

## The risks of epidural and transforaminal steroid injections in the Spine: Commentary and a comprehensive review of the literature

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### Abstract

**Background:** Multiple type of spinal injections, whether epidural/translaminar or transforaminal, facet injections, are offered to patients with/without surgical spinal lesions by pain management specialists (radiologists, physiatrists, and anesthesiologists). Although not approved by the Food and Drug Administration (FDA), injections are being performed with an increased frequency (160%), are typically short-acting and ineffective over the longer-term, while exposing patients to major risks/complications.

**Methods:** For many patients with spinal pain alone and no surgical lesions, the "success" of epidural injections may simply reflect the self-limited course of the disease. Alternatively, although those with surgical pathology may experience transient or no pain relief, undergoing these injections (typically administered in a series of three) unnecessarily exposes them to the inherent risks, while also delaying surgery and potentially exposing them to more severe/permanent neurological deficits.

**Results:** Multiple recent reports cite contaminated epidural steroid injections resulting in meningitis, stroke, paralysis, and death. The Center for Disease Control (CDC) specifically identified 25 deaths (many due to Aspergillosis), 337 patients sickened, and 14,000 exposed to contaminated steroids. Nevertheless, many other patients develop other complications that go unreported/underreported: Other life-threatening infections, spinal fluid leaks (0.4-6%), positional headaches (28%), adhesive arachnoiditis (6-16%), hydrocephalus, air embolism, urinary retention, allergic reactions, intravascular injections (7.9-11.6%), stroke, blindness, neurological deficits/paralysis, hematomas, seizures, and death.

**Conclusions:** Although the benefits for epidural steroid injections may include transient pain relief for those with/without surgical disease, the multitude of risks attributed to these injections outweighs the benefits.

**Key Words:** Complications, epidural spinal injections, infection, spinal fluid leaks

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### INTRODUCTION

Pain specialists, including anesthesiologists, physiatrists, and radiologists, are increasingly performing multiple

epidural/transforaminal spinal injections. These injections expose patients with or without surgical disease, to significant morbidity and even mortality. Although injections may relieve symptoms for those without

surgical lesions, this “relief” may simply coincide with the self-limited course of the disease. Furthermore, for those with surgical lesions, injections may significantly delay requisite surgery, resulting in increased permanent neurological deficits [Tables 1-3].

The infectious risks of epidural/transforaminal steroid injections have recently been published, particularly those contaminated with Aspergillosis resulting in fatal meningitis. Nevertheless, for years, patients have been

exposed to at least a 1-2% risk of infection (probably many go unreported/under-reported), 50% of which involve *Staphylococcus aureus*, resulting in diskitis, osteomyelitis, epidural abscess, as well as meningitis.<sup>[14]</sup>

Attention, however, should also be paid to the additional and even more common risks of epidural/transforaminal injections. These include: Increased neurological deterioration/paralysis/quadruplegia, intravascular injections (7.9-11.6%), cerebrospinal fluid (CSF) fistulas (0.4-6%),

**Table 1: Complications and outcomes of spinal interlaminar epidural (Interlaminar epidural steroid injection) and Transforaminal epidural steroid injections**

Author/data	Complications	Complications
Manchikanti 10,000 TFESI	Intravascular injections 11.6% Adhesiolysis 7.9% Lumbar 4% Thoracic 4.1% Cervical	Dural punctures 0.5 1% Cervical 1.3% Thoracic 0.8% Lumbar 1.8% Adhesiolysis
Schaufele 20 Patients ILESI 20 Patients TFESI	One year outcomes TFESI 9 (45%) Required 1-2 more injections 2 (10%) Required surgery 14 (70%) Improved 2 points	One year outcomes ILESI 8 (40%) Required 1-2 more injections 5 (25%) Required surgery 9 (45%) Improved 2 points
Botwin 157 Patients Cervical study 345 Injections	16.8% Complications 6.7% Neck pain 4.6% Headaches 1.7% Vasovagal reaction	1.5% Facial flushing 0.3% Fever 0.3% Dural puncture
Ma 844 Patients 1036 Cervical blocks	0% Catastrophic complications	(1.66%) Minor complications (14 patients)
Waldman 215 Patients 790 Cervical epidural nerve blocks	Complications (per patient) 0.93% (2) Dural punctures 1.4% (3) Vasovagal syncope 0.47% (1) Superficial infection	Complications (per injection) 0.25% (2) Dural punctures 0.38% (3) Vasovagal syncope 0.13% (1) Superficial infection
Manchikanti Facet nerve blocks  43,000 injections 7500 episodes	Complications >1% 11.4% Intravascular injury 76.3% Local bleeding 19.6% Oozing 1.2% Hematoma/profuse Bleeding	Complications <1% Soreness, root irritation Vasovagal reactions Complications 0 Dural puncture/infection
Scanlon 78 Complications ILESI/TFESI	Complications 16 Vertebrobasilar infarcts 12 Cervical cord infarct	2 Brain/cord infarcts 13 Fatal outcomes
Landa Goodman Zimmerer 36 Patients spinal epidural abscesses (SEA)	0-1.9% Epidural hematoma 1-2 Infection risk Spinal epidural abscesses secondary to 16 Hematogenous spread 16 Spine operations 4 Epidural injections	0.1% Severe infections Epidural injections responsible for SEA 11.1% Epidural abscesses (4/36) 20% Surgical/epidural Injections 4/20)
Berger 137,250 Epidural analgesia for labor	0.04-6% Dural punctures 37% Managed-blood patches at 24 hours	Blood patches efficacy 86 Failure rate 44 Persistent headache
Webb Epidural analgesia for labor	0.4-6% Dural punctures	28% Postural headaches (persisted)

ILESI: Interlaminar epidural steroid injections,TFESI:Transforaminal epidural steroid injections

**Table 2: Epidural cervical injections resulting in quadriplegia or cardiac arrest**

Author/data	Complications	Etiology
Bose		
C6-C7 ILESI	Quadriplegia No recovery	Presumed vascular event Intravascular injection
Ludwig		
C6-C7 TFESI	Quadriparesis High T2 cord signal O-C4/5 No recovery	Presumed vascular event Intravascular injection
Karasek		
C6-C7 TFESI	Quadriplegia No recovery	Presumed vascular event Intravascular injection
Stauber		
C6-C7 ILESI	Cardiopulmonary arrest Pneumocephalus Recovered	Probable cardioacceleratory center (sympathetic block)
Epstein		
ILESI	Quadriplegia	Intramedullary cord injection
(Personal communication)	Partial recovery	

TFESI: Transforaminal epidural steroid injections, ILESI: Interlaminar epidural steroid injection

persistent positional headaches (28%), arachnoiditis (6-16%), hydrocephalus, air embolism, urinary retention, allergic reactions, intravascular injections (7.9-11.6%), stroke, blindness, neurological deficits/paralysis, hematomas, seizures, and death [Tables 1 and 2].<sup>[7,14,15,22-26,39,40]</sup> Although there may be transient benefits of epidural/transforaminal spinal injections for patients with both nonsurgical and surgical disease, these injections over several months, may unnecessarily subject patients to major life-threatening risks while delaying potential requisite surgery. In short, the risks outweigh the benefits.

**NEWS OF INFECTIONS ATTRIBUTED TO EPIDURAL/TRANSFORAMINAL STEROID INJECTIONS**

The Morbidity Mortality Weekly Report of the Centers for Disease Control (CDC) and Prevention published the following report on October 19, 2012:

Multistate outbreak of fungal infection associated with injection of methylprednisolone acetate (MPA) solution from a single compounding pharmacy – United States, 2012.<sup>[12]</sup> The Tennessee Department of Health was alerted that a patient tested positive for *Aspergillus fumigatus* meningitis 46 days after an epidural steroid injection (ESI) (preservative-free MPA solution that had been “compounded at New England Compounding Center (NECC) in Framingham, Massachusetts.” By October 10,

2012, the CDC, multiple health departments, and the Food and Drug Administration (FDA) found 137 cases and 12 deaths in 10 states. By October 29, 2012, the CDC had identified 25 deaths due to epidural steroid-related meningitis (many due to *Aspergillus*), with 337 patients sickened in 18 states, and an additional 14,000 patients likely exposed to contaminated steroids.<sup>[3]</sup>

**The failure to adequately regulate specialty pharmacies**

A failure to adequately regulate specialty pharmacies is the present focus of discussion, as “greenish black foreign matter” and “white filamentous tissue” have been found in contaminated vials of steroids.<sup>[3]</sup> The New York Times also reported in October of 2012 “greenish-yellow residue on sterilization equipment, surfaces coated with levels of mold, and bacteria that exceeded the company’s own environmental limits” in one of the specialty pharmacies.<sup>[29]</sup>

**New England compounding center**

The NECC provided the contaminated vials of MPA that was presumed to have caused the recent fungal meningitis outbreak associated with epidural/transforaminal spinal injections.<sup>[3]</sup> Interestingly, one year ago, the label for the steroid Kenalog, manufactured by Bristol-Myers Squibb, was changed to indicate “epidural injection was not recommended.” Pfizer, however, continued to sell their version of MPA (Depo-Medrol) without warning.

**Summary:** The CDC (October 29, 2012) reported 25 deaths due to meningitis, 337 patients sickened in 18 states, and an additional 14,000 patients probably exposed to contaminated steroids.<sup>[12]</sup> Greater FDA regulation of compounding centers is warranted to avert such exposures/outbreaks in the future.

**News of meningitis attributed to epidural/transforaminal steroid injections plus other risks of nerve damage, paralysis, and strokes**

Pollack noted not only the recent outbreak of fungal meningitis resulting from epidural/transforaminal spinal injections, but also highlighted that these “same injections have also long been linked to other rare but devastating complications, including nerve damage, paralysis, and strokes.”<sup>[3,29]</sup> He specifically detailed that epidural injections utilizing steroids, “while approved for uses like relieving inflammation in joints, have not been approved by the FDA for epidural injections, next to the spinal cord.”<sup>[29]</sup> Also referring to those who died of meningitis, Dr. William Landau, a professor of neurology at Washington University in St. Louis, Missouri, noted: “Not only were these people killed, but there was no ethical reason to give this treatment.”<sup>[29]</sup>

**Summary:** Epidural/transforaminal spinal injections may not only result in fungal meningitis, but are also associated with other devastating complications, that include nerve damage/paralysis, and strokes. Furthermore, “while approved for uses

**Table 3: Sections and Summaries**

News of Infections Attributed to Epidural/Transforaminal Steroid Injections The Failure to Adequately Regulate Specialty Pharmacies New England Compounding Center	<b>Summary:</b> The Center for Disease Control (October 29, 2012) reported 25 deaths due to meningitis, 337 patients sickened in 18 states, and an additional 14,000 patients probably exposed to contaminated steroids. <sup>[12]</sup> Greater Food and Drug Administration (FDA) regulation of compounding centers is warranted to avert such exposures/outbreaks in the future.
News of Meningitis Attributed to Epidural/Transforaminal Steroid Injections Plus Other Risks of Nerve Damage, Paralysis, and Strokes	<b>Summary:</b> Epidural/transforaminal spinal injections may not only result in fungal meningitis, but are also associated with other devastating complications, that include nerve damage/paralysis, and strokes. Furthermore, "while approved for uses like relieving inflammation in joints, have not been approved by the FDA for epidural injections, next to the spinal cord." <sup>[29]</sup>
Frequency of Epidural/Transforaminal Fluoroscopic Spinal Injections Interlaminar Lumbar Epidural Injections	<b>Summary:</b> Rosas <i>et al.</i> note the estimated frequency of low back pain/sciatica is prevalent, accounting for 13% (the second most common) of medical office visits in the US. <sup>[34]</sup> Furthermore, ESI are "most commonly performed intervention in the management of chronic low back pain in the United States."
Increase of 160% of Steroid Injections Over 10 Years Driven by Aging/Desperate Patients and Monetary Considerations	<b>Summary:</b> Dr. Manchikanti, Chairman of the American Society of Interventional Pain Physicians, observed that there has been a 160% increase in epidural injections from 2000 to 2010, and that too many are being performed without meeting proper criteria. Furthermore, 20% of physicians performing these procedures are not adequately trained. He raised the issue of "financial incentives" being responsible for this marked increase in procedures.
Indications for Epidural and Transforaminal Injections	<b>Summary:</b> Landa <i>et al.</i> defined two major types of cervical and lumbar spinal injections; the translaminar (TLESI) and transforaminal (TFESI) approaches. <sup>[19]</sup> The former best addresses diffuse symptoms, while the latter, typically focus on single nerve root pathology.
Benefits for the Efficacy of Epidural Injections Utility of Epidural Steroid Injections in Averting Surgery in Patients Originally Deemed Surgical Candidates	<b>Summary:</b> In a prospective, randomized, controlled, double blind study involving 55 patients with lumbar radiculopathy, more patients receiving selective nerve root injections of bupivacaine with betamethasone vs. bupivacaine alone opted over the long-term (13–28 months) for nonoperative management ("success"). <sup>[30]</sup>
Minimal Complications of 10,000 Fluoroscopic-Guided Epidural Injections	<b>Summary:</b> Manchikanti <i>et al.</i> determined that in 10,000 fluoroscopic guided epidural injections, the risk of intravascular complications was highest for adhesiolysis (11.6%) and lumbar transforaminal procedures (7.9%), while the frequency of dural punctures was 0.5% (highest for adhesiolysis 1.8% followed by thoracic procedures). <sup>[26]</sup>
Efficacy of Lumbosacral Transforaminal Steroid Injections 30% or Greater Reduction in Radicular Pain with Transforaminal Epidural Injections Utilizing 3 Different Doses of Dexamethasone	<b>Summary:</b> Ahadian <i>et al.</i> documented the comparable safety and efficacy of transforaminal epidural injections utilizing 4 mg (33 patients), 8 mg (33 patients), and 12 mg (32 patients) of Dexamethasone at 4, 8, and 12 weeks postinjection. <sup>[2]</sup> By the 12 <sup>th</sup> postinjection week, VAS scores declined to 26.6%, the ODI showed minimal residual findings, and there were no adverse events.
Evidence-based Literature Documents Efficacy of Lumbosacral Transforaminal Steroid Injections Performed Under Fluoroscopy or CT Guidance	<b>Summary:</b> Benny <i>et al.</i> documented that lumbosacral transforaminal injections (8 of 10 randomized control studies and 9 prospective trials) performed under CT or fluoroscopic guidance injections showed positive short- and long-term outcomes. <sup>[6]</sup>
Efficacy of Multiple Types of Spinal Injections, Including Transforaminal Epidural Steroids In Resolving Radicular Pain	<b>Summary:</b> Roberts <i>et al.</i> identified 9 randomized studies which utilized fluoroscopy to perform transforaminal epidural steroid injections for the treatment of radiculopathy. <sup>[32]</sup> They noted that TFESI were not only better than placebo, but also were superior to interlaminar and caudal injections. The one exception was subacute/chronic radiculopathy, where a single TFESI was as effective as a single transforaminal injection of bupivacaine or saline.
Better Outcomes with Transforaminal Epidural Steroid Injections vs. Interlaminar Injections for Lumbar Disc Disease	<b>Summary:</b> Schaufele <i>et al.</i> retrospectively analyzed the efficacy of TFESI vs. TLESI, and found that those undergoing TFESI experienced better resolution of pain, required fewer subsequent injections, and fewer subsequent operations. <sup>[37]</sup>
Greater Effectiveness of Bilateral Transforaminal Epidural Steroid Injections for Treating Patients with Spinal Stenosis	<b>Summary:</b> Bilateral TFESI produced more effective control of symptoms in patients with spinal stenosis (SS) vs. TLESI. <sup>[20]</sup> This was likely attributed to higher concentrations of steroids achieved in the ventral epidural space vs. dorsal compartment which is typically occupied by not only scar and fibrosis, but also marked ossification/hypertrophy of the yellow ligament that blocks steroid dissemination.

(Contd...)

### Table 3: Sections and Summaries

Comparable Efficacy of Different Spinal Injections Comparable Efficacy of Epidural Steroid Injections vs. Intramuscular Injections of Steroids with a Local Anesthetic	<b>Summary:</b> In Wilson-MacDonald <i>et al.</i> study, 93 patients who were considered potential surgical candidates, exhibited comparable 2-year outcomes (Oxford Pain Chart and ODI) utilizing epidural steroid injections or intramuscular injections of steroids combined with a local anesthetic. <sup>[42]</sup> They found no substantial difference over the longer term, and the incidence of subsequent surgery was similar for both groups.
Relative Efficacy of Caudal Epidural Injections with Local Anesthetic With or Without Steroids	<b>Summary:</b> In a 2-year randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections (with or without steroids), Manchikanti <i>et al.</i> concluded that both types of injection were an effective treatment for a select group of patients who have chronic function-limiting low back and lower extremity pain secondary to central spinal stenosis. <sup>[24]</sup>
Blind (without Fluoroscopy) Interlaminar Spinal Epidural Steroid Injections Provide Short-Term Relief for Disc Herniations and Radiculitis But Not Spinal Stenosis	<b>Summary:</b> Epidural steroid spinal injections performed blindly (without fluoroscopy), are one of the most common procedures performed in the US for chronic low back pain. Although Parr <i>et al.</i> demonstrated short-term pain relief for disc herniations and radiculitis, the evidence is lacking for both short- and long-term treatment of spinal stenosis. <sup>[28]</sup>
Risks of Epidural/Transforaminal Epidural Spinal Injections Limited Efficacy of Injections	<b>Summary:</b> Deyo observed that in multiple clinical trials utilizing epidural spinal injections performed at the University of Washington, that "seven clinical trials showed the injections were helpful, another seven found them no better or even worse than a placebo, and three (had) unclear results." <sup>[3]</sup> He also observed other risks of these injections that included: Infection, injections into the spinal fluid, intravascular injections, nerve damage, hemorrhages, and arachnoiditis.
Epidural Steroid Injections Provide No Additional Improvement	<b>Summary:</b> Valat <i>et al.</i> compared the efficacy of epidural steroid injections vs. isotonic saline, finding that "the efficacy of isotonic saline administered epidurally for sciatica cannot be excluded, but epidural steroid injections provide no additional improvement." <sup>[39]</sup>
Epidural Steroids Offer No Significant Functional Benefits or Reduction in the Need for Surgery	<b>Summary:</b> Carrette <i>et al.</i> , in a double-blind, randomized trial, determined that for 158 patients with herniated discs evaluated utilizing the ODI at 3, 6, 12 weeks and 1 year following injections, that even if epidural methylprednisolone resulted in some short-term benefits, it offers no significant functional benefit, nor does it reduce the need for surgery. <sup>[10]</sup>
Epidural Steroids Offer No Sustained Benefits or Reduce the Need for Surgery	<b>Summary:</b> Arden <i>et al.</i> evaluated the efficacy of 3 ESI vs. interligamentous saline injections (3 weeks apart) in patients with unilateral sciatica for 1-18 months. <sup>[5]</sup> They found that ESI offered transient benefit in symptoms at 3 weeks in patients with sciatica, but no sustained benefits in terms of pain, function or need for surgery. From 6 to 52 weeks post-injection, "no benefit was demonstrated."
Rare Major But Common Minor Complications of Fluoroscopic Facet Joint Nerve Blocks.	<b>Summary:</b> Manchikanti <i>et al.</i> reported on 43,000 intermittent fluoroscopically guided facet joint nerve blocks injections performed during 7500 visits, and observed the following complications: Intravascular injection (11.4%), local bleeding (76.3%), oozing (19.6%), local hematoma with profuse bleeding (1.2%) with less than 1% experiencing other complications (e.g. dural puncture, spinal cord irritation, infection). <sup>[25]</sup>
Safety of Cervical Epidural Steroid Injections Comparable Long-term Efficacy of Cervical Epidural Steroid Injections Performed with/without Morphine	<b>Summary:</b> Castagnera <i>et al.</i> noted that long-term results (48 post-injection months) did not differ between two groups of patient with nonsurgical cervical disease, receiving one dose of epidural steroids with lidocaine (S) vs. steroids with morphine sulfate (S+M). <sup>[11]</sup> Success rates were 78.5% (S), and 80% (S+M), and specific pain relief was also comparable: (86.8% (S) and 86.9% (S+M)). <sup>[11]</sup>
Minimal Complications of Cervical Epidural Steroid Spinal Injections Performed Under Fluoroscopy	<b>Summary:</b> In Botwin <i>et al.</i> series involving 157 patients undergoing 354 cervical epidural steroid injections at the C6-C7 or C7-T1 levels, although 16.8% of patients exhibited complications, none required hospital stays or developed persistent morbidity. <sup>[9]</sup>
Few Complications of Cervical Epidural Steroid injections	<b>Summary:</b> Abbasi <i>et al.</i> concluded that a review of the literature revealed a 0-16.8% incidence of complications associated with cervical epidural spinal injections, but acknowledged that the design of most studies was suboptimal (e.g. future prospective, randomized studies were warranted). <sup>[1]</sup>
Efficacy and Safety (64%) of cervical Epidural Steroids for radiculopathy	<b>Summary:</b> Rowlingson and Kirschenbaum series, performing 45 cervical epidural steroid injections in 25 patients with cervical radiculopathy, resulted in a 64% incidence of good or excellent responses. <sup>[35]</sup>

(Contd...)



**Table 3: Sections and Summaries**

Few complications attributed to 1036 extraforaminal cervical Nerve Blocks	<b>Summary:</b> Performing 1036 extraforaminal cervical nerve blocks in 844 patients resulted in no major but 14 (1.66%) minor complications that more frequently occurred with deep rather than superficial injections. <sup>[23]</sup>
Rare Cervical complications following 790 steroid Epidural Nerve Blocks	<b>Summary:</b> Waldman evaluated 215 patients undergoing 790 cervical epidural nerve blocks, finding 2 dural punctures, 3 vasovagal events, and 1 delayed superficial infection. <sup>[40]</sup>
Risks of Cervical epidural steroid injections no long-standing benefit of epidural steroids/local Anesthetic vs. Sterile Saline/local Anesthetic	<b>Summary:</b> In Anderberg <i>et al.</i> prospective randomized study of 40 patients undergoing either cervical ESI/local anesthetic vs. sterile saline/local anesthetic, at 5 postinjection weeks, patients receiving steroid injections had less pain, but not over the longer term. <sup>[4]</sup>
Permanent neurological complications (e.g. Quadriplegia) Associated with cervical Epidural or transforaminal Steroid Injections	<b>Summary:</b> Scanlon <i>et al.</i> cited 8 instances of inadvertent intravascular injections leading to brain and spinal cord injury and identified an additional 4 cases of major particulate corticosteroid embolic injury to the cerebellum and brainstem in the literature. <sup>[36]</sup> In their own survey of members of the American Pain Society, the 21.4% response rate (287 of 1340) revealed 78 complications including 16 vertebrobasilar brain infarcts, 12 cervical spinal cord infarcts, and 2 combined brain/spinal cord infarcts, with 13 fatal outcomes.
Risks of Inadvertent Intravascular Injections During Attempted Cervical Steroid Injections Inadvertent "Vascular Injections" Result in Quadriparesis During Attempted Epidural Cervical Steroid Injections	<b>Summary:</b> In the Bose <i>et al.</i> study, a patient developed quadriplegia and a respiratory arrest following an attempted CESI at the C6-C7 level; they concluded that it was likely a "vascular event" that left the patient with a major permanent neurological deficit. <sup>[8]</sup>
Transforaminal Cervical Injection Resulted in Vascular Infarction to Cord	<b>Summary:</b> Following a left C6 TFESI, Ludwig's 53-year-old patients developed left arm and bilateral lower extremity weakness. The MR confirmed hyperintense intramedullary cord signal changes within 24 hours extending from the odontoid to the C4-C5 level, consistent with a diffuse vascular infarction. <sup>[22]</sup>
Inadvertent "Intravascular Injections" of Cervical Local Anesthesia Result in Transient Quadriplegia	<b>Summary:</b> Karasek and Bogduk noted the adverse consequences of performing a C6-7 transforaminal injection utilizing local anesthesia that resulted in an inadvertent injection into a cervical radicular artery. <sup>[17]</sup> Fortunately, their patient's immediate quadriplegia resolved within 20 minutes. Had this been a steroid injection, particulate matter may have acted as an embolus and caused a permanent injury.
Cardiac Arrest Due to Cervical Epidural Steroid Injection	<b>Summary:</b> Stauber and Nazair presented a 67-year-old female who following a C6-C7 epidural cervical steroid injection sustained pneumocephalus and a cardiopulmonary arrest. <sup>[38]</sup> The latter was likely attributed to blockade of the sympathetics resulting in bradycardia/arrest.
Author's Personal Communication with Pediatric Neurosurgeon	<b>Summary:</b> A personal communication (2010) with the author revealed a 16-year-old female treated by an outside physician who became quadriplegic following a cervical epidural injection. The MR immediately demonstrated a fluid signal within the cord itself, consistent with a direct intramedullary cord injection. Despite being treated with hyperbaric oxygen, she did not sustain a full recovery (personal communication)
Multiple Complications of Epidural or Transforaminal Injections Multiple Complications of Epidural/Transforaminal Injections Are Often Underreported	<b>Summary:</b> Risks of epidural/transforaminal injections include: Infection, epidural hematoma (0-1.9%), intravascular injections, nerve damage, CSF fistulas/headaches, air embolism, urinary retention, allergic reactions, seizures, blindness, and others. <sup>[7,14,15,19,41,43]</sup>
Infection Risks of Epidural or Transforaminal Epidural Injections	<b>Summary:</b> Epidural/TFESIs are associated with infection rates varying from 1% to 2%, with more serious infections observed in 0.1% of patients. <sup>[14]</sup>
Meningitis Secondary to Spinal Injections	<b>Summary:</b> Kainer <i>et al.</i> evaluated the recent outbreak of fungal infections that recently followed epidural or paraspinal injections of preservative-free methylprednisolone acetate from one compounding pharmacy in New England. <sup>[16]</sup> They reported that 66 patients, averaging 69 years of age exhibited meningitis (73%), cauda equina syndrome or focal infection (15%), or posterior circulation stroke/with or without meningitis (12%). Despite treatment with Voriconazole (61 patients: 92%) supplemented in 35 patients (53%) with liposomal amphotericin B, 9 patients (12%) died, and 7 of the 9 had sustained a stroke.
Epidural Abscess Secondary to Spinal Injections	<b>Summary:</b> In Zimmerer <i>et al.</i> 36 patients with spinal epidural abscesses, 4 patients had undergone spinal injections and comprised 11.1% of patients in the overall series, but a higher 20% of those with secondary (surgery vs. injection) reasons for developing SEA. <sup>[43]</sup>

(Contd...)

### Table 3: Sections and Summaries

Risks of Epidural Abscess and Meningitis Warrant Antibiotic Prophylaxis	<b>Summary:</b> In 14 cases of epidural abscess or meningitis identified in the literature attributed to epidural steroid injections, 8 (67%) exhibited positive blood, cerebrospinal fluid, or epidural pus cultures documenting <i>Staphylococcus aureus</i> . Therefore, appropriate antibiotic prophylaxis for these procedures is warranted. <sup>[15]</sup>
Risks of Dural Puncture/Cerebrospinal Fluid Fistulas/Persistent Headaches	<b>Summary:</b> In a survey of 36 academic institutions involving 137,250 women in labor/deliveries, the frequency of inadvertent dural punctures occurring during epidural analgesia ranged from 0.4% to 6%. <sup>[7]</sup> Epidural blood patches failed in 86% of patients, and 44% experienced persistent headaches.
Risks of Inadvertent Dural Puncture (0.04–6%) and 86% Inefficacy of Epidural Blood Patches for Patients in Labor Receiving Epidural Analgesia	<b>Summary:</b> Webb <i>et al.</i> reported a higher baseline but comparable maximum risk (0.4–6%) of inadvertent dural puncture utilizing a 17-gauge Tuohy needle to administer epidural analgesia for women in labor. <sup>[41]</sup> The frequency of postural headaches was a higher 70–80%, with 28% exhibiting chronic headaches compared with only a 5% frequency of headaches for matched controls.
0.4–6% Incidence of CSF Leaks Resulting in Postural Headaches Following Epidural Injections for Patients in Labor	<b>Summary:</b> Goodman <i>et al.</i> noted two cases in which TLEI and TFLEI resulted in dural and subdural punctures. <sup>[13]</sup> Interventionalists should recognize the different patterns of contrast dissemination, and should particularly avoid the direct injection of steroids into the epidural compartment.
Inadvertent Dural and Subdural Punctures	<b>Summary:</b> In Goodman <i>et al.</i> 2 cases, attempted transforaminal epidural steroid injections resulted in inadvertent intradural and subdural injections. <sup>[13]</sup>
Epidural Injections Resulting in Inadvertent Dural Puncture and Subdural Injections	<b>Summary:</b> When Lima <i>et al.</i> performed intrathecal injections of normal saline vs. methylprednisolone into a dog model, methylprednisolone resulted in the following histological changes: “Meningeal thickening, lymphocytic infiltrates in the blood vessels, adhesion of pia, arachnoid, and dura matter with nerve roots were surrounded by fibrosis and necrosis of the spinal cord.” <sup>[21]</sup>
Adhesive Arachnoiditis	<b>Summary:</b> In Rodriguez Luna <i>et al.</i> reported that adhesive arachnoiditis occurs in between 6% and 16% of patients having primary or revision lumbar surgery. <sup>[33]</sup>
Increased Risks of Adhesive Arachnoiditis Following Intrathecal Injection of Methylprednisolone: Animal-based Laboratory Study	<b>Summary:</b> Koerts <i>et al.</i> reported that 86% of cases of spinal adhesive arachnoiditis occur in the lumbar region, and are due to: Contamination of the subarachnoid space with blood (e.g. CSF leak/dural tear), infection, myelography (especially oil-based), epidural steroid injections, spinal surgery (disc/stenosis), and trauma. <sup>[18]</sup>
Clinical Example of Irreversible Paraplegia Secondary to Adhesive Arachnoiditis	<b>Summary:</b> Riley and Spiegel documented subdural hematoma and subdural hematoma with adhesive arachnoiditis with chronic sacral radiculopathy as the result of utilizing large volume epidural blood patches in two respective patients with postdural puncture headaches. <sup>[31]</sup>
Clinical Example of Postoperative Spinal Adhesive Arachnoiditis Resulting in Hydrocephalus and Equina Syndrome	<b>Summary:</b> Direct contraindications to performing epidural steroid injections include prior surgery and infection.
Increased Risks of Adhesive Arachnoiditis and Subdural Hematoma with Epidural Blood Patch for Postdural Puncture Headaches in two Patients	<b>Summary:</b> Many insurance companies motivate physicians (with higher reimbursements) to perform epidural injections in their office (typically without the benefit/added safety of fluoroscopy (typically not reimbursed) to avoid facility fees. <sup>[27]</sup> Fees quoted for nerve blocks ranged from \$83 in an ASC vs. \$183 in an office, while those for epidural injections performed in an ASC averaged \$107 vs. \$247 in an office; facility fees also varied typically from \$300 to \$650
Direct Contraindications for Epidural Steroid Injections	Epidural Injections Are the Most Common Nerve Blocks
Costs of Epidural Injections: Facility and Physician Fees	Increased Frequency of Epidural/Transforaminal Injections
	Epidural/Transforaminal Injections are Ineffective
	Comparable Efficacy of Epidural Steroids vs. Epidural Saline Injections
	Comparable Outcomes and No Reduction in Need for Surgery
	Risks of Epidural/Transforaminal Injections
	Risks of Meningitis
	Facet Joint Injections: Ineffective and Associated with Multiple Complications
	Complication Rate 0–16.8% for Cervical Epidural/Transforaminal Injections
	Specific Risks of Inadvertent Intravascular Injections Leading to Brain/Cord Injury
	Risk of Quadriplegia with Intramedullary Cervical Injection
	Risk of Adhesive Arachnoiditis
	Animal Series
	Clinical Series
	Insurers Promoting Unsafe Practices
Conclusion	

FDA: Food and drug administration

like relieving inflammation in joints, have not been approved by the FDA for epidural injections, next to the spinal cord.”<sup>[29]</sup>

## **FREQUENCY OF EPIDURAL/TRANSFORAMINAL FLUOROSCOPIC SPINAL INJECTIONS**

### **Interlaminar lumbar epidural injections**

Rosas, *et al.* indicated that lumbar radicular/sciatic complaints impact millions of Americans, and that the management of these complaints has a major impact on society.<sup>[34]</sup> The estimated frequency of these complaints is 13%, and constitutes the “second most common symptom-related cause for medical office visits in the United States.” They further noted that epidural injections are now the “most commonly performed intervention in the management of chronic low back pain in the United States.”

*Summary:* Rosas, *et al.* note the estimated frequency of low back pain/sciatica is prevalent, accounting for 13% (the second most common) of medical office visits in the US.<sup>[34]</sup> Furthermore, ESI are the “most commonly performed intervention in the management of chronic low back pain in the United States.”

### **Increase of 160% of steroid injections over 10 years driven by aging/desperate patients and monetary considerations**

Dr. Manchikanti, Chairman of the American Society of Interventional Pain Physicians observed: “We are doing too many of these (spinal injections), and many of those don’t meet the proper criteria.”<sup>[25]</sup> He further observed, “about 20% of doctors who perform the procedures were not adequately trained.” When reviewing Medicare records, he found that the frequency of these injections increased by 160% from 2000 to 2010. He attributed this to the needs of older patients in desperate need of pain relief, and by financial incentives. “Medicare and private insurers pay \$100 to several hundred dollars for an injection, and there are pain clinics that do almost nothing but injections.”<sup>[25]</sup>

*Summary:* Dr. Manchikanti, Chairman of the American Society of Interventional Pain Physicians, observed that there has been a 160% increase in epidural injections from 2000 to 2010, and that too many are being performed without meeting proper criteria. Furthermore, 20% of physicians performing these procedures are not adequately trained. He raised the issue of “financial incentives” being responsible for this marked increase in procedures.<sup>[25]</sup>

### **Indications for epidural and transforaminal injections**

The two major types of epidural spinal injections employed in the cervical and lumbar regions include the translaminar (TLESi) and transforaminal (TFESI) approaches.<sup>[19]</sup> The translaminar procedure is utilized to

address more diffuse symptoms, while the transforaminal approach is employed to directly treat a single nerve root. Landa, *et al.* found that these injections demonstrated “efficacy for up to 6 months of pain relief, although long-term benefits are less reliable.”<sup>[19]</sup> They acknowledged that these injections can also result in severe complications.

*Summary:* Landa, *et al.* defined two major types of cervical and lumbar spinal injections; the translaminar (TLESi) and transforaminal (TFESI) approaches.<sup>[19]</sup> The former best addresses diffuse symptoms, while the latter; typically focus on single nerve root pathology.

## **BENEFITS FOR THE EFFICACY OF EPIDURAL INJECTIONS**

### **Utility of epidural steroid injections in averting surgery in patients originally deemed surgical candidates**

Riew, *et al.* designed a prospective, randomized, controlled, double blind study to determine how effective selective nerve root injections (SNRIs) utilizing steroids vs. bupivacaine alone could be in avoiding surgery for patients with demonstrated “surgical” disc herniations.<sup>[30]</sup> All 55 patients had radiculopathy that correlated with radiographically documented surgical disease (e.g., herniated discs). Patients were randomly selected for SNRI with bupivacaine vs. bupivacaine with betamethasone; patients could choose to receive up to four injections. Over the follow-up duration of 13-28 months, 9 of 27 patients receiving bupivacaine alone, but a higher 20 of 28 receiving bupivacaine with the steroid, decided against surgery (defined as a “success”): This difference was significant ( $P < 0.004$ ). The authors projected that in the future, more patients with radiculopathy (1-2 level discs) should first undergo SNRIs with corticosteroids before opting for surgery.

*Summary:* In a prospective, randomized, controlled, double blind study involving 55 patients with lumbar radiculopathy, more patients receiving SNRIs of bupivacaine with betamethasone vs. bupivacaine alone opted over the long-term (13-28 months) for nonoperative management (“success”).<sup>[30]</sup>

### **Minimal complications of 10,000 fluoroscopic-guided epidural injections**

Manchikanti, *et al.* offered a prospective, nonrandomized study involving 10,000 patients who over 20 months received: 39% caudal epidurals, 23% cervical interlaminar epidurals, 14% lumbar interlaminar epidurals, 13% lumbar transforaminal epidurals, 8% percutaneous adhesiolysis, and 3% thoracic interlaminar epidural procedures [Table 1].<sup>[26]</sup> All procedures were performed in an Ambulatory Surgical Center (ASC) by three physicians. Intravascular complications were greater for adhesiolysis (11.6%) and lumbar transforaminal (7.9%) injections vs. 0.5% for



lumbar, 3.1% for caudal, 4% for thoracic, and 4.1% for cervical epidurals. Dural punctures (DPs), observed in 0.5% of patients occurred in the following: 1% cervical, 1.3% thoracic, 0.8% lumbar, and in 1.8% of patients undergoing adhesiolysis. The authors concluded that major complications were rare, but minor side effects were common.

**Summary:** Manchikanti, *et al.* determined that in 10,000 fluoroscopic-guided epidural injections, the risk of intravascular complications was highest for adhesiolysis (11.6%) and lumbar transforaminal procedures (7.9%), while the frequency of DPs was 0.5% (highest for adhesiolysis 1.8% followed by thoracic procedures 1.3%).<sup>[26]</sup>

## EFFICACY OF LUMBOSACRAL TRANSFORAMINAL STEROID INJECTIONS

### Greater reduction (>30%) in radicular pain with transforaminal epidural injections utilizing three different doses of dexamethasone

In Ahadian, *et al.* prospective, randomized, double-blind trial, the relative efficacy of transforaminal epidural injections utilizing 4 mg (33 patients), 8 mg (33 patients), and 12 mg (32 patients) of Dexamethasone were studied at four time intervals: 1, 4, 8, and 12 weeks post-injection.<sup>[2]</sup> A 30% or greater reduction in radicular pain utilizing the Visual Analog Scale (VAS) was considered a “success.” Other outcome measures included the: Oswestry Low Back Disability Index (ODI), Subject Global Impression of Change, Subject Global Satisfaction Scale, and adverse events (AEs). Over the 4, 8, and 12 post-procedure weeks, the average reduction in radicular pain based on the VAS was 41.7%, 33.5%, and 26.6%, respectively. The ODI revealed minimal residual findings by the 12<sup>th</sup> week after injection, and no AE were encountered. They concluded that results were comparable for all three-dosage groups, and that Dexamethasone was both safe and effective for transforaminal injections.

**Summary:** Ahadian, *et al.* documented the comparable safety and efficacy of transforaminal epidural injections utilizing 4 mg (33 patients), 8 mg (33 patients), and 12 mg (32 patients) of Dexamethasone at 4, 8, and 12 weeks post-injection.<sup>[2]</sup> By the 12<sup>th</sup> post-injection week, VAS scores declined to 26.6%, the ODI showed minimal residual findings, and there were no AEs.

### Evidence-based literature documents efficacy of lumbosacral transforaminal steroid injections performed under fluoroscopy or CT guidance

Benny, *et al.* reviewed the “best evidence-based literature” to determine whether lumbosacral transforaminal steroid injections (TFESI) were effective.<sup>[6]</sup>

Utilizing PubMed, Medline, Cochrane databases,

and the U.S. National Library of Medicine, they identified studies in which patients were followed for a minimum of 3 months following lumbosacral TFESI. Eight of 10 randomized control studies, and 9 prospective trials utilizing computed tomography (CT) or fluoroscopic-guided injections documented “positive outcomes in both the short-term and long-term results.”<sup>[6]</sup>

**Summary:** Benny, *et al.* documented that lumbosacral transforaminal injections (8 of 10 randomized control studies and 9 prospective trials) performed under CT or fluoroscopic guidance injections showed positive short- and long-term outcomes.<sup>[6]</sup>

### Efficacy of multiple types of spinal injections, including transforaminal epidural steroids in resolving radicular pain

Roberts, *et al.* also utilized multiple databases (Medline, Embase, Cochrane) to assess the efficacy of ESI, transforaminal (TFESI), foraminal (FESI), selective nerve root block, nerve root injection (NRI), SNRI, periradicular infiltration, and periradicular injection for treating radicular pain.<sup>[32]</sup> The nine studies, utilizing randomized designs and fluoroscopy, documented that TFESI were superior to placebo for treating radicular symptoms, and that injections could avoid surgery. They also established that TFESI injections were superior to interlaminar ESI (ILESI) and caudal ESI for managing radiculopathy. They observed that for patients with “subacute or chronic radicular symptoms, there is good evidence that a single TFESI has similar efficacy to a single transforaminal injection of bupivacaine or saline.”<sup>[32]</sup>

**Summary:** Roberts, *et al.* identified nine randomized studies, which utilized fluoroscopy to perform transforaminal epidural steroid injections (TFESI) for the treatment of radiculopathy.<sup>[32]</sup> They noted that TFESI were not only better than placebo, but also were superior to interlaminar and caudal injections. The one exception was subacute/chronic radiculopathy, where a single TFESI was as effective as a single transforaminal injection of bupivacaine or saline.

### Better outcomes with transforaminal epidural steroid injections vs. interlaminar injections for lumbar disc disease

Schaufele *et al.* retrospectively evaluated the short-term pain resolution and long-term surgical requirements for 20 patients having TFESIs vs. 20 patients undergoing fluoroscopically guided interlaminar injections [Table 1].<sup>[37]</sup> In all cases, patients exhibited radiculopathy attributed to magnetic resonance (MR)-documented lumbar disc herniations. Patients were followed over 18 months. The Verbal Numerical Rating Scale (VNRS, 0-10 scale) was assessed prior to the injection, an hour following the injection, an average of 17.1 days later, and 1 year later. At 1-year post-injection, for those in the transforaminal vs.

interlaminar groups, 9 (45%) vs. 8 (40%) patients required one or two additional injections, and 2 (10%) vs. 5 (25%) required surgery, while 14 (70%) vs. 9 (45%) patients improved 2 points or more on the VNRS scale. They concluded that TFESI injections proved more effective in managing symptomatic lumbar disc herniations, and resulted in “better short-term pain improvement, and fewer long-term surgical interventions.”

**Summary:** Schaufele, *et al.* retrospectively analyzed the efficacy of TFESI vs. TLESI, and found that those undergoing TFESI experienced better resolution of pain, required fewer subsequent injections, and fewer subsequent operations.<sup>[37]</sup>

### Greater effectiveness of bilateral transforaminal epidural steroid injections for treating patients with spinal stenosis

Lee, *et al.* contrasted the efficacy of the interlaminar (TLESI) vs. bilateral transforaminal (TFESI) ESIs for treating pain attributed to either spinal stenosis (SS) or herniated intervertebral disc (HIVD).<sup>[20]</sup> Patients were symptomatic with axial back pain for 3 months, and were “assigned” to either treatment category (not randomized). Outcomes were variously assessed utilizing the Numerical Rating Scale (NRS), the Patient Satisfaction Index (PSI), and the Roland 5-point pain score (administered at pretreatment, 2 weeks, 2 months, and 4 months after injections). Both types of injections promoted resolution of HIVD and SS symptoms within 2 weeks to 4 months. However, those with SS were more significantly relieved utilizing TFESI injections, while no differences were encountered for HIVD. Theoretically, bilateral TFESI in SS patients likely produced higher ventral epidural concentrations of steroids and were, therefore, more successful. Alternatively, TLESI in SS patients resulted in lower dorsal epidural concentrations due to the markedly increased dorsal fibrosis and scarring, and compression attributed to hypertrophy/ossification of the yellow ligament (OYL).

**Summary:** Bilateral TFESI produced more effective control of symptoms in patients with SS vs. TLESI.<sup>[20]</sup> This was likely attributed to higher concentrations of steroids achieved in the ventral epidural space vs. dorsal compartment, which is typically occupied by not only scar and fibrosis, but also marked hypertrophy/OYL that blocks steroid dissemination.

## COMPARABLE EFFICACY OF DIFFERENT SPINAL INJECTIONS

### Comparable efficacy of epidural steroid injections vs. intramuscular injections of steroids with a local anesthetic

In the Wilson-MacDonald, *et al.* randomized controlled trial, patients received either ESIs or intramuscular

injections of steroids combined with a local anesthetic.<sup>[42]</sup> Ninety-three patients, all considered potential surgical candidates, were assessed utilizing the Oxford Pain Chart and ODI over a 2-year period. Although they observed a significant decrease in pain for those receiving steroids over the short-term, there was no substantial difference over the longer term, and the incidence of subsequent surgery was similar for both groups.

**Summary:** In the Wilson-MacDonald, *et al.* study, 93 patients, all considered potential surgical candidates, exhibited comparable 2-year outcomes (Oxford Pain Chart and ODI) utilizing ESIs or intramuscular injections of steroids combined with a local anesthetic.<sup>[42]</sup> They found no substantial difference over the longer term, and the incidence of subsequent surgery was similar for both groups.

### Relative efficacy of caudal epidural injections with local anesthetic with or without steroids

In the Manchikanti, *et al.* study, the 2-year results of a randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections (with or without steroids) for producing long-term relief of symptoms attributed to central lumbar SS were assessed.<sup>[24]</sup> The series included 100 patients randomized to Group I (caudal epidural injections of lidocaine 0.5% and Group II (caudal epidural injections of 0.5% lidocaine 9 mL and 1 mL of steroid (6 mg nonparticulate betamethasone). Outcomes were measured (3, 6, 12, 18, and 24 months) utilizing the NRS, the ODI, the employment status, and use of narcotics. Success on the ODI score required pain relief of 50% or more, and at least 3 weeks of relief following the first two injections.<sup>[24]</sup> They found significant pain relief in 51% of patients in Group I and 57% in Group II at 2 years, while significant pain relief/functional status improvement ( $\geq 50\%$ ) was seen in 38% in Group I and 44% in Group II (2 years). They concluded that caudal epidural injections utilizing local anesthetic with or without steroids resulted in a modest degree of relief for patients, and that either regimen constituted an “effective treatment for a select group of patients who have chronic function-limiting low back and lower extremity pain secondary to central SS.”<sup>[24]</sup>

**Summary:** In a 2-year randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections (with or without steroids), Manchikanti *et al.* concluded that both types of injection were an “effective treatment for a select group of patients who have chronic function-limiting low back and lower extremity pain secondary to central SS.”<sup>[24]</sup>

### Blind (without fluoroscopy) interlaminar spinal epidural steroid injections provide short-term relief for disc herniations and radiculitis but not spinal stenosis

Parr, *et al.* noted that ESIs are “one of the most commonly performed interventions in the United States (US) in

managing chronic low back pain.”<sup>[28]</sup> They are performed utilizing multiple techniques (interlaminar, caudal, transforaminal) addressing different pathology (disc herniations, SS, pain without documented disc herniations, and “radiculitis”). Their study reviewed the literature regarding the “blind” (no fluoroscopy or CT guidance) impact of lumbar interlaminar epidural injections with or without steroids. Data was obtained from PubMed and EMBASE (1966-2008) and from other sources. They found evidence of positive short-term but not long-term pain relief for disc herniations and radiculitis, while both short- and long-term evidence was “lacking” for SS.

**Summary:** Epidural steroid spinal injections performed blindly (without fluoroscopy), are one of the most common procedures performed in the US for chronic low back pain. Although Parr, *et al.* demonstrated short-term pain relief for disc herniations and radiculitis, evidence was lacking for both short- and long-term treatment of SS.<sup>[28]</sup>

## RISKS OF EPIDURAL/TRANSFORAMINAL EPIDURAL SPINAL INJECTIONS

### Limited efficacy of injections

According to Dr. Deyo, Professor of Family Medicine (Oregon Health and Science University), despite the increase in steroid spinal injections, “people with back pain are reporting more functional and work limitations, rather than less.”<sup>[3]</sup> He further cited a University of Washington study in which “seven clinical trials showed the injections were helpful, another seven found them no better or even worse than a placebo, and three (had) unclear results.”<sup>[3]</sup> He also observed other risks of these injections that included: Infection, injections into the spinal fluid, intravascular injections, nerve damage, hemorrhages, and arachnoiditis.

**Summary:** Deyo observed that in multiple clinical trials utilizing epidural spinal injections performed at the University of Washington, that “seven clinical trials showed the injections were helpful, another seven found them no better or even worse than a placebo, and three (had) unclear results.”<sup>[3]</sup> He also observed other risks of these injections that included: Infection, injections into the spinal fluid, intravascular injections, nerve damage, hemorrhages, and arachnoiditis.

### Epidural steroid injections provide no additional improvement

Valat, *et al.* compared the efficacy of epidural corticosteroid injections (2 mL prednisolone acetate (50 mg) vs. 2 mL isotonic saline (both administered  $\times 3$ ) for patients with sciatica for between 15 and 180 post-injection days.<sup>[39]</sup> In 42 patients in the control group (CG), and 43 in the steroid-treated cohort, “the efficacy of isotonic saline administered epidurally for sciatica cannot be excluded, but ESIs provide no additional improvement.”<sup>[39]</sup>

**Summary:** Valat, *et al.* compared the efficacy of ESIs vs. isotonic saline, finding “the efficacy of isotonic saline administered epidurally for sciatica cannot be excluded, but ESIs provide no additional improvement.”<sup>[39]</sup>

### Epidural steroids offer no significant functional benefits or reduction in the need for surgery

In a randomized, double-blind trial, Carrette, *et al.* assessed whether three ESIs utilizing MPA (80 mg in 8 mL of isotonic saline) vs. isotonic saline (1 mL) were effective in the management of sciatica.<sup>[10]</sup> The 158 patients in this series all had herniated discs, and Oswestry Disability Index Scores (ODI) higher than 20 (increased disability). At 3 weeks, 6 weeks, 3 months, and 1 year, they found no significant differences in outcomes for the two groups. They concluded, that even if epidural methylprednisolone resulted in some short-term benefits, it “offered no significant functional benefit, nor did it reduce the need for surgery.”

**Summary:** Carrette, *et al.*, in a double-blind, randomized trial, determined that for 158 patients with herniated discs evaluated utilizing the ODI at 3, 6, 12 weeks and 1 year following injections, that even if epidural methylprednisolone resulted in some short-term benefits, it “offers no significant functional benefit, nor does it reduce the need for surgery.”<sup>[10]</sup>

### Epidural steroids offer no sustained benefits or reduce the need for surgery

Arden, *et al.*, in a multicenter, double-blind, randomized study, evaluated the efficacy of lumbar ESIs for 228 patients over a 12-month period.<sup>[5]</sup> Patients who had been symptomatic with unilateral sciatica for between 1 and 18 months, randomly received either three lumbar ESI (triamcinolone acetonide) vs. interligamentous saline injections; there were 3 weeks between injections for both groups. Utilizing the Oswestry Disability questionnaire (ODI), at 3 weeks the steroid group showed “a transient benefit over the placebo group.” However, from 6 to 52 weeks post-injection, “no benefit was demonstrated.” At the conclusion of the study, most patients still complained of significant pain and disability regardless of the type of injection they received. The authors found that “ESI offered transient benefit in symptoms at 3 weeks in patients with sciatica, but no sustained benefits in terms of pain, function, or need for surgery.”<sup>[5]</sup>

**Summary:** Arden, *et al.* evaluated the efficacy of three ESI vs. interligamentous saline injections (3 weeks apart) in patients with unilateral sciatica for 1-18 months.<sup>[5]</sup> They found that ESI offered transient benefit in symptoms at 3 weeks in patients with sciatica, but no sustained benefits in terms of pain, function, or need for surgery. From 6 to 52 weeks post-injection, “no benefit was demonstrated.”

### Rare major but common minor complications of fluoroscopic facet joint nerve blocks

Manchikanti, *et al.* performed a prospective cohort (nonrandomized) study of the complications/AE of intermittent fluoroscopically guided facet joint nerve blocks, one of the two most common injections performed for chronic spinal pain [Table 1].<sup>[25]</sup> Over a 20-month interval, the authors performed 43,000 injections in 7500 visits: 3370 cervical, 3180 lumbar, and 950 in the thoracic region. All were performed under fluoroscopic guidance in an ASC. Complications included: Intravascular entry of the needle (11.4%), local bleeding (76.3%), oozing (19.6%), and local hematoma with profuse bleeding (1.2%). Less than 1% experienced bruising, soreness, root irritation, or vasovagal reactions. No frequencies were provided for the incidence of DPs, headaches, spinal cord irritation/injury, or infections. They concluded that major complications were extremely rare, but that minor side effects were common.

**Summary:** Manchikanti, *et al.* reported on 43,000 intermittent fluoroscopically guided facet joint nerve blocks injections performed during 7500 visits, and observed the following complications: Intravascular injection (11.4%), local bleeding (76.3%), oozing (19.6%), and local hematoma with profuse bleeding (1.2%) with less than 1% experiencing other notable complications.<sup>[25]</sup>

### SAFETY OF CERVICAL EPIDURAL STEROID INJECTIONS

#### Comparable long-term efficacy of cervical epidural steroid injections performed with/without morphine

Castagnera, *et al.* assessed the long-term impact of administering one cervical epidural steroid injection (CESI) without (14 with 0.5% lidocaine plus triamcinolone acetonide) (S group) and with morphine sulfate (10 mL steroid plus morphine sulfate 2.5 mg) (S + M group).<sup>[11]</sup> Patients randomized to both groups had experienced over 12 months of cervical radiculopathy, but were not considered surgical candidates. Cervical epidural injections, performed from C7-T1 with an 18-gauge needle and up to 10 mL of isotonic saline, were utilized to treat patient's radicular complaints. Evaluations, performed up to 48 post-injection months, revealed that "despite observing a better transient improvement the day after CESI in the S + M group, long-term results did not differ between the two. Success rates were respectively 78.5% (S), and 80% (S + M), and specific pain relief was also comparable: 86.8% (S) and 86.9% (S + M).

**Summary:** Castagnera, *et al.* noted that long-term results (48 post-injection months) did not differ between two

groups of patient with nonsurgical cervical disease, receiving one dose of epidural steroids with lidocaine (S) vs. steroids with morphine sulfate (S + M).<sup>[11]</sup> Success rates were 78.5% (S), and 80% (S + M), and specific pain relief was also comparable: (86.8% (S) and 86.9% (S + M).<sup>[11]</sup>

#### Minimal complications of cervical epidural steroid spinal injections performed under fluoroscopy

Botwin, *et al.* in a retrospective cohort study, evaluated the frequency of complications associated with utilizing fluoroscopy to perform cervical epidural spinal injections [Table 1].<sup>[9]</sup> The series included 157 consecutive patients with cervical radiculopathy attributed to MR or CT documented disc disease or spondylosis; patients were followed up to 1 post-injection year. Epidural injections were performed utilizing an interlaminar technique at the C7-T1 or C6-C7 levels with an 18-gauge or 9-mm Tuohy needle. Patients were injected with 2 mL of 1% lidocaine (Xylocaine) and 80 mg of triamcinolone acetonide (Kenalog). The 157 patients, who received 345 injections, exhibited a 16.8% overall complication rate. Complications included: 23 with increased neck pain (6.7%), 16 with non-positional headaches (resolved within 24 hours) (4.6%), 6 with insomnia (night of the injection) (1.7%), 6 vasovagal reactions (1.7%), 5 facial flushing (1.5%), 1 with fever the night of the procedure (0.3%), and 1 with an inadvertent DP (0.3%). As no patients required hospital stays and no morbidity persisted, the authors concluded that fluoroscopically guided interlaminar cervical epidural injections were safe for patients with cervical radiculopathy.

**Summary:** In the Botwin, *et al.* series involving 157 patients undergoing 354 CESIs at the C6-C7 or C7-T1 levels, although 16.8% of patients exhibited complications, none required hospital stays or developed persistent morbidity.<sup>[9]</sup>

#### Few complications of cervical epidural steroid injections

Abbasi, *et al.* reviewed the literature regarding complications of interlaminar CESI injection.<sup>[1]</sup> Most of the complications were reported in poorly designed studies (e.g., retrospective studies, case reports, and "extrapolated" data). Complications, varying from 0% to 16.8%, were typically categorized as minor or major. The authors concluded that the literature is limited in providing useful information regarding the complications of epidural cervical steroid injections, and that data needs to be gathered from future randomized, double-blind analyses.

**Summary:** Abbasi, *et al.* concluded that a review of the literature revealed a 0-16.8% incidence of complications associated with cervical epidural spinal injections, but acknowledged that the design of most studies was



suboptimal (e.g., future prospective, randomized studies were warranted).<sup>[1]</sup>

### **Efficacy and safety (64%) of cervical epidural steroids for radiculopathy**

Rowlison and Kirschenbaum evaluated the safety/efficacy of performing 45 CESIs in managing 25 patients with cervical radiculopathy.<sup>[35]</sup> Notably, 64% of patients who exhibited good or excellent responses to these injections had previously failed to attain relief utilizing other modalities. The authors found that the patient's history, pain description, and neurological complaints/findings were valuable in patient selection. Their recommendation was that anesthesiologists, already knowledgeable about ESIs in the lower back, should utilize these same techniques in the cervical spine.

**Summary:** Rowlison and Kirschenbaum series, performing 45 CESIs in 25 patients with cervical radiculopathy, resulted in a 64% incidence of good or excellent responses.<sup>[35]</sup>

### **Few complications attributed to 1036 extraforaminal cervical nerve blocks**

Ma, *et al.* performed 1036 extraforaminal cervical nerve blocks in 844 patients (1999-2003) [Table 1].<sup>[23]</sup> The study examined the correlation between needle positioning and complications. They found no "catastrophic complications" (e.g., vessel damage, paralysis, death), but found that 14 patients (1.66%) had a minor complication. Complications attributed to deep injections (798 blocks: 1.89%) were comparable to those occurring with shallow injections (238 blocks: 0.84%). Only the anterior placement of the needle tip vs. ideal needle placement correlated with higher complication rates (6.06% vs. 1.55%). The authors concluded that this procedure was both safe and effective.

**Summary:** Performing 1036 extraforaminal cervical nerve blocks in 844 patients resulted in no major but 14 (1.66%) minor complications that more frequently occurred with deep rather than superficial injections.<sup>[23]</sup>

### **Rare cervical complications following 790 steroid epidural nerve blocks**

Waldman prospectively evaluated 215 patients who had undergone 790 consecutive cervical epidural nerve blocks [Table 1].<sup>[40]</sup> Patients were followed for 6 post-procedure weeks. Complications included: Two unintentional DPs (both required epidural blood patches (EBPs)), three vasovagal syncope, and one late superficial infection (treated with incision/drainage and oral antibiotics). He concluded that these procedures were both safe and effective with minimal sequelae.

**Summary:** Waldman evaluated 215 patients undergoing 790 cervical epidural nerve blocks. He found the following complications: Two DPs, three vasovagal events, and one delayed superficial infection.<sup>[40]</sup>

## **RISKS OF CERVICAL EPIDURAL STEROID INJECTIONS**

### **No long-standing benefit of epidural steroids/local anesthetic vs. sterile saline/local anesthetic**

In a prospective cohort study, Anderberg, *et al.* found in 40 randomized patients, epidural cervical steroid injections/local anesthetic vs. sterile saline/local anesthetic injections administered for unilateral radiculopathy/degenerative disease, produced comparable 3-week post-injection outcomes.<sup>[4]</sup> Although at 5 post-injection weeks, the patients receiving steroid injections had less pain, this was not true over the long-term. They cited other studies that documented 3 months of decreased pain with cervical ESI, but noted that they too could not confirm long-standing pain relief.

**Summary:** In Anderberg, *et al.* prospective randomized study of 40 patients undergoing either cervical ESI/local anesthetic vs. sterile saline/local anesthetic, at 5 post-injection weeks, patients receiving steroid injections had less pain, but not over the long-term.<sup>[4]</sup>

### **Permanent neurological complications (e.g., quadriplegia) associated with cervical epidural or transforaminal steroid injections**

Scanlon, *et al.* surveyed pain specialists regarding the incidence of neurologic infarctions (vascular injuries secondary to direct vascular injection) following cervical TFESIs in patients with radiculopathy [Table 1].<sup>[36]</sup> Noting these procedures are commonly performed, they cited eight instances of inadvertent brain and spinal cord injury resulting from intravascular injections. Four additional cases of major cerebellum/brainstem infarction following cervical TFESI with methylprednisolone were also identified. They utilized anonymous surveys sent to all US physician members of the American Pain Society. The 21.4% response rate (287 of 1340) revealed 78 complications: 16 vertebralbasilar brain infarcts, 12 cervical spinal cord infarcts, and 2 combined brain/spinal cord infarcts. Thirteen fatal outcomes included: 5 with brain infarcts, 1 with combined brain/spinal cord infarcts (1 following high spinal anesthesia), 1 associated with a seizure, and 5 with unspecified etiologies.<sup>[36]</sup> Four cases performed with corticosteroids alone (methylprednisolone) resulted in three cerebellar infarcts and one posterior cerebral territory infarct; three were fatal, and two autopsies demonstrated no evidence of vertebral artery trauma. The authors concluded that cervical TF-ESI may have severe neurological sequelae attributed largely to particulate corticosteroid emboli, and/or potential vertebral artery perforation (dissection/thrombosis or vasospasm).

**Summary:** Scanlon, *et al.* cited eight instances of inadvertent intravascular injections leading to brain and



spinal cord injury and identified an additional four cases of major particulate corticosteroid embolic injury to the cerebellum and brainstem in the literature.<sup>[36]</sup> In their own survey of members of the American Pain Society, the 21.4% response rate (287 of 1340) revealed 78 complications including: 16 vertebrobasilar brain infarcts, 12 cervical spinal cord infarcts, and 2 combined brain/spinal cord infarcts, with 13 fatal outcomes.

## **RISKS OF INADVERTENT INTRAVASCULAR INJECTIONS DURING ATTEMPTED CERVICAL STEROID INJECTIONS**

### **Inadvertent “vascular injections” result in quadriparesis during attempted epidural cervical steroid injections**

Bose, *et al.* noted that 64-76% of patients undergoing CESIs for pain/radiculopathy subjectively improved, and major AEs attributed to these injections were rarely reported in the literature [Table 2].<sup>[8]</sup> They felt that few clinicians report AE (due to the risk of medicolegal suits and other factors), and that few journals generally accept case reports (this is well known overall), particularly with such negative outcomes. Bose, *et al.*'s patient developed quadriplegia and respiratory arrest following an ESI at the C6-C7 level; the patient's status remained unchanged at 6 post-injection months.<sup>[8]</sup> Notably, the injection was performed by “a fellowship-trained pain management specialist in an outpatient surgicenter using C-arm fluoroscopic guidance.”<sup>[8]</sup> Despite the patient's quadriplegia, MR studies performed 6 hours after the injection and 6 months later failed to show any significant radiographic findings. The authors attributed the deficit/quadriplegia to an intravascular injection (“vascular event”).

**Summary:** In the Bose, *et al.* study, a patient developed quadriplegia and a respiratory arrest following an attempted CESI at the C6-C7 level; they concluded that it was likely a “vascular event” that left the patient with a major permanent neurological deficit.<sup>[8]</sup>

### **Transforaminal cervical injection resulted in vascular infarction to cord**

Ludwig reported a 53-year-old male with chronic cervical pain and multilevel degenerative pathology who underwent a left C6 TFESI under fluoroscopic guidance [Table 2].<sup>[22]</sup> Approximately 10-15 minutes following the procedure, he developed left arm and bilateral lower extremity weakness. The first cervical MR showed no focal abnormalities, while the 24 hour study documented a patchy increased T2 signal in the cord from the odontoid to the C4-C5 level, consistent with a diffuse infarct to the cord. This deficit was attributed to a “vascular event.” The authors concluded that transforaminal cervical injections carry an increased risk of vascular infarctions to the cord.

**Summary:** Following a left C6 TFESI, Ludwig's 53-year-old patient developed left arm and bilateral lower extremity weakness. The MR confirmed hyperintense intramedullary cord signal changes within 24 hours extending from the odontoid to the C4-C5 level, consistent with a diffuse vascular infarction.<sup>[22]</sup>

### **Inadvertent “intravascular injections” of cervical local anesthesia result in transient quadriplegia**

Karasek and Bogduk evaluated the adverse consequences of performing a C6-C7 transforaminal injection of local anesthesia that resulted in an inadvertent injection into a cervical radicular artery [Table 2].<sup>[17]</sup> Although the patient immediately became quadriplegic, fortunately it resolved within 20 minutes. They acknowledged that although injecting a local anesthetic may have only a “temporary effect on spinal cord function, particulate steroids may act as an embolus and cause permanent impairment.”<sup>[17]</sup>

**Summary:** Karasek and Bogduk noted the adverse consequences of performing a C6-C7 transforaminal injection utilizing local anesthesia that resulted in an inadvertent injection into a cervical radicular artery.<sup>[17]</sup> Their patient's immediate quadriplegia resolved within 20 minutes; however, had this been a steroid injection, particulate matter may have acted as an embolus and caused a permanent injury.

### **Cardiac arrest due to cervical epidural steroid injection**

Stauber and Nazari reported that CESIs pose a low risk of complications such as subdural hematoma, respiratory depression, vasovagal response, and pneumocephalus [Table 2].<sup>[38]</sup> They reported a 67-year-old female with rheumatoid arthritis and chronic neck pain who received a C6-C7 epidural cervical steroid injection who suffered immediate cardiopulmonary arrest. Following resuscitation, she was found to have pneumocephalus; she later recovered without sequelae. Potential reasons for her cardiac arrest included cardioacceleratory center blockade that theoretically led to blockage of the sympathetics, and marked bradycardia. Other potential mechanisms included: “Severe vasovagal response, iatrogenic pneumocephalus, and involvement of the phrenic nerve followed by apnea.”<sup>[38]</sup>

**Summary:** Stauber and Nazari's 67-year-old female following a C6-C7 epidural cervical steroid injection sustained pneumocephalus and a cardiopulmonary arrest.<sup>[38]</sup> The latter was likely attributed to blockade of the sympathetics resulting in bradycardia/arrest.

**Author's personal communication with pediatric neurosurgeons**  
A personal communication (2010) with the author revealed a 16-year-old female treated by an outside physician who became quadriplegic following a cervical epidural injection. The MR immediately demonstrated a fluid signal within the cord itself, consistent with

a direct intramedullary cord injection. Despite being treated with hyperbaric oxygen, she did not sustain a full recovery (personal communication) [Table 2].

## **MULTIPLE COMPLICATIONS OF EPIDURAL OR TRANSFORAMINAL INJECTIONS**

### **Multiple complications of epidural/transforaminal injections are often underreported**

In Landa, *et al.* review of epidural/transforaminal spinal injections, they noted that serious complications of these injections are often underreported [Table 1].<sup>[7,14,15,19,41,43]</sup> Risks typically include infection, epidural abscess, meningitis, diskitis, epidural hematoma (0-1.9% risk of retroperitoneal hematoma for patients on anticoagulation), intravascular injections, nerve trauma/damage, mistaken subdural injections of medication, intradural injections/CSF fistulas, persistent headaches, air embolism, urinary retention, exposure to increased radiation, allergic reactions, seizures, blindness, osteonecrosis, osteoporosis, weight gain, and pituitary suppression.<sup>[7,14,15,19,41,43]</sup>

**Summary:** Risks of epidural/transforaminal injections include: Infection, epidural hematoma (0-1.9%), intravascular injections, nerve damage, CSF fistulas/headaches, air embolism, urinary retention, allergic reactions, seizures, blindness, and others.<sup>[7,14,15,19,41,43]</sup>

### **Infection risks of epidural or transforaminal epidural injections**

Goodman, *et al.* cited the frequency of infections from epidural/transforaminal steroid injections as varying from 1% to 2% with more severe infections being noted in approximately 0.1% of patients [Table 1].<sup>[14]</sup>

**Summary:** Epidural/TFESIs are associated with infection rates varying from 1% to 2%, with more serious infections observed in 0.1% of patients.<sup>[14]</sup>

### **Meningitis secondary to spinal injections**

Kainer, *et al.* evaluated the outbreak of fungal infections that recently followed epidural or paraspinal injections of preservative-free MPA from one compounding pharmacy in New England.<sup>[16]</sup> Patients presented with “fungal meningitis, posterior circulation stroke, spinal osteomyelitis, or epidural abscess.” The 66 patients identified averaged 69 years of age (range 23-91), and the average time between the injection and onset of symptoms was 18 days (range 0-56). Patients exhibited meningitis (73%), cauda equina syndrome or focal infection (15%), or posterior circulation stroke/with or without meningitis (12%). Complaints included headache (73%), new/increased back pain (50%), neurologic symptoms (48%), nausea (39%), and neck stiffness (29%). CSF white-cell counts from initial lumbar

punctures for those with flagrant meningitis (with/without stroke vs. focal infection) was 648 per cubic millimeter (range 6-10,140). Protein levels averaged 114 mg per deciliter (range 29-440), while glucose levels averaged 44 mg per deciliter (range 12-121). Twenty-two patients had laboratory documentation of: *Exserohilum rostratum* infection (21 patients) or *Aspergillus fumigatus* infection (1 patient). Infection risk increased with “exposure to lot 06292012@26, older vials, higher doses, multiple procedures, and translaminar approaches.” Treatment included Voriconazole (61 patients: 92%), while 35 patients (53%) were also treated with liposomal amphotericin B. Notably, 9 patients (12%) died, and 7 of the 9 had sustained a stroke.

**Summary:** Kainer, *et al.* evaluated the recent outbreak of fungal infections that recently followed epidural or paraspinal injections of preservative-free MPA from one compounding pharmacy in New England.<sup>[16]</sup> They reported that 66 patients, averaging 69 years of age exhibited meningitis (73%), cauda equina syndrome or focal infection (15%), or posterior circulation stroke/with or without meningitis (12%). Despite treatment with Voriconazole (61 patients: 92%) supplemented in 35 patients (53%) with liposomal amphotericin B, 9 patients (12%) died, and 7 of the 9 had sustained a stroke.

### **Epidural abscess secondary to spinal injections**

Zimmerer, *et al.* evaluated 36 patients (31 with major comorbidities) with spinal epidural abscesses (SEA) treated over a 4-year period [Table 1].<sup>[43]</sup> Followed from between 12 and 60 posttreatment months, they most commonly exhibited *Staphylococcus aureus* (18 patients = 50%). For 16 patients (44%), the SEA occurred due to primary hematogenous spread. In the remaining 20 (56%) patients, it was secondary to spinal injections (4 patients) or surgery (16 patients). The frequency of injection-induced SEA was 11.1% for the series overall and comprised 20% of those with secondary causes (surgery/injections) for developing SEA infections.

**Summary:** In the Zimmerer, *et al.* study of 36 patients with SEA, 4 patients had undergone spinal injections and comprised 11.1% of patients in the overall series, but a higher 20% of those with secondary (surgery vs. injection) reasons for developing SEA.<sup>[43]</sup>

### **Risks of epidural abscess and meningitis warrant antibiotic prophylaxis**

Epidural abscess and/or meningitis rarely occur following epidural corticosteroid injections.<sup>[15]</sup> In 14 cases of epidural abscesses elicited from the literature, 8 (67%) had positive blood, CSF, or epidural pus cultures documenting *Staphylococcus aureus*. The recommendation is that patients undergoing these procedures should receive appropriate preprocedure prophylactic antibiotics.

**Summary:** In 14 cases of epidural abscess or meningitis

identified in the literature attributed to ESIs, 8 (67%) exhibited positive blood, CSF, or epidural pus cultures documenting *Staphylococcus aureus*, suggesting that appropriate antibiotic prophylaxis for these procedures is warranted.<sup>[15]</sup>

## **RISKS OF DURAL PUNCTURE/ CEREBROSPINAL FLUID FISTULAS/ PERSISTENT HEADACHES**

### **Risks of inadvertent dural puncture (0.04–6%) and 86% inefficacy of epidural blood patches (EBP) for patients in labor receiving epidural analgesia**

Berger, *et al.* observed that an excellent way to evaluate the frequency of intradural punctures occurring during epidural injections was to study those occurring inadvertently during epidural analgesia for women in labor [Table 1].<sup>[7]</sup> Their survey included 36 (78%) of 46 academic institutions in the US and Canada, involving 137,250 annual deliveries. The frequency of inadvertent DP ranged from 0.04% to 6%. These were typically managed without bed rest (85% were mobilized), with increased oral hydration (61%), and with EBPs (37% within 24 hours). Although multiple AEs occurred as a consequence of performing EBPs, the two most salient ones included an 86% incidence of patch failures, and 44% frequency of persistent headaches. They concluded, “Optimism regarding the efficacy of EBP is not supported by the evidence available, and may be unwarranted.”

**Summary:** In a survey of 36 academic institutions involving 137,250 women in labor/deliveries, Berger, *et al.* found the frequency of inadvertent DPs occurring during epidural analgesia ranged from 0.4% to 6%.<sup>[7]</sup> Notably, EBPs failed in 86% of patients, and 44% experienced persistent headaches.

### **0.4–6% Incidence of CSF leaks resulting in postural headaches following epidural injections for patients in labor**

Webb, *et al.* also reported that for women receiving an epidural anesthetic for childbirth, the frequency of inadvertent DP (17-gauge Tuohy needle) ranged from 0.4% to 6% [Table 1].<sup>[41]</sup> This resulted in a high incidence of postural headaches (between 70% and 80%) that persisted (e.g., chronic headaches) in 28% of patients vs. 5% of matched controls. Few studies clearly cited the risk of CSF fistulas following “epidural spinal injections,” and even fewer document the relatively high incidence of spinal headaches (often persistent) that follow.

**Summary:** Webb, *et al.* reported a higher baseline but comparable maximum risk (0.4–6%) of inadvertent DP utilizing a 17-gauge Tuohy needle to administer epidural analgesia for women in labor.<sup>[41]</sup> The frequency of postural headaches was a higher 70–80%, with 28% exhibiting chronic headaches compared with only a 5% frequency of headaches for matched controls.

## **Inadvertent dural and subdural punctures**

Goodman, *et al.* discussed how epidural spinal injections/transforaminal injections should be performed, but noted that inadvertent dural and subdural punctures and injections of steroids do occur.<sup>[13]</sup> Interventionalists performing these procedures should be able to recognize the different patterns of contrast dissemination for those subjected to subdural punctures, and should avoid direct injections of steroids into the subdural or intrathecal compartments.

**Summary:** Goodman, *et al.* noted two cases in which TLES and TFLEI resulted in dural and subdural punctures.<sup>[13]</sup> Interventionalists should recognize the different patterns of contrast dissemination, and should particularly avoid the direct injection of steroids into the epidural compartment.

## **Epidural injections resulting in inadvertent dural puncture and subdural injections**

Goodman, *et al.* also reported two cases of dural penetration during lumbar TFESIs [Table 1].<sup>[13,14]</sup> This resulted in the subdural and intrathecal spread of contrast. Interventionalists should recognize the radiographic signs of inadvertent intradural and subdural injections of contrast, and avoid subsequently injecting steroids.<sup>[13]</sup>

**Summary:** In Goodman, *et al.*, two cases of TFESIs resulted in inadvertent intradural and subdural injections.<sup>[13]</sup>

## **ADHESIVE ARACHNOIDITIS**

### **Increased risks of adhesive arachnoiditis following intrathecal injection of methylprednisolone: Animal-based laboratory study**

Lima, *et al.* documented in a randomized, double-blind, controlled animal trial that intradural injection (e.g., model for clinical inadvertent epidural injection), of methylprednisolone (e.g., inadvertent injection clinically feasible), one of the steroids commonly used to perform epidural injections, resulted in complications including adhesive arachnoiditis.<sup>[21]</sup> In their study they documented the histological changes attributed to the intrathecal injection of methylprednisolone in dogs. The study included 14 dogs who received intrathecal injections; Group I received 1 mL of 0.9% normal saline, while Group II received 1 mL (1.15 mg/kg) methylprednisolone. At 21 days, their lumbar and sacral spinal cords were histologically examined. Group I dogs showed no histological changes, while Group II animals demonstrated: “Meningeal thickening and lymphocytic infiltrates in the blood vessels,” “adhesion of pia, arachnoid, and dura matter and the nerve roots were surrounded by fibrosis (3 animals),” and “necrosis of the spinal cord (1 animal).” The authors concluded that intrathecal injection of methylprednisolone directly contributed to “histological changes in the spinal cord and meninges of the animals studied.”

**Summary:** When Lima, *et al.* performed intrathecal injections of normal saline vs. methylprednisolone into dog models, methylprednisolone resulted in the following histological changes: “Meningeal thickening, lymphocytic infiltrates in the blood vessels, adhesion of pia, arachnoid, and dura matter with nerve roots were surrounded by fibrosis and necrosis of the spinal cord.”<sup>[21]</sup>

### **Clinical example of irreversible paraplegia secondary to adhesive arachnoiditis**

Rodriguez Luna, *et al.* reported that adhesive arachnoiditis occurs in between 6% and 16% of patients having primary or revision lumbar surgery.<sup>[33]</sup> They reported a 40-year-old patient who following lumbar surgery developed adhesive arachnoiditis and persistent serous fluid drainage resulting in an irreversible cauda equina syndrome.

**Summary:** Rodriguez Luna, *et al.* reported that adhesive arachnoiditis occurs in between 6% and 16% of patients having primary or revision lumbar surgery.<sup>[33]</sup>

### **Clinical example of postoperative spinal adhesive arachnoiditis resulting in hydrocephalus and cauda equina syndrome**

Koerts, *et al.* described how a 45-year-old male developed the delayed presentation of spinal adhesive arachnoiditis characterized by hydrocephalus and a cauda equina syndrome following multiple spine operations.<sup>[18]</sup> The authors review the literature for adhesive arachnoiditis, noting that 86% of cases occur in the lumbar region, and are variously attributed to contamination of the subarchnoid space with blood (e.g., CSF leak/dural tear), infection, myelography (especially oil-based), ESIs, spinal surgery (disc/stenosis), and trauma. Typically, MR studies may demonstrate clumped nerve roots attached to the peripheral dura or centrally clumped. These findings are attributed to increased intradural fibrin deposition, inflammatory responses, collagen deposition, and granulomatous reaction.

**Summary:** Koerts, *et al.* reported that 86% of cases of spinal adhesive arachnoiditis occur in the lumbar region, and are due to: Contamination of the subarchnoid space with blood (e.g., CSF leak/dural tear), infection, myelography (especially oil-based), ESIs, spinal surgery (disc/stenosis), and trauma.<sup>[18]</sup>

### **Increased risks of adhesive arachnoiditis and subdural hematoma with epidural blood patch for postdural puncture headaches in 2 patients**

Riley and Spiegel documented subdural hematoma and adhesive arachnoiditis as the result of utilizing large volume EBPs in patients with postdural puncture headaches in two patients.<sup>[31]</sup>

**Summary:** Riley and Spiegel documented subdural hematoma and subdural hematoma with adhesive arachnoiditis with chronic sacral radiculopathy as the

result of utilizing large volume EBPs in two respective patients with postdural puncture headaches.<sup>[31]</sup>

### **DIRECT CONTRAINDICATIONS FOR EPIDURAL STEROID INJECTIONS**

Direct contraindications to performing ESIs include patients who have had previous surgery (e.g., laminectomy where there is no epidural compartment), or where the patient has/had an infection. Failing to heed these restrictions will result in higher peri-procedural complications.

**Summary:** Direct contraindications to performing ESIs include prior surgery and infection.

### **COSTS OF EPIDURAL INJECTIONS: FACILITY AND PHYSICIAN FEES**

In The Medical Bill Survival Guide (Amazon.com), Nichols Newsad wrote about the costs of epidural spinal injections.<sup>[27]</sup> No Fault and Worker’s Compensation are major primary insurers covering pain management. Differences in cost are largely dependent on where these procedures are performed. Hospital or ASCs are more expensive (overhead), and include the costs of both anesthesia and the C-arm. A C-arm (costs about \$100,000) is readily available in a hospital/ASC, but not in a physicians office, and its use is (unfortunately for the patients) typically not reimbursed. Over 50% of the ASCs in the US are at least partially owned by doctors and physicians prescribing and performing these procedures, and thus, financially gaining from where these procedures are performed. More and more, insurance companies are trying to motivate physicians to perform nerve blocks in their offices, avoiding institutional fees (and without the benefit/safety of fluoroscopy); reportedly, fees vary from \$300 to \$650. Fees for nerve blocks may range from \$83 in an ASC vs. \$183 in a private office. The physician in-office fee for an epidural injection averaged \$247 vs. in an ASC setting \$107. Financial considerations must be weighed along with the risks and benefits of where epidural spinal injections are performed. Clearly, hospital/ASC settings, which have the added benefit of fluoroscopic guidance should not be discouraged by insurance companies offering reduced reimbursement.

**Summary:** Many insurance companies motivate physicians (with higher reimbursements) to perform epidural injections in their office (typically without the benefit/added safety of fluoroscopy (typically not reimbursed) to avoid facility fees.<sup>[27]</sup> Fees quoted for nerve blocks ranged from \$83 in an ASC vs. \$183 in an office, while those for epidural injections performed in an ASC averaged \$107 vs. \$247 in an office; facility fees also varied typically from \$300 to \$650.



## CONCLUSION

### Epidural injections are the most common nerve blocks

Epidural/transforaminal or other types of epidural spinal injections and/or facet injections/nerve root blocks are now the most commonly performed procedures in the US for managing chronic low back pain. They are being performed in record numbers, often by anesthesiologists, physiatrists, and radiologists who are neither trained in nor have any expertise in neurology or spinal (neurosurgical/orthopedic) surgery. Furthermore, these procedures are not FDA approved, and, according to the majority of the literature, are both ineffective and unsafe.<sup>[7,10,14,15,19,39,41,43]</sup>

#### *Increased frequency of epidural/transforaminal injections*

Medicare data alone document a 160% increase in these procedures between 2000 and 2012, while also noting that about (probably at least) 20% of those performing these procedures are inadequately trained.<sup>[29]</sup>

#### *Comparable efficacy of epidural steroids vs. Epidural saline injections*

Valat, *et al.* compared the efficacy of ESIs vs. isotonic saline, and found that “the efficacy of isotonic saline administered epidurally for sciatica cannot be excluded, but ESIs provide no additional improvement.”<sup>[39]</sup>

In the Anderberg, *et al.* prospective randomized study of 40 patients undergoing either cervical ESI/local anesthetic vs. sterile saline/local anesthetic, at five post-injection weeks, patients receiving steroid injections had less pain, but not over the long-term.<sup>[4]</sup>

#### *Comparable outcomes and no reduction in need for surgery*

Carette, *et al.*, in a double-blind, randomized trial, determined that for 158 patients with herniated discs, evaluated utilizing the ODI at 3, 6, 12 weeks and 1 year following injections, that even if epidural methylprednisolone resulted in some short-term benefits, it “offers no significant functional benefit, nor does it reduce the need for surgery.”<sup>[10]</sup> Arden *et al.* similarly determined that although ESI offered transient benefits in symptoms at 3 weeks in patients with sciatica, there were no sustained benefits in terms of pain, function, or the eventual need for surgery.<sup>[5]</sup>

### Risks of epidural/transforaminal injections

Patients with both nonsurgical and surgical disease are being exposed to significant risks/complications associated with epidural/transforaminal injections, which include: Infection (diskitis, osteomyelitis, epidural abscess, meningitis), epidural hematoma (0-1.9%), intravascular injections, nerve damage/increased neurological deterioration/paralysis/quadruplegia, intravascular injections (7.9-11.6%), CSF fistulas (up to 6%)/persistent headaches (28%), air embolism, urinary retention, allergic reactions, seizures, adhesive arachnoiditis, blindness, and others.<sup>[7,14,15,19,41,43]</sup>

#### *Risks of meningitis*

Kainer, *et al.* reported on the recent outbreak of fungal infections attributed to epidural or paraspinal injections of preservative-free MPA from one compounding pharmacy in New England.<sup>[16]</sup> The 66 patients (averaging 69 years of age) exhibited meningitis (73%), cauda equina syndrome or focal infection (15%), or posterior circulation stroke/with or without meningitis (12%). Even with treatment, utilizing Voriconazole (61 patients: 92%) supplemented in 35 patients (53%) with liposomal amphotericin B, 9 patients (12%) died; 7 of the 9 had sustained a stroke.<sup>[16]</sup>

By October 29, 2012, the CDC had identified 25 deaths due to epidural steroid-related meningitis (many due to Aspergillosis), with 337 patients sickened in 18 states, and an additional 14,000 patients likely exposed to contaminated steroids.<sup>[3]</sup>

#### *Facet joint injections: Ineffective and associated with multiple complications*

Facet joint injections are ineffective, and may, furthermore, be associated with significant complications. Manchikanti, *et al.* reported on 43,000 intermittent fluoroscopically guided facet joint nerve blocks injections performed during 7500 visits, and observed the following complications: Intravascular injection (11.4%), local bleeding (76.3%), oozing (19.6%), and local hematoma with profuse bleeding (1.2%).<sup>[25]</sup>

#### *Complication rate 0-16.8% for cervical epidural/transforaminal injections*

Abbasi, *et al.* concluded that a review of the literature revealed a 0-16.8% incidence of complications associated with cervical epidural spinal injections.<sup>[1]</sup>

#### *Specific risks of inadvertent intravascular injections leading to brain/cord injury*

Scanlon, *et al.* cited eight instances of inadvertent intravascular injections leading to brain and spinal cord injury and identified an additional four cases of major particulate corticosteroid embolic injury to the cerebellum and brainstem in the literature.<sup>[36]</sup> In their own survey of members of the American Pain Society, the 21.4% response rate (287 of 1340) revealed 78 complications including: 16 vertebrobasilar brain infarcts, 12 cervical spinal cord infarcts, and 2 combined brain/spinal cord infarcts, with 13 fatal outcomes.

In Bose, *et al.*, a patient developed quadriplegia and a respiratory arrest following an attempted CESI at the C6-C7 level, concluding that it was likely a vascular event that left the patient with a major permanent neurological deficit.<sup>[8]</sup>

Following a left C6 TFESI, Ludwig's 53-year-old patient developed left arm and bilateral lower extremity weakness, and MR confirmed intramedullary cord signal changes within 24 hours from the odontoid to the C4-C5 levels consistent with diffuse vascular infarction.<sup>[22]</sup>



Karasek and Bogduk noted the adverse consequences of performing a C6-7 transforaminal injection utilizing local anesthesia that resulted in an inadvertent injection into a cervical radicular artery.<sup>[17]</sup> Their patient's immediate quadriplegia resolved within 20 minutes; however, had this been a steroid injection, particulate matter may have acted as an embolus and caused a permanent injury.

#### *Risk of quadriplegia with intramedullary cervical injection*

A personal communication with the author revealed a 16-year-old female treated by an outside physician who became quadriplegic following a cervical epidural injection.

#### *Risk of cardiopulmonary arrest and pneumocephalus with cervical ESI*

In Stauber and Nazari's case study, a 67-year-old female, following a C6-C7 epidural cervical steroid injection, sustained pneumocephalus and a cardiopulmonary arrest.<sup>[38]</sup> They attributed the latter to temporary blockade of the sympathetics.

#### *Risk of Adhesive Arachnoiditis*

##### *Animal series*

When Lima, *et al.* performed intrathecal injections of normal saline vs. methylprednisolone into dogs model, methylprednisolone resulted in the following histological changes: "Meningeal thickening, lymphocytic infiltrates in the blood vessels, adhesion of pia, arachnoid, and dura mater with nerve roots were surrounded by fibrosis and necrosis of the spinal cord."<sup>[21]</sup>

##### *Clinical series*

Adhesive arachnoiditis occurs in between 6% and 16% of patients undergoing primary or revision lumbar surgery.<sup>[33]</sup> Over 86% of these cases occur in the lumbar region, and are due to: Contamination of the subarchnoid space with blood (e.g., CSF leak/dural tear), infection, myelography (especially oil-based), ESIs, spinal surgery (disc/stenosis), and trauma.<sup>[18]</sup> In one study, a 40-year-old patient developed an irreversible cauda equina syndrome attributed to adhesive arachnoiditis following lumbar surgery.<sup>[33]</sup> In a second case, a 45-year-old male developed delayed adhesive arachnoiditis, hydrocephalus, and a cauda equina syndrome several years following multiple spinal operations.<sup>[18]</sup> In a third study, two patients who were treated for postural headaches with EBPs, respectively, developed a subdural hematoma and subdural hematoma with adhesive arachnoiditis/chronic sacral radiculopathy due to large volumes of epidural blood utilized to perform these patches, and in the latter case, the number of patches placed in a short period of time.<sup>[31]</sup>

#### **Insurers promoting unsafe practices**

Many insurance companies motivate physicians (with higher reimbursements) to perform epidural injections in their office (typically without fluoroscopy, which is often

not reimbursed (yet costs \$100.00) to avoid facility fees.<sup>[27]</sup> Fees quoted for epidural injections performed in an ASC averaged \$107 vs. \$247 in an office; facility fees varied typically from \$300 to \$650. Insurance companies should be admonished for promoting unsafe practices.

## REFERENCES

- Abbasi A, Malhotra G, Malanga G, Elovic EP, Kahn S. Complications of interlaminar cervical epidural steroid injections: A review of the literature. *Spine (Phila Pa 1976)* 2007;32:2144-51.
- Ahadian FM, McGreevy K, Schulteis G. Lumbar transforaminal epidural dexamethasone: A prospective, randomized, double-blind, dose-response trial. *Reg Anesth Pain Med* 2011;36:572-8.
- American Medical Association Morning Rounds, in Affiliation with Bulletin HEALTHCARE, CDC: 25 dead in meningitis outbreak, cases reach 337 in 18 states. Monday, October 29, 2012.
- Anderberg L, Annertz M, Persson L, Brandt L, Säveland H. Transforaminal steroid injections for the treatment of cervical radiculopathy: A prospective and randomized study. *Eur Spine J* 2007;16:321-8.
- Arden NK, Price C, Reading I, Stubbing J, Hazelgrove J, Dunne C, *et al.* A multicentre randomized controlled trial of epidural corticosteroid injections for sciatica: The WEST study. *Rheumatology (Oxford)* 2005;44:1399-406.
- Benny B, Azari P. The efficacy of lumbosacral transforaminal epidural steroid injections: A comprehensive literature review. *J Back Musculoskelet Rehabil* 2011;24:67-76.
- Berger CW, Crosby ET, Grodecki W. North American survey of the management of dural puncture occurring during labor epidural analgesia. *Can J Anaesth* 1998;45:110-4.
- Bose B. Quadriplegia following cervical epidural steroid injections: Case report and review of the literature. *Spine J* 2005;5:558-63.
- Botwin KP, Castellanos R, Rao S, Hanna AF, Torres-Ramos FM, Gruber RD, *et al.* Complications of fluoroscopically guided interlaminar cervical epidural injections. *Arch Phys Med Rehabil* 2003;84:627-33.
- Carette S, Leclaire R, Marcoux S, Morin F, Blaise GA, St-Pierre A, *et al.* Epidural corticosteroid injections for sciatica due to herniated nucleus pulposus. *N Engl J Med* 1997;336:1634-40.
- Castagnera L, Maurette P, Pointillart V, Vital JM, Erny P, S  n  gas J. Long-term results of cervical epidural steroid injection with and without morphine in chronic cervical radicular pain. *Pain* 1994;58:239-43.
- Centers for Disease Control and Prevention (CDC). Multistate outbreak of fungal infection associated with injection of methylprednisolone acetate solution from a single compounding pharmacy-United States, 2012. *MMWR Morb Mortal Wkly Rep* 2012;61:839-42.
- Goodman BS, Bayazitoglu M, Mallemapati S, Noble BR, Geffen JF. Dural puncture and subdural injection: A complication of lumbar transforaminal epidural injections. *Pain Physician* 2007;10:697-705.
- Goodman BS, Posecion LV, Mallemapati S, Bayazitoglu M. Complications and pitfalls of lumbar interlaminar and transforaminal epidural injections. *Curr Rev Musculoskelet Med* 2008;1:212-22.
- Hooten WM, Kinney MO, Huntoon MA. Epidural abscess and meningitis after epidural corticosteroid injection. *Mayo Clin Proc* 2004;79:682-6.
- Kainer MA, Reagan DR, Nguyen DB, Wiese AD, Wise ME, Ward J, *et al.* Fungal infections associated with contaminated methylprednisolone in Tennessee. *N Engl J Med* 2012;367:2194-203.
- Karasek M, Bogduk N. Temporary neurologic deficit after cervical transforaminal injection of local anesthetic. *Pain Med* 2004;5:202-5.
- Koerts G, Rooijackers H, Abu-Serieh B, Cosnard G, Raftopoulos C. Postoperative spinal adhesive arachnoiditis presenting with hydrocephalus and cauda equina syndrome. *Clin Neurol Neurosurg* 2008;110:171-5.
- Landa J, Kim Y. Outcomes of interlaminar and transforaminal spinal injections. *Bull NYU Hosp Jt Dis* 2012;70:6-10.
- Lee JH, An JH, Lee SH. Comparison of the effectiveness of interlaminar and bilateral transforaminal epidural steroid injections in treatment of patients with lumbosacral disc herniation and spinal stenosis. *Clin J Pain* 2009;25:206-10.
- Lima RM, Navarro LH, Carness JM, Barros GA, Marques ME, Solanki D,

- et al. Clinical and histological effects of the intrathecal administration of methylprednisolone in dogs. *Pain Physician* 2010;13:493-501.
22. Ludwig MA, Burns SP. Spinal cord infarction following cervical transforaminal epidural injection: A case report. *Spine (Phila Pa 1976)* 2005;30:E266-8.
23. Ma DJ, Gilula LA, Riew KD. Complications of fluoroscopically guided extraforaminal cervical nerve blocks. An analysis of 1036 injections. *J Bone Joint Surg Am* 2005;87:1025-30.
24. Manchikanti L, Cash KA, McManus CD, Pampati V, Fellows B. Results of 2-year follow-up of a randomized, double-blind, controlled trial of fluoroscopic caudal epidural injections in central spinal stenosis. *Pain Physician* 2012;15:371-84.
25. Manchikanti L, Malla Y, Wargo BW, Cash KA, Pampati V, Fellows B. Complications of fluoroscopically directed facet joint nerve blocks: A prospective evaluation of 7,500 episodes with 43,000 nerve blocks. *Pain Physician* 2012;15:E143-50.
26. Manchikanti L, Malla Y, Wargo BW, Cash KA, Pampati V, Fellows B. A prospective evaluation of complications of 10,000 fluoroscopically directed epidural injections. *Pain Physician* 2012;15:131-40.
27. Newsad N. Medical Bill Survival Guide (print and e-book). Available from: <http://www.Amazon.com>. [Last accessed on 2012 Aug 17].
28. Parr AT, Diwan S, Abdi S. Lumbar interlaminar epidural injections in managing chronic low back and lower extremity pain: A systematic review. *Pain Physician* 2009;12:163-88.
29. Pollack A. Before a wave of meningitis, shots were tied to risks. *Health: New York Times*; 2012.
30. Riew KD, Yin Y, Gilula L, Bridwell KH, Lenke LG, Lauryssen C, et al. The effect of nerve-root injections on the need for operative treatment of lumbar radicular pain. A prospective, randomized, controlled, double-blind study. *J Bone Joint Surg Am* 2000;82-A: 1589-93.
31. Riley CA, Spiegel JE. Complications following large-volume epidural blood patches for postdural puncture headache. Lumbar subdural hematoma and arachnoiditis: Initial cause or final effect? *J Clin Anesth* 2009;21:355-9.
32. Roberts ST, Willick SE, Rho ME, Rittenberg JD. Efficacy of lumbosacral transforaminal epidural steroid injections: A systematic review. *PM R* 2009;1:657-68.
33. Rodríguez Luna JG, Sandoval Sánchez V, Benavides Rodríguez D, Olivares Camacho JL, Taboada JB. Paraplegia due to adhesive arachnoiditis. A case report. *Acta Ortop Mex* 2009;23:232-6.
34. Rosas HG, Lee KS. Performing fluoroscopically guided interlaminar lumbar epidural injections. *AJR Am J Roentgenol* 2012;199:419.
35. Rowlingson JC, Kirschenbaum LP. Epidural analgesic techniques in the management of cervical pain. *Anesth Analg* 1986;65:938-42.
36. Scanlon GC, Moeller-Bertram T, Romanowsky SM, Wallace MS. Cervical transforaminal epidural steroid injections: More dangerous than we think? *Spine (Phila Pa 1976)* 2007;32:1249-56.
37. Schaufele MK, Hatch L, Jones W. Interlaminar versus transforaminal epidural injections for the treatment of symptomatic lumbar intervertebral disc herniations. *Pain Physician* 2006;9:361-6.
38. Stauber B, Ma L, Nazari R. Cardiopulmonary arrest following cervical epidural injection. *Pain Physician* 2012;15:147-52.
39. Valat JP, Giraudeau B, Rozenberg S, Goupille P, Bourgeois P, Micheau-Beaugendre V, et al. Epidural corticosteroid injections for sciatica: A randomized, double blind, controlled clinical trial. *Ann Rheum Dis* 2003;62:639-43.
40. Waldman SD. Complications of cervical epidural nerve blocks with steroids: A prospective study of 790 consecutive blocks. *Reg Anesth* 1989;14:149-51.
41. Webb CA, Weyker PD, Zhang L, Stanley S, Coyle DT, Tang T, et al. Unintentional dural puncture with a Tuohy needle increases risk of chronic headache. *Anesth Analg* 2012;115:124-32.
42. Wilson-MacDonald J, Burt G, Griffin D, Glynn C. Epidural steroid injection for nerve root compression. A randomized, controlled trial. *J Bone Joint Surg Br* 2005;87:352-5.
43. Zimmerer SM, Conen A, Müller AA, Sailer M, Taub E, Flückiger U, et al. Spinal epidural abscess: Etiology, predisponent factors and clinical outcomes in a 4-year prospective study. *Eur Spine J* 2011;20:2228-34.

