDA safety announcement, expressing concern that the FDA warning did “not differentiate between the risks and benefits of transforaminal versus interlaminar routes of administration, and particulate versus non-particulate formulations of steroids” (60).

Numerous factors influence the choice of injected corticosteroid, including FDA warnings, published articles, recommendations from specialty societies, and package inserts. Data from these varied sources may be contradictory, requiring judgments on safety and efficacy based on personal experience, the regulatory environment, and the availability of drugs in the hospital formulary.
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figure 2

cervical structures and needle placement for nrb. (a) schematic drawing of the supine cervical spine depicts cross-sectional relationships of structures in the spinal canal and foramina. Radicular and segmental medullary arteries are too small to identify with mr imaging. in cervical nrb, needle placement is posterior to great vessels and nerve plexus. the needle targets the foramen posteriorly and inferiorly in close proximity to the exiting nerve and dorsal root ganglion (+). as = anterior scalene muscle, ca = carotid artery, jv = jugular vein, ms = middle scalene muscle. (b) ct angiographic image at c5–6 disk level shows posterior location of the jugular vein (jv). a graphically depicted needle (nrb) is overlaid at 45° and shows superimposition on the external jugular vein (ej). to shift the great vessels from the needle path during cervical nrb, turn the head away from the symptomatic side. lateral approach may be necessary when mr imaging reveals great vessels in a posterior location. enhancing vessels (arrows) surround nerve root ganglia (+) in foramina. ca = carotid artery, va = vertebral artery.

the interview

the patient interview is critical in procedural selection and planning. i have four goals: (a) obtain a focused clinical history, (b) correlate symptoms with imaging findings, (c) approve the requested procedure or propose a different one, and (d) obtain written informed consent. in new patients, these goals often can be accomplished within 10 minutes. in returning patients, less time is required because usually little has changed and previously successful procedures can be repeated. it only takes a few questions to determine the outcome of the prior injection and reestablish the pain generator.

during history taking, one should focus on spine-related symptoms. systematic questioning (fig 3) quickly yields enough clinical information to guide the targeted inspection of imaging studies and the formulation of a treatment plan (correlation of symptoms and imaging findings is addressed in the next section). begin with the discrimination of axial pain from radiculopathy. when leg and back pain coexist, ask which one is predominant. most patients would be willing to live

first interaction, the interview, focuses on clinical history and incorporates the consent process. the second and third interactions, the blow-by-blow and the teachable moment, respectively, take place during and immediately after the intervention while the patient lies on the fluoroscopy table. the final interaction, the discharge, occurs once the patient is dressed and is waiting to leave.
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symptom-imaging correlation), and procedural selection. Explain the procedure, and educate the patient about risks. It may be necessary to disclose that the FDA has not approved corticosteroids for epidural administration. Besides fulfilling ethical and regulatory requirements, the consent process should uncover clinical conditions, medications, and allergies that increase risk and compromise outcome. The major issues are anticoagulation therapy, active infection, and contrast material reaction. When you are describing bleeding and infection risks, ask about anticoagulant and antibiotic treatments. Inquire about latex allergy, diabetes, and other recent steroid injections. In my practice, our administrative assistant screens patients prior to the procedure to avoid the discovery of unresolved issues, such as anticoagulation therapy, in the fluoroscopy suite.

The Blow-by-Blow

Occasionally, patients refuse to receive information during the procedure. As a coping strategy, they wear headphones to listen to music, or they prefer silence, choosing to mentally transport themselves to another place. However, most patients want to know what is happening and value a blow-by-blow narrative. The blow-by-blow serves several purposes. Patients feel connected and informed. It relieves anxiety and eliminates the element of surprise. It conveys forward progress. Verbal communication also engages the technologist, fellow, and any other individuals involved in the procedure. My custom is to announce when I am deciding where to insert the needle, putting a dot on the skin with a marker, cleaning the skin, preparing the medications, numbing the skin, positioning the needle, and injecting dye to make sure the needle is in the right place. I express my satisfaction with needle placement before I inject the steroid solution. During injection, I warn patients that the injection could cause pressure or pain. When concordant symptoms are produced, I reassure patients and state that the needle is correctly placed. Patients appreciate knowing that the procedure is going as expected.

Figure 3

<table>
<thead>
<tr>
<th>Q: Where is your pain? Is it mostly in your leg or back?</th>
</tr>
</thead>
</table>
| A: LEG PAIN
| Q: Is your pain on one side or both sides? |
| A: unilateral or mostly unilateral
|  - obtain dermatomal information if pain is radicular |
| Q: Is the pain in front (L3, L4), side (L5) or back (S1) of thigh? |
|  - specificity is increased when pain radiates below knee |
| Q: Does it pass
|  - from front of thigh into inner calf (L3)? |
|  - over kneecap to shin and instep (L4)? |
|  - from outer calf to top of foot and middle toes (L5)? |
|  - from back of calf into heel and outside part of foot (S1)? |
| Imaging correlation: disk herniation, foraminal stenosis, facet cyst |
| Intervention: NRB, facet cyst rupture |
| A: bilateral and equal |
|  - obtain dermatomal information if pain is radicular |
|  - explore signs of neurogenic claudication |
| Q: Is pain worse with standing and walking? |
| Q: Is pain relieved by sitting or bending forward? |
| Imaging correlation: spinal or foraminal stenosis, segmental instability |
| Intervention: ESI, bilateral NRB |

A: BACK PAIN

| Q: Is your pain midline, on one side or both sides? |
| A: midline
|  - explore signs of Bastrup syndrome |
| Q: Do you have midline point pain and tenderness? |
| Imaging correlation: interspinous edema, fluid |
| A: lateralizing |
|  - explore signs of facet syndrome, Bartolotti syndrome |
| Q: Do you have paraspinal point pain and tenderness? |
| Imaging correlation: facet arthropathy, lumbosacral pseudoarthrosis |
| A: bilateral |
|  - explore signs of facet syndrome |
| Q: Does the pain radiate into buttock, groin or posterior thigh? |
| Q: Is pain worse with prolonged standing? |
| Q: Is pain worse with extension-rotation movements? |
| Imaging correlation: facet arthropathy, spondylolysis, discogenic edema |
| Intervention: ESI, facet (pars) injection, trigger point injection |

A: BOTH LEG AND BACK PAIN

| Q: If you had to choose, which one would you want me to treat? |
| A: depending on answer, follow questioning above |
| Imaging correlation: spinal or foraminal stenosis, segmental instability |
| Intervention: ESI, NRB, facet injection, trigger point injection |

Figure 3: Flowchart shows interview questions to be asked during history taking. A = answer, Q = question.

with the lesser pain if the major pain could be relieved.

Radicular symptoms often enable one to verify the pain generator during imaging correlation. In contrast, nonspecific axial pain poses diagnostic challenges. It can be acute or chronic, mild or severe, intermittent or constant, dull or sharp, localized or migratory, or any combination thereof. Patients often point to a general region in the neck or low back. Clinical history and physical examination have limited value in determining the cause of axial pain and guiding procedural selection (61).

Informed consent follows history taking, correlation of symptoms with imaging findings (hereafter, symptom-imaging correlation), and procedural selection. Explain the procedure, and educate the patient about risks. It may be necessary to disclose that the FDA has not approved corticosteroids for epidural administration. Besides fulfilling ethical and regulatory requirements, the consent process should uncover clinical conditions, medications, and allergies that increase risk and compromise outcome. The major issues are anticoagulation therapy, active infection, and contrast material reaction. When you are describing bleeding and infection risks, ask about anticoagulant and antibiotic treatments. Inquire about latex allergy, diabetes, and other recent steroid injections. In my practice, our administrative assistant screens patients prior to the procedure to avoid the discovery of unresolved issues, such as anticoagulation therapy, in the fluoroscopy suite.
The Teachable Moment
The teachable moment begins immediately after needle removal while washing off the skin antiseptic. To set positive expectations, state that the goal of the procedure was achieved (ie, the steroid was delivered to the intended target). Indicate the rationale for injecting the steroid. Explain that the steroid works by decreasing inflammation, not by shrinking the disk herniation, reversing arthritis, or opening stenotic spinal canals. Patients should understand that the drug is a powerful anti-inflammatory agent but that the degree of pain relief depends on whether inflammation is causing the symptoms. In patients who might benefit from seeing the fluoroscopic images, reinforce the technical success of the procedure by pointing out needle placement and contrast material flow on the monitor.

The Discharge
The discharge process generates information about immediate pain response. Symptoms might be decreased, unchanged, or increased depending on the level of preprocedural pain and the volume of injected anesthetic. Prompt pain relief creates a positive attitude about the procedure and promotes the placebo effect. A surprising number of patients claim pain reduction even if no local anesthetic was injected. In dictated reports, record the postprocedural pain response (eg, right leg pain decreased from a score of 8 of 10 to a score of 2 of 10). If symptoms are improved at the time of discharge, I continue to set positive expectations by explaining to the patient that the steroid was mixed with anesthetic and, therefore, it is in the same correct location.

One must explain the time frame for steroid effectiveness and provide activity guidelines. Patients can become disappointed the day after injection if their pain remains unchanged. Because particles release the steroid gradually, it takes 2–3 days to reach full effectiveness. Advise patients to limit themselves to baseline levels of exercise and physical therapy for 4–6 days. Patients whose condition improves after 2–3 days are tempted to overdo it before the drug has reached full effectiveness, thereby stirring up inflammation that overwhelms the steroid and diminishes the overall treatment benefit.

Patients often ask how long the injection will help. The time course is surprisingly predictable in patients with chronic conditions, such as spinal stenosis and facet arthropathy. Symptoms decrease during the first 2–3 weeks after injection when the anti-inflammatory effects are strongest but return to baseline levels over the following 6–8 weeks as the particulate steroid dissipates. In patients with acute conditions, such as disk herniation and annular tear, the steroid can break the inflammatory cycle and relieve pain for more than 6–8 weeks. When new symptoms are superimposed on long-standing ones, such as acute radiculopathy superimposed on chronic low back pain, explain that corticosteroid injection may accelerate a return to the baseline condition. Steroid administration decreases the new reversible nociceptive pain but leaves the long-standing irreversible neuropathic pain unchanged.

Role of Imaging in Procedural Selection
Symptom-imaging correlation guides procedural selection and planning (Movie 1 [online]). It enables one to verify the appropriateness of the requested intervention or justify modification. Procedural modification is most practical when the radiologist has authorization to proceed independently. For the radiologist who possesses the skill, experience, and confidence to assume responsibility for treatment decisions and, therefore, therapeutic outcomes, the role in pain management expands beyond rote injection.

Imaging results are available in the majority of cases. During screening, our administrative assistant asks patients to bring their MR images if they were obtained at a different institution. On rare occasions, we proceed without the benefit of symptom-imaging correlation.

Procedural selection begins with a judgment on the pain generator. The following symptom-imaging correlation exercise is popular with our fellows because it hones skills in both history taking and MR image interpretation. The exercise has two variations. In one variation, we interview the patient before we review the MR images. We then deduce the most likely pain generator and predict the MR imaging findings. In the other variation, we review the MR images before we interview the patient, then we deduce the most likely pain generator and predict the patient’s symptoms. Symptom-imaging correlations are often obvious, but surprising mismatches do occur. These mismatches teach valuable nuances in pain management and MR image interpretation.

In younger patients with acute or subacute radiculopathy, dermatomal information serves to focus MR image review. Symptoms usually correlate perfectly with nerve entrapment because of lateralization of single-level disk abnormalities. Occasionally, a symptom-specific search will lead to the diagnosis of an intraforaminal or lateral disk extrusion that explains symptoms but that was overlooked at the time of MR image interpretation (Fig 4). Transforminal NRB targets the pain generator and delivers the steroid directly to the inflamed nerve root (62–64) (Figs 5, 6).

In older patients with chronic unilateral radiculopathy, symptom-imaging correlation is more challenging because of multilevel spondylosis. Therapeutic success is also more challenging when severe stenosis causes irreversible nerve damage and neuropathic pain. Transforminal NRB remains a recommended treatment option if dermatomal information reveals a specific pain generator. One exception is nerve compression by a facet cyst. To address this problem, one can combine percutaneous cyst rupture with intra-articular corticosteroid injection (65) (Fig 7).

In older patients with chronic bilateral radiculopathy, the radiologist should solicit signs of neurogenic claudication. Intermittent back pain is precipitated by prolonged standing or
walking and is relieved by sitting or leaning forward. One should expect MR imaging to reveal spinal stenosis, which is the leading reason for spinal surgery (18). When MR imaging shows multilevel stenosis, dermatomal information may indicate the level of pain generator. Interlaminar ESI is the recommended procedure because the corticosteroid can spread cranially and caudally over multiple disk levels.

When symptoms suggest lumbar facet syndrome (posterior ramus syndrome), one must scrutinize the zygapophyseal joints for signs of inflammation, including effusion, capsulitis, and periarticular edema. Back pain may radiate into the buttocks, groin, or posterior thigh and may worsen with prolonged standing and extension and rotation or lateral bending movements (71). Sclerotomal maps for posterior rami depict the patterns of referred pain from facet joints but are less accurate than dermatomal maps for patterns of referred pain from ventral rami (72). Clinical history and physical examination findings cannot be used to predict treatment responses to facet injections (73). If corticosteroid administration alleviates symptoms, systematic anesthetic injections (medial branch blocks) yield corroborative diagnostic information prior to radiofrequency ablation.

Segmental instability creates multiple pain generators and causes debilitating symptoms that respond poorly to injections. Initially, when back pain predominates, symptoms may respond to ESI, facet injections, or a combination thereof. Progressive facet degeneration leads to articular hypermobility, attritional bone loss, and malalignment. Increasing anterolisthesis exacerbates spinal stenosis and foraminal nerve impingement. When neurogenic claudication and radiculopathy become superimposed on back pain, segmental instability often forces surgical intervention and spinal fusion.

In patients with chronic nonlocalizing low back pain, one must inspect disks and facets to judge the relative importance of discogenic and arthropathic abnormalities. The basic procedural alternatives are ESI and facet injection. These limited choices seem trivial enough, but decision making can be problematic due to overlapping clinical syndromes and equivocal MR imaging findings (66–68). Incidental MR imaging abnormalities in asymptomatic adults are difficult to discriminate from true pain sources in symptomatic patients (15,61,69,70). The default intervention is ESI. In the absence of MR imaging findings that support a different level of injection, the radiologist should select the L4–5 level because injectate typically flows cranially and caudally, and it will cover the three lowest mobile disk spaces.

Figure 4: Intraforaminal disk extrusion missed at prospective interpretation in a 41-year-old woman with acute L4 radiculopathy. Axial T2-weighted MR image shows unsuspected L4–5 intraforaminal disk extrusion (white arrowhead) causing mechanical impingement on left L4 nerve root ganglion (arrow). During NRB (not shown), the needle targeted the L4 ventral ramus peripheral to the foramen to avoid severe pain production due to foraminal stenosis and nerve root displacement. Right L4 nerve root ganglion (black arrowhead) is in its normal location and is surrounded by fat.

Figure 5: Lumbar NRB in a 64-year-old man with right leg pain correlating with L4–5 lateral recess stenosis and right L5 mechanical impingement. Anteroposterior fluoroscopic image in the prone position shows the needle (arrow) in supraneural location between L5 and S1 pedicles (+). Contrast material (arrowheads) flows cranially into the spinal canal along the L5 epiradicular space to the level of the L4–5 disk space and pain generator in lateral recess.
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2 [online]). Expert interventionalists develop individualized techniques and often approach the same problems and procedures in different ways. Some physicians prefer to use computed

finger. If this site corresponds to bone marrow edema or another potential pain generator on MR images, it can be targeted for diagnostic information and therapeutic response.

Pearls and Pitfalls of Fluoroscopy-guided Injections

The following pearls and pitfalls focus on fluoroscopy-guided injections (Movie 2 [online]). Expert interventionalists develop individualized techniques and often approach the same problems and procedures in different ways. Some physicians prefer to use computed
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During CT-guided procedures, because of the limitations of fluoroscopic guidance, conventional scanning is delayed until operators leave the room, intravascular contrast material washes away, thereby precluding vessel identification. Intermittent fluoroscopy, if performed before and after but not during contrast material injection, also fails to show opacified vessels (52,89). In mixed injections with concurrent intra- and extravascular contrast material flow, only the extravascular contrast material remains visible, creating the false reassurance of extravascular needle placement. Some authors have proposed the use of CT-fluoroscopic techniques to improve the real-time detection of opacified vessels (90–92). However, vessels outside of the limited stack of CT images remain impossible to identify.

A potential advantage of fluoroscopy is the range of detector rotation, which enables steep craniocaudal angulation. Steeper craniocaudal angles are often required in L5 and S1 NRBs, as well as in lumbar ESIs, in the setting of interlaminar collapse or exaggerated lumbar lordosis.

The advantages of both modalities can be attained with one unit that combines C-arm fluoroscopy with cone-beam CT (93,94). The flat-panel detector spins and acquires a volumetric data set enabling multiplanar two-dimensional reformations and three-dimensional reconstructions. Because the fluoroscopic image is overlaid onto the three-dimensional data set, the unit can align itself according to selected skin entry and target locations for bull’s-eye needle navigation. If necessary, final needle position and contrast material location are documented with a second volumetric acquisition.

Risk and Risk Mitigation

Adverse events are exceedingly rare when experienced practitioners use fluoroscopic guidance and inject contrast material to confirm needle position (16). In more than 8000 cervical, thoracic, and lumbar interventions performed by me or under my supervision, none have been complicated by hemorrhage, infection, or neurologic damage. Radiologists should recognize and manage immediate and delayed complications or perform patient triage for appropriate care. Adverse events can occur during injection (pain, hemorrhage, reaction to contrast material, vasovagal reaction, dural puncture, nerve or vessel damage), immediately after injection (pain, hemorrhage, extremity weakness, paresthesia), or days later (infection, headache, flushing reaction to steroid). Most adverse events can be avoided by anticipating risks discovered during history taking and image review.

Bleeding risk increases with age, underlying coagulopathy, severity of spondylolisthesis, and difficulty of needle placement (95). Although the incidence is unknown, bleeding risk increases in patients who have undergone anticoagulation therapy, and it increases substantially in patients taking multiple anticoagulant and antiplatelet medications, including nonsteroidal anti-inflammatory drugs (95). Epidural hematoma rarely occurs; however, it poses the greatest threat because of spinal cord or cauda equina compression, and it requires surgical evacuation to prevent permanent neurologic sequelae. Incidence has been estimated at 1:220000 after subarachnoid anesthesia and at 1:150000 after epidural anesthesia in healthy patients (96). Epidural hematoma has been described after ESI and facet injection in patients without coagulopathy or anticoagulation therapy (96). Patients should discontinue use of anticoagulants for appropriate intervals, and they should coordinate bridging therapy according to instructions from referring physicians or consulting cardiologists (97). ESI is considered safe in patients taking nonsteroidal anti-inflammatory drugs (98). In a study of 1214 patients who underwent ESI, no hemorrhagic complications occurred in 383 (32%) patients taking nonsteroidal anti-inflammatory drugs (98).

Iodinated contrast material should be approved for myelography in case of inadvertent intrathecal administration. One should recognize patterns of layering subarachnoid contrast to avoid saddle anesthesia and ascending paralysis from anesthetics and arachnoiditis from corticosteroids. Nearly 3% of scheduled...
patients have had known or suspected reactions to contrast material (16). In these patients, options include (a) premedication with oral prednisone and diphenhydramine, (b) steroid injection without contrast material confirmation of needle location, and (c) injection of a gadolinium-based contrast agent. Gadolinium chelates provide off-label alternatives to iodinated contrast material and appear safe for use in epidural injection (99). Intrathecal administration should be carefully avoided. Digital subtraction fluoroscopy may improve visualization of gadolinium-based contrast material, which is less radiopaque than iodinated contrast material.

Extensive arterial and venous networks crisscross the epidural and epidural radicular spaces of the spinal canal and neural foramina (Figs 1, 2, 8). Overall, intravenous needle placements are more common in patients with cervical NRBs (incidence range, 19.4%–32.8%) than in those with lumbar NRBs (incidence range, 11.2%–13.1%), but actual incidence depends on injection level (10–13). In the cervical spine, vascular cannulation is more likely from C3–4 to C5–6 (range, 40%–57%) (13). In the lumbosacral spine, it is more than twice as likely at S1 (21.3% incidence) compared to lumbar levels (8.1% incidence) (10–12). In both the cervical spine and the lumbar spine, aspiration fails to produce a flashback of blood in 45%–73% of intravenous needle placements subsequently proved via contrast material opacification (10,100).

Simultaneous intra- and extravascular contrast material flow (mixed injection) is observed more commonly than is intravascular flow alone in both cervical NRBs and lumbar NRBs (12,13). In the cervical spine, mixed injection was reported in 18.9% of injections as compared with vascular flow alone, which was reported in 13.9% of injections (13). Concurrent flow creates challenges because extravascular contrast material can obscure vessels. To best detect vessels, one should optimize fluoroscopic techniques by decreasing the field of view, dimming the lights, using digital subtraction angiography, and injecting contrast agents that contain a higher concentration of organic iodine (eg, 300 mg/mL).

Injected steroids have systemic glucocorticoid effects in addition to local anti-inflammatory effects. Fortuitous benefits include temporarily decreased pain from arthritis and spondyloarthropathy. Undesired consequences include elevation of the blood glucose level, suppression of the immune system, and suppression of the hypothalamic-pituitary axis. One should caution patients with diabetes to monitor their blood glucose levels for 7–10 days after the procedure. Ask patients about antibiotics they are taking, and reschedule patients who are taking antibiotics for active infections. Prophylactic antibiotics are not a contraindication. Repeated steroid injections at short intervals (less than 8 weeks for particulate preparations) can inhibit recovery of the hypothalamic-pituitary axis and can lead to decreased bone mineral density (101–103). Cushingoid symptoms, although rare, can persist for several months after steroid injections have been terminated (28,104).

Injectate composition and volume depend on numerous factors and vary widely between practitioners (Table). Choice of corticosteroid should take into account the risk of intravascular or intrathecal injection and, therefore, particle size and the addition of preservatives (benzyl alcohol) or vehicles (polyethylene glycol) (105,106). Corticosteroid particles may aggregate and form larger particles when mixed with local anesthetics and contrast agents containing certain preservatives (49,50).

Commonly used anesthetics include lidocaine, bupivacaine, and ropivacaine. Formulations with preservatives (methylparaben) and vasoconstrictors (epinephrine) should be avoided. Methylparaben is classified as an antimicrobial preservative, and it is added for its bacteriostatic activity. Choice of anesthetic should take into account patient health, pain severity, and postdischarge activities. Use anesthetics with caution in elderly or unsteady patients and in individuals who are planning to drive or take public transportation immediately after they are discharged. Patients with baseline weakness or paresthesia are more susceptible to anesthetic effects and may develop profound postprocedural weakness, even if only a small volume of anesthetic is administered.

Procedural Tips and Techniques

In the majority of spine procedures, patients are placed in the prone position. This position can exaggerate lumbar lordosis, aggravate nerve root entrapment, and provoke facet-related pain. Patient comfort is more important than perfect prone positioning, as the goal is to limit progressive discomfort and involuntary movement. Placement of a pillow under the pelvis can help to reduce lordosis and can relieve symptoms. Patients who cannot lie in the prone position may be able to tolerate
Drug Doses in Common Therapeutic Spinal Injections

<table>
<thead>
<tr>
<th>Injection Type</th>
<th>Dose</th>
</tr>
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<tbody>
<tr>
<td>Lumbar ESI</td>
<td></td>
</tr>
<tr>
<td>MGH protocol</td>
<td>BTM 15 mg (2.5 mL) followed by saline (2–4 mL) mixed with lidocaine 1% 0–10 mg (0–1 mL)</td>
</tr>
<tr>
<td>Published protocol†</td>
<td></td>
</tr>
<tr>
<td>Corticosteroid dose</td>
<td>MPA 40–120 mg (1–3 mL), TCA 60–120 mg (1.5–3 mL), BTM 9–18 mg (1.5–3 mL)</td>
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<tr>
<td>Anesthetic dose</td>
<td>Bupivacaine 0.25%–0.5% 15–40 mg (3–8 mL), lidocaine 0.5%–1.0% 15–40 mg (3–8 mL)</td>
</tr>
<tr>
<td>Saline volume</td>
<td>Saline 0–8 mL</td>
</tr>
<tr>
<td>Thoracolumbar transforaminal nerve root injection</td>
<td></td>
</tr>
<tr>
<td>MGH protocol at or above conus</td>
<td>DSP 8–12 mg (2–3 mL)</td>
</tr>
<tr>
<td>MGH protocol below conus‡</td>
<td>BTM 6–15 mg (1–2.5 mL) mixed with saline 1–2.5 mL &amp; lidocaine 1% 0–10 mg (0–1 mL)</td>
</tr>
<tr>
<td>Published protocols</td>
<td></td>
</tr>
<tr>
<td>Corticosteroid dose</td>
<td>MPA 20–80 mg (0.5–2.0 mL), TCA 20–40 mg (0.5–1.0 mL), BTM 6–9 mg (1.0–1.5 mL), DSP 4–8 mg (1–2 mL)</td>
</tr>
<tr>
<td>Anesthetic dose</td>
<td>Lidocaine 0.5%–1.0% 10–20 mg (1–4 mL), bupivacaine 0.25%–0.5% 5–20 mg (1–8 mL)</td>
</tr>
<tr>
<td>Cervical transforaminal nerve root injection</td>
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<tr>
<td>MGH protocol</td>
<td>DSP 8–12 mg (2–3 mL)</td>
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<td>Published protocols</td>
<td></td>
</tr>
<tr>
<td>Corticosteroid dose</td>
<td>DSP 4–12 mg (1–3 mL), BTM 6 mg (1 mL), TCA 40 mg (1 mL), MPA 40 mg (1 mL)</td>
</tr>
<tr>
<td>Anesthetic dose</td>
<td>Bupivacaine 0.25%–0.5% 2.5–5 mg (1 mL), lidocaine 0.5%–2.0% 5–20 mg (1 mL)</td>
</tr>
<tr>
<td>Lumbar or cervical facet injection</td>
<td></td>
</tr>
<tr>
<td>MGH protocol</td>
<td>TCA 40 mg (1 mL) mixed with ropivacaine 0.5% 5 mg (1 mL) or lidocaine 1% 10 mg (1 mL)</td>
</tr>
<tr>
<td>Published protocols</td>
<td></td>
</tr>
<tr>
<td>Corticosteroid dose</td>
<td>TCA 20–60 mg (0.5–1.5 mL), BTM 3–6 mg (0.5–1.0 mL), MPA 20–60 mg (0.5–1.5 mL)</td>
</tr>
<tr>
<td>Anesthetic dose</td>
<td>Lidocaine 1%–2% 5–20 mg (0.5–1.0 mL)</td>
</tr>
</tbody>
</table>

Note.—Medication and dose selections require physician discretion. BTM = betamethasone acetate, 3 mg/mL; MPA = methylprednisolone acetate, 40 mg/mL; TCA = triamcinolone acetonide, 40 mg/mL.

* Massachusetts General Hospital (MGH) protocols are routinely modified based on recommendations by specialty societies and consensus groups.

† Published protocols may not reflect current recommendations by specialty societies and consensus groups.

‡ Corticosteroid dose is proportionate to epidural flow.

imaging in the oblique or lateral decubitus position.

Fluoroscopic set-up can neutralize the challenges posed by lordosis, scoliosis, spondylolisthesis, and oblique patient positioning. By standardizing needle trajectory, even deformed spondylotic spines can be depicted in conventional anteroposterior, lateral, and oblique views at the level of injection. Set-up usually involves four systematic maneuvers. First, one must identify the level of intervention. Second, one must rotate the detector left-right to obtain a straight anteroposterior projection of the spine. Third, one must adjust the craniocaudal tilt to normalize endplate relationships. The final maneuver involves rotating the detector left-right to obtain a bull’s-eye projection for needle navigation. Fluoroscopy units that enable one to use saved positions allow rapid transition between different views.

One should archive fluoroscopic images to document the procedure, needle position, and contrast material distribution for billing and medicolegal purposes. Referring surgeons may review the images with patients and determine whether the steroid reached its intended target. In patients who have undergone repeated injections, the images provide templates for reproducing safe and effective needle placement. One should archive a minimum of two images. The first image, obtained before steroid delivery, shows extravascular contrast material. The second, obtained after steroid delivery, shows contrast material washout and proves that the steroid flowed into the same location as the contrast material.

Lumbosacral transforaminal injection.—The rationale for transforaminal NRB is precise drug delivery to the inflamed nerve root (Figs 5, 9). The epidural space, which is the target in needle placement, surrounds the ventral ramus. Because the epiradicular and epidural spaces are continuous, injectate flows selectively along the spinal nerve and nerve root into the spinal canal (Figs 5, 6). Transforaminal injection delivers the corticosteroid directly to the pain generator in the foramen or ventral epidural space. Thus, NRB can yield a superior therapeutic effect with a smaller corticosteroid dose than that used with interlaminar ESI (35,62–64,107). In ESI, the corticosteroid takes the path of least resistance, spreading indiscriminately from the dorsal epidural space throughout the spinal canal.

When the foramen is patent, intraradicular needle placement can be supraneural (subpediculate) or infraneural (retrodiskal) (Figs 10, 11). Select the supraneural location, the so-called safe triangle, for reliable epiradicular flow of...
the steroid along the nerve root to the next higher disk level (64) (Fig 5). The safe triangle is bounded by the pedicle superiorly, the exiting nerve medially, and the vertebral body anteriorly (64) (Fig 10). Veins, and sometimes the radicular artery, course through the safe triangle, explaining the frequency of vascular cannulation and the “unsafe triangle” moniker (108). Curved needles may have advantages over straight needles for evading vessels and navigating obstructions (eg, hypertrophic facet joints).

If veins compromise supraneural injection, reposition the needle inferiorly and posteriorly in the foramen. This infraneural approach targets the Kambin triangle and favors dorsal and caudal epidural flow (109). The Kambin triangle is bounded by the exiting nerve superiorly, the caudal vertebral body inferiorly, and the facet joint posteriorly. Infraneural placement is more likely to result in annulus fibrosus perforation and inadvertent discography (Fig 12). In patients with foraminal stenosis or lateral disk herniation, target the ventral ramus peripheral to the foramen to avoid severe pain production during injection and failed delivery of medication (Figs 4, 10).

NRB at S1 requires epidural needle placement and poses unique access challenges. Both transforaminal and transosseous techniques are feasible after excluding Tarloff cysts and dural ectasia during MR image review. The dorsal S1 foramen is constant in location and orientation but variable in caliber. When the foramen is narrow, transforaminal navigation can be difficult or impossible without meticulous fluoroscopic set-up (Fig 9). A curved needle (5°–10° along the distal centimeter) helps passage through a small angled foramen. Do not rotate a curved needle in the foramen because of the risk of lacerating vessels, including the lateral sacral artery. In patients with osteopenia, a 22-gauge straight needle can be used to penetrate sacral plates with a twisting or oscillating motion. Appropriate epidural depth is determined with lateral fluoroscopy. Trajectory cannot be altered once the needle is drilled through bone. The same transosseous technique can be used to advance a straight needle through a paraspinous fusion mass for lumbar NRB.

During most NRBS, expect injection to produce transient radicular symptoms. To avoid the overproduction of severe long-lasting pain, ask patients to control the injection rate. Explain that symptoms should not exceed 5–6 on a 0–10 pain scale. Patients indicate when to inject and when to pause. Patients are reassured by this degree of control; however, stoic individuals may request continued injection despite severe pain because they fear partial steroid dosing. Watch their faces for signs of discomfort, and observe their body language. If the injection rate is too slow, steroid particles can settle in the needle and clog it. When injection pressure unexpectedly increases, reinsert the stylet to clear the needle and reinject. When injection pressure unexpectedly increases, reinject. When injection pressure unexpectedly increases, reinsert the stylet to clear the needle and clog it. When injection pressure unexpectedly increases, reinject. When injection pressure unexpectedly increases, reinject. When injection pressure unexpectedly increases, reinject. When injection pressure unexpectedly increases, reinject. When injection pressure unexpectedly increases, reinject. When injection pressure unexpectedly increases, reinject.

NRB generates diagnostic information from pain provocation during needle placement, pain provocation during injection, immediate pain relief from the anesthetic, or delayed pain relief from the corticosteroid. In dictated reports, record the provocative response (pain production during injection) as concordant or nonconcordant and the immediate analgesic response (pain reduction after injection). Selective NRB is intended to yield only diagnostic information. An anesthetic, not a steroid, is injected. In selective NRB, the needle tip touches the ventral ramus peripheral to the foramen and provokes radicular pain that is assessed for concordance with typical symptoms. The volume of anesthetic is limited to avoid spread to nontarget nerves.
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Cervical transforaminal injection.— Cervical transforaminal injection is indicated in radiculopathy with or without axial neck pain. Injectionists may follow procedural protocols established by specialty societies, such as the Spine Intervention Society (or SIS) (100–116). The 2004 Spine Intervention Society practice guidelines for cervical NRB recommended intraforaminal positioning of the needle tip as deep as the midpoint of articular pillars but never deeper than a vertical line connecting the uncinate processes (117). After reports of catastrophic neurologic injuries from cervical NRBs, some investigators recommended intraforaminal needle placement (N1) in the safe triangle (s) or infraneural (I3) in the Kambin triangle (cross). At S1, the needle (N4) crosses the posterior S1 foramen and enters the epidural space inferior to the S1 pedicle.

Figure 10: Transforaminal lumbosacral needle placements. Schematic drawing of the lumbosacral spine shows coronal relationships of nerve roots, nerve root ganglia, and posterior spinal nerves. In stenotic foramina, extraforaminal needle placement (N1) targets ventral ramus peripherally. In patent foramina, needle placement can be supraneural (N2) in the safe triangle (s) or infraneural (N3) in the Kambin triangle (cross). At S1, the needle (N4) crosses the posterior S1 foramen and enters the epidural space inferior to the S1 pedicle.

Subtraction fluoroscopy, CT guidance, and nonparticulate corticosteroid administration. Others have questioned the benefit of cervical transforaminal injection with any technique, given the difficulty associated with visualization of small vessels, including the radicular artery (84,121,122).

To perform fluoroscopy-guided cervical NRB with an anterolateral approach, place the patient in the prone position and turn his or her head away from the side of injection to shift the carotid artery from the needle path. Trajectory modification may be necessary when MR or CT images show an unusually posterior carotid artery or tortuous vertebral artery (123). When MR images are unavailable for procedural planning, reschedule the injection or position the needle more posteriorly and peripherally than usual, especially in older individuals who might have tortuous arteries. Skip skin anesthesia in case the external jugular vein underlies the desired needle entry site.

Figure 11: Oblique fluoroscopic image shows the set-up for lumbar NRB. During anteroposterior fluoroscopy (images not shown), the detector was tilted craniocaudally to align the L5 pedicle with the caudal margin of the transverse process (thin curved line), to maximize the space between the L5 transverse process and the sacrum and to standardize osseous relationships for reproducible needle placement. The x-ray beam is parallel to the L5 superior endplate (arrows). The detector was rotated laterally to open supraneural (S) and infraneural (I) routes between the L5 transverse process, lateral facet border (thick curved line), and iliac wing (arrowheads). Degree of rotation depends on morphology of facet and iliac wing, desired needle placement relative to foramen, and straight versus curved needle technique. Straight needle technique requires direct trajectory and, therefore, greater detector rotation. A curved needle may improve navigation through narrow spaces and around hypertrophic facets.
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shown comparable short-term effects (116,124). Immediately after needle removal, decrease hydrostatic pressure and the likelihood of hematoma by having patients sit upright. Lumbar interlaminar epidural steroid injection.—Standardized fluoroscopic set-up helps to decrease needle manipulation, radiation dose, and overall procedure time (Figs 14, 15). In younger patients, copious epidural fat and wide interlaminar spaces facilitate successful needle placement. Insert the needle from the side with more severe symptoms, since injectate tends to spread more to the side of needle placement. In older patients, degenerative curvature, spondylotic deformity, interlaminar collapse, bony proliferation, and surgical changes create access challenges. In patients with rotatory nerve (Fig 13). Needle length depends on neck girth and target level, and it ranges from 1.5 to 2.5 inches. Remove any stylet and flush the 25-gauge needle with contrast material, filling the hub prior to insertion to obviate gas delivery. Direct the needle to the lateral margin of the articular pillars, switching between oblique and posteroanterior fluoroscopy to check the needle trajectory and depth. Document extravascular needle placement during contrast material injection with real-time anteroposterior fluoroscopy. Digital subtraction angiography may improve vessel detection (115). Exit veins by advancing the needle several millimeters. If needle advancement fails to result in vein exit, reposition the needle more caudally along the expected course of the target nerve. Short extension tubing (dead space, 0.4 mL) helps to avoid hand exposure during fluoroscopy and inadvertent needle motion during syringe exchange. Inject a nonparticulate corticosteroid. In the cervical spine, nonparticulate and particulate corticosteroids have

Figure 12: Inadvertent diskogram during NRB in a 51-year-old man with left L3 radiculopathy correlating with L3–4 intraforaminal disk extrusion. (a) Axial T1-weighted MR image at the L3–4 disk level shows a large left intraforaminal disk extrusion (arrowheads) displacing left L3 nerve (white arrow). Right L3 nerve (black arrow) location is normal and surrounded by fat. (b) Anteroposterior fluoroscopic image in the prone position. Curved needles are present on the left side at L3–4 and L4–5. At L3–4, infraneural (retrodiscal) needle (black arrowhead) punctured the disk annulus, resulting in intradiscal contrast (white arrowheads). Radiculax symptoms were immediately exacerbated due to distension of the herniation sac (arrow). L4–5 = L4–5 disk space.

Figure 13: Inadvertent C7 NRB during attempted C8 NRB in a 44-year-old man with right C8 radiculopathy correlating with C7-T1 intraforaminal disk extrusion. Anteroposterior fluoroscopic image in the supine position shows the needle (arrow) targets right C8 nerve at C7-T1 foramen. Pain provocation prevented further needle advancement. Needle trajectory was satisfactory, but the needle tip terminated peripheral to lateral masses (black lines), distant from the C8 nerve. Injected contrast material (arrowheads) flowed along nontarget C7 nerve into C6–7 foramen between C6 and C7 pedicles. Black ○ = pedicles from C6-T2.

Figure 14: Targeting midline posterior epidural fat in interlaminar ESI. Midline sagittal reformatted CT image of the lumbar spine and posterior epidural fat at L2–3 (white ∗) indicates safe zone for needle placement in ESI. As a general rule, dorsal epidural fat is most prominent between the bases of spinous processes (white line between black ∗ at L4 and L5) at the disk space level (intersection of white and black lines at L4–5). Needle (N) at L3–4 shows desired tip location in dorsal epidural fat. Needle trajectory projects cranial to disk level (black line at L3–4). In normal spines, L5-S1 has the least dorsal epidural fat.
Simulates epidurography, but injection pressure unexpectedly increases after administration of approximately 1 mL of the contrast agent. If lateral and anteroposterior images enable confirmation of interspinous, interlaminar, or facet joint opacification, advance the needle for epidural access. Epidurographic patterns vary considerably between patients and between time points in the same patient (127). Injectate takes the path of least resistance, collecting at the needle tip or spreading over multiple levels. It may flow cephalad or caudad, right or left, circumferentially around the thecal sac or transforaminally along a nerve root. The plica mediana dorsalis, a midline septum that anchors the dural membrane posteriorly, can divide the dorsal epidural space and restrict injectate flow unilaterally. Needle repositioning may be desirable if contrast material spreads contralateral to the side of symptoms. Always inject under low pressure.

Spinal stenosis and postoperative scoliosis, approach from the side of the convex curvature to shorten the needle throw (Fig 15). Should the needle tip catch on a lamina or spinous process, turn the bevel toward bone and twist or rock the needle gently until it slides off and advances. Steer away from asymmetrically thickened ligamentum flavum and facet synovial cysts. At the level of hemilaminotomy or hemilaminectomy, interlaminar access should be contralateral to the surgical bed to avoid peridural adhesions that increase risk of dural puncture.

A critical juncture approaches as the needle passes through the ligamentum flavum. Initially, when force is applied to the syringe plunger, high pressure prevents contrast material flow. Sudden loss of resistance usually means that the needle has reached the epidural space. Before making the final decision to inject the corticosteroid, carefully observe the contrast material distribution to exclude intravascular, intrathecal, retrodural, or intraligamentous spread. Assume intravascular injection until proven otherwise (Fig 8). In patients undergoing lumbar interlaminar ESI, the lateral view can show both vascular and intrathecal flow; however, the anteroposterior view best excludes vessels when lateral image quality is degraded due to body habitus. To evade vessels, advance the needle, redirect it, or reinsert it at a different level.

Intrathecal injection shows immediate dependent layering of contrast material in the subarachnoid space. After dural puncture, ESI can be attempted at a different level or terminated and rescheduled to avoid any possibility of complication due to intrathecal steroid and anesthetic administration. The retrodural space (retrodural space of Okada) can be recognized because it usually communicates with the interligamentous space (125,126). The intraligamentous space is associated with facet degeneration and ligamentum flavum delamination (125). In the lateral view, contrast agent distribution initially simulates epidurography, but injection pressure unexpectedly increases after administration of approximately 1 mL of the contrast agent. If lateral and anteroposterior images enable confirmation of interspinous, interlaminar, or facet joint opacification, advance the needle for epidural access.

Epidurographic patterns vary considerably between patients and between time points in the same patient (127). Injectate takes the path of least resistance, collecting at the needle tip or spreading over multiple levels. It may flow cephalad or caudad, right or left, circumferentially around the thecal sac or transforaminally along a nerve root. The plica mediana dorsalis, a midline septum that anchors the dural membrane posteriorly, can divide the dorsal epidural space and restrict injectate flow unilaterally. Needle repositioning may be desirable if contrast material spreads contralateral to the side of symptoms. Always inject under low pressure.

Spinal stenosis and postoperative

**Figure 15**

Fluoroscopic set-up for L4–5 interlaminar ESI. (a) After tilting the detector caudocranially during anteroposterior fluoroscopy (not shown) and projecting L4–5 interlaminar arch (thick curved line) above L4 inferior endplate (arrowheads), laterally rotate the detector 18°–22° to align the apex of the interlaminar arch between the bases of spinous processes (+). Interlaminar arch at target level should align with arches above and below (curved thin lines at L3-4 and L5-S1). Degree of detector rotation depends on scoliosis and rotatory curvature of spine. Align needle (arrow) between bases of spinous processes for midline needle placement in dorsal epidural fat. (b) Lateral fluoroscopic image shows the needle tip (arrow) enters dorsal epidural space at level of L4–5 disk (straight black line). Needle projects between L4 and L5 spinous processes (curved black lines). Ventral epidural contrast enhancement (arrowheads) is seen. (c) Anteroposterior fluoroscopic image shows midline placement of needle (arrow) between L4 and L5 spinous processes (+). Left paramedian approach was chosen because of asymmetric disk degeneration causing levoconvex curvature and right-sided interlaminar collapse.
peridural scarring can block free flow of the corticosteroid. When injectate pools locally at a stenotic level or between stenotic levels, anticipate pain production. Symptoms are usually transient when delivering small aliquots and dissipate after 20–30 seconds. When larger volumes are injected quickly, persistent leg symptoms limit delivery of the full dose and force early termination of the procedure. At levels of severe symptomatic spinal stenosis, ESI may exacerbate symptoms that require hospitalization for pain control despite prominent posterior epidural fat.

Transforaminal ESI is an NRB variant procedure intended to be semiselective in patients who have unilateral nonradicular symptoms and nonselective in patients who lack interlaminar access due to multilevel laminectomy, hardware, or bone graft. The goal of the procedure is diffuse epidural spread rather than nerve selectivity. Thus, foraminal patency is more important than the exact level of injection. Stenotic foramina should be avoided because of obstructed epidural flow. Although needle placement and initial flow patterns can be identical in transforaminal ESI and NRB, extra diluent disperses the corticosteroid in transforaminal ESI.

**Lumbar and cervical facet joint injection.**—In patients with early osteoarthritis, facet-related pain reflects synovitis or capsulitis and responds to corticosteroid injection. If the steroid breaks the inflammatory cycle, pain relief lasts longer than the drug lifespan. In patients with advanced osteoarthritis, irreversible cartilage loss limits treatment effectiveness. After 6–8 weeks, particular preparations will have dissipated and symptoms will have predictably returned. Hypertrophic facet degeneration can be managed with periodic injections or with medial branch radiofrequency denervation. Attritional degeneration poses a difficult problem due to the loss of bone stock, causing spondylolisthesis, stenosis, and segmental instability. Invariably, treatment effects do not last as long, or they become nonexistent.

Direct needles at cartilage interfaces or capsular recesses (Figs 7, 16). Fluoroscopic set-up should account for articular orientation, curvature, and degeneration (Fig 1). When osteophytes block the joint space or when listhesis deforms it, target capsular recesses to increase the likelihood of intra-articular needle placement. Periarticular corticosteroid injection may offer the same therapeutic benefits as intra-articular corticosteroid administration (31,128). Document the extra-articular leak of contrast material into a synovial cyst, intraligamentous cavity, or retrodural space (125,126,129). At lumbar levels, synovial cyst rupture is feasible by placing the needle into the facet joint with fluoroscopic guidance or directly into the cyst or facet joint with CT guidance (Fig 7). Facet joints communicate with pars defects; therefore, they can be used to deliver a steroid directly into the pseudoarthrosis (130) (Fig 16).

In the cervical spine, both lateral (joint space) and posterior (capsular recess) approaches are feasible. In posterior approaches, displace the mandible by turning the head opposite the symptomatic side. Place pillows under the chest to flex the neck and shorten needle distances. At lower cervical levels especially, decrease the throw by inserting needles perpendicular to the skin. When the needle touches bone, angle the detector parallel to the joint space and move the needle tip superiorly or inferiorly into the joint recess.

**Conclusion**

Spine intervention and pain management create rewarding opportunities for radiologists. Radiologists with appropriate training can take responsibility for treatment decisions and outcomes, helping patients delay or avoid surgery. These radiologists build patient-physician relationships, counseling patients with the goal of improving quality of life. Radiologists can leverage their expertise in MR image interpretation to...
correlate imaging findings with clinical symptoms and establish pain generators. They can use their knowledge of fluoroscopic anatomy to target those pain generators and plan safe and effective needle placement.

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