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Iatrogenic cervical spinal cord injury after interlaminar cervical epidural injection

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ABSTRACT

Objectives: Describe a catastrophic complication of cervical epidural injection (CEI) in a patient with prior anterior cervical discectomy with fusion (ACDF).

Setting: Interlaminar CEI at C7-T1 was performed under minimal sedation.

Discussion: Right hemiparesis, diffuse dysesthesia, and tactile allodynia were immediately described after the procedure. 24 hours after CEI, an MRI showed an increased T2 signal and decreased T1 signal in the spinal cord extending from C3-T3. Postsurgical ACDF changes, cervicovertebral ligament anomalies, repetitive microtrauma from serial CEI's, and epidural space compromise may have complicated the loss of resistance technique and increased the risk for dural puncture and intrinsic cord injury.

Conclusion: Knowledge of cervical spinal anatomy, biomechanical implications of ACDF, ligamentous inflammation, pre-operative image review, and perioperative patient feedback are valuable insights that may mitigate the risk of severe adverse events.

Dear Editor,

Globally, it is estimated that neck pain is ranked fourth among 291 conditions that contribute to years of living with disability. Neck pain also ranks twenty-first in terms of overall burden as defined by disability-adjusted life years [1]. While acute neck pain frequently resolves with conservative management, interventions such as epidural injections or surgical procedures are often considered in the treatment paradigm for chronic refractory neck pain. Cervical epidural injections (CEI) are generally indicated for conditions like cervical radiculopathy and radiculitis showing mixed efficacy and are less extensively studied for cases of discogenic pain, axial pain, spinal stenosis, and post-surgery syndrome [2,3]. The therapeutic mechanism behind epidural injections is to allow for the anti-inflammatory properties of the injectate to inhibit prostaglandin synthesis and reduce inflammatory mediators at targeted areas [4]. In about 35% of patients with radicular pain, injections provide pain relief and disability improvements after two months [5]. In more than 80% of patients, these interventions may delay or avoid surgical management at a minimum of two years [6]. For those with persistent, mixed nociceptive and neuropathic pain postoperatively and therefore diagnosed with cervical post-surgery syndrome, CEIs were shown to have significant improvement in both pain relief and functional status in approximately 70% of the patients after 2 years [4,7]. As CEI use expands, with approximately 200,000 cervical injections performed annually and an 119% increase in cervical and thoracic interlaminar injections from 2000 to 2013 in the Medicare population, the serious complications of these injections must be highlighted [8,9]. Additionally, there remains a gap in literature on the risk of CEI complications for patients with prior spinal decompression experiencing cervical post-surgery syndrome. Here, we present our experience with a patient who developed a spinal cord injury (SCI) after interlaminar CEI for uncontrolled cervicalgia in this setting.

A woman in her mid-40's presented to the emergency room with diffuse pain, prickling sensations, and right upper and lower extremity weakness, immediately after an outpatient interlaminar CEI at the C7-T1 level. She had a history of cervical herniated discs, degenerative disc disease, rheumatoid arthritis, and had previously undergone anterior cervical discectomy and fusion (ACDF) at the C4–C5 and C5–C6 levels six years prior. Over this six-year interval period, she received cervical epidurals every four to six months by the same outpatient pain management practice, both with and without minimal sedation given preoperative anxiety. Her cervicalgia consisted primarily of daily axial neck pain, intermittently burning in quality without radicular symptoms or motor weakness, that would ultimately improve in severity and frequency after CEI and gradually return over the ensuing months. The details of whether a pre-procedure MRI was reviewed and an illustrative view of fluoroscopic images are not available to the authors. Based on the operative note, for the most recent injection, the patient was first placed in prone position and underwent sterile preparation. Minimal sedation was administered with 2mg of intravenous midazolam to achieve anxiolysis, with the patient remaining alert, oriented, and immediately responsive to verbal and tactile stimuli. Superficial anesthesia was provided just right of midline over the superior aspect of the T1 lamina visualized on an anteroposterior (AP) view using a standard 1.5 inch 27-gauge needle with 3 mL of lidocaine 1% without epinephrine. Then, a 3.5 inch 18-gauge Tuohy needle was advanced perpendicular to the skin just right lateral of midline to the superior aspect of the T1 lamina using the loss of resistance (LOR) technique. Upon advancement, the patient expressed significant distress and burning dysesthesia beyond baseline in her neck and low back. The proceduralist retracted the needle within the ligamentous plane and the patient's pain reduced in severity. The needle was redirected about 1 cm lateral to the initial position to reengage the ligamentum flavum. A lateral view was obtained showing the needle in close approximation posterior to the

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spinolaminar line. LOR was achieved as the spinolaminar line was traversed. Then, after negative aspiration, 3 mL of Omnipaque 240 was injected with extension tubing using live fluoroscopy demonstrating epidural spread, and an injectate consisting of 3 mL of lidocaine 1%, 1 mL of dexamethasone, and 2 mL of normal saline was slowly administered. Following the injection, she described severe and persisting dysesthesias that evolved over her chest and armpits, tactile allodynia, and right-sided hemiparesis. The patient was then transferred to the nearest acute care facility via EMS.

The patient's vital signs were unremarkable (blood pressure 127/80, heart rate 88 bpm, respiratory rate 18 cpm, temperature 98.4 F, SpO2 98% on room air) without dysautonomic findings. Cranial nerve, cardiovascular, respiratory, and abdominal examination findings were unremarkable. The patient was in significant distress due to pain; however, she exhibited a logical and oriented thought process, appropriate mood with intermittent emotional lability during acute pain episodes, and demonstrated no deficits in alertness, orientation, memory, insight or judgment. The ASIA exam was performed approximately 24 hours after admission. Right-sided myotome evaluation revealed a 5/5 grade power in C5, 3/5 in C6-T1, and 3/5 in L2-S1 levels. Left-sided myotome evaluation revealed a 5/5 grade power in C5, 3/5 in C6-T1, and 4/5 in L2-S1 levels. Sensory examination revealed a right-sided 2/2 grade from the C2–C4 dermatomes, 1/2 from C5–S1 with dysesthesia, and 2/2 from S2–S5 dermatome levels. Her left-sided sensory evaluation revealed a 2/2 grade from C2–C4 dermatomes, 1/2 from C5-T11 with dysesthesia, 1/2 from T12-S1 with hypoesthesia, and 2/2 from S2–S5 dermatome levels. The patient deferred rectal examination, however she described adequate rectal pressure sensation and voluntary anal sphincter contraction and furthermore demonstrated intact bowel continence.

At presentation, complete blood counts and metabolic panels were unremarkable. A head and neck CT scan performed in the emergency room lacked acute hemorrhage and showed intact hardware from her previous ACDF at C4-5 and C5-6 levels without periprosthetic lucency or fracture. MRI with and without contrast of the brain and cervical spine performed 24 hours after admission showed no intracranial abnormalities, epidural mass, collection or abnormal enhancement. However, there was an abnormally increased T2 signal and decreased T1 signal in the spinal cord predominantly on the right extending from C3 through T3 without expansion or enhancement, compared to her CT imaging on presentation and postoperative outpatient MRI six years prior. Anterior osteophyte formation on C4–C5, C5–C6, and C6–C7 levels was also observed [Fig. 1]. Her clinical presentation was most referable to an incomplete cervical SCI with an ASIA impairment scale (AIS) grade D at the neurologic level of C4, secondary to an interlaminar CEI complication. There was no surgical intervention during her hospital course. The patient was treated with a course of dexamethasone intravenously, and she experienced hyperglycemia that was controlled by sliding scale insulin. Neuropathic pain medications were titrated with minor improvements and without anticholinergic side effects. Ultimately, her clinical findings prompted inpatient rehabilitation for ambulatory dysfunction and pain management upon discharge from the acute care facility. The patient, who showed significant decline in functional status with her new gross and fine motor impairments, made progress in acute rehabilitation and was discharged home after three weeks with close supervision to contact guard assistance for ADLs, a quad cane due to fall risk from persisting RLE weakness, and continued outpatient-based therapies three times weekly.

Complications from CEIs are well documented and range from mild to severe. Mild complications include dural puncture headache, increased neck pain, stiffness, intracranial hypotension, and vasovagal reactions. Severe complications from CEIs include epidural hematoma, infections, intravascular injections resulting in strokes, and neurological deficits from intramedullary injections [10–12]. While the overall complication rate for interlaminar and transforaminal epidural injections was low at around 2.4%, the specific rate for CEIs varies [13]. In one literature review, the overall rate of mild CEI-associated complications was as high as 17%. In contrast, there were only thirteen case reports referencing serious complications that were found prior to September 2019, of which, only four highlighted direct SCI [8,13]. Another study investigating closed malpractice claims in chronic neck pain management highlighted 51 out of 294 cases reporting cervical procedure complications, where 20 cases declared SCI from direct needle trauma via the interlaminar epidural approach [14]. With varying findings between peer-reviewed reports and malpractice claims, establishing a rate for severe CEI complications remains elusive, and there needs to be a clearer representation in the literature associated with these procedures.

In regards to the surgical management of neck pain, with cervical radiculopathy being a primary indication, the surgical options most commonly involve ACDF and to a lesser extent, posterior cervical foraminotomy (PCF), both working to achieve nerve root decompression [15–17]. Other surgical options include ACDF with complete uncinectomy, which helps patients with more severe bony foraminal stenosis, and endoscopic approaches, which help to mitigate tissue trauma [15,17]. Nevertheless, the impact of these surgical interventions on spinal anatomy and its association with postoperative risks during CEI has not been thoroughly investigated in the existing literature. The surgical approaches, techniques employed, and additional patient-specific considerations can contribute to variations in the outcome. For example, performing ACDF with direct decompression, which involves resecting impinging elements, can lead to an increased risk of epidural hematoma and epidural fibrosis, in contrast to indirect decompression which uses a large intervertebral graft to indirectly widen the neural foramen and central epidural space [18]. If there is residual stenosis, injection of any fluid bolus entering the canal may theoretically place the patient at heightened risk of neurologic events due to increasing the fluid volume present in an already space restricted spinal canal. We recommend that appropriate cross-sectional imaging (MRI with and without contrast) be completed prior to interventions such as CEI following ACDF to assess the existing anatomy and form an appropriate treatment strategy.

Furthermore, in one study following 100 patients who underwent ACDF, the disc space height changed from a mean of 5.49 $\pm$ 1.17 mm before surgery to 6.62 $\pm$ 1.12 mm at 12 months post-surgery, with disc space height reducing as time went on. There were also eight cases in the study that had a reduced disc space height from its initial preoperative values at the 12-month mark, highlighting the variability in postoperative results [19]. After ACDF, the neural foramen cross-sectional area also experiences changes that are related to both the intervertebral height and the cervical lordosis angle [7]. These are factors that change with operative measures, have a relationship with interventional cervical procedures, and may have been implicated in the iatrogenic SCI described in this case. However, to date, there are no studies discussing these factors in relation to CEI complications.

This patient's case serves as a reminder and an anatomical correlate of a rare but severe potential complication of interlaminar CEIs. While direct needle trauma to the spinal cord is noted to be a prominent neurologic complication of interlaminar CEI procedures, and the suspected mechanism of injury in this case, there has been little reported in the literature in comparison to intravascular injection of corticosteroids [11,12]. Moreover, this patient reported experiencing primarily axial rather than radicular pain, for which the efficacy of CEI remains poor [2,3]. Instead, the consideration of a cervical medial branch radiofrequency ablation may have better addressed her pain while avoiding the epidural space entirely. The patient suffered from cervical post-surgery syndrome and likely had complicated anatomy, worsened by a narrow cervical epidural space and little adipose tissue within the space. The authors recommend imaging and thorough clinical assessment prior to any procedure so as to be sure of the anatomy prior to intervention. On admission after CEI, the patient's anteroposterior cervical canal diameter was 12.49mm and epidural space was 1.59mm on MRI. The average AP dimension of the target cervical epidural space is

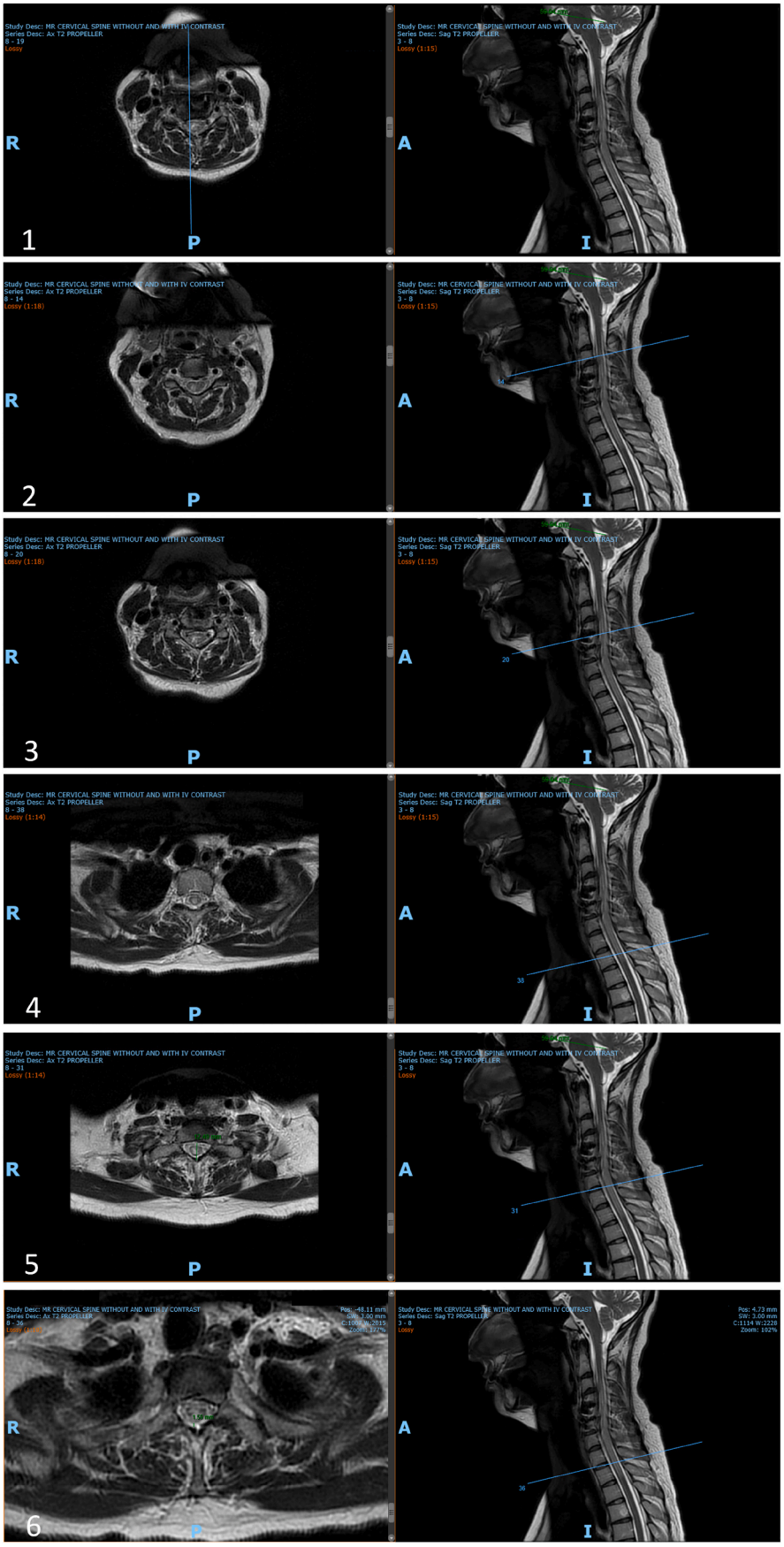

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Fig. 1. T2-weighted MRI axial and sagittal images of the cervical spine 24 hours after SCI presentation. Images (1–6.) R: Right; P: Posterior; A: Anterior; I: Inferior; mm: millimeters
(1): T2 Sagittal view just right of midline highlighting extent of fluid signal and cord injury. (2): T2 axial view at C3–C4 level demonstrating fluid signal within the cord. (3): T2 axial view at C4–C5 level demonstrating fluid signal within the cord. (4): T2 axial view at T2 level demonstrating fluid signal within the cord. (5): T2 axial view at C7-T1 injection level demonstrating fluid signal within the cord and 12.49mm anteroposterior diameter (seen in green). (6): T2 axial view at C7-T1 injection level demonstrating fluid signal within the cord and 1.59mm epidural space (seen in green). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

between 1 and 4mm, with only a potential space superiorly along with midline gaps in the ligamentum flavum, highlighting the procedural challenge [20]. One investigational study demonstrated a 53% rate of false loss of resistance when entering the epidural space using conventional fluoroscopy for interlaminar CEI's. CT fluoroscopy may be used to overcome these anatomic challenges by better approximating needle depth [21]. It is well characterized that ACDF increases mechanical stress on adjacent vertebral levels, and this was evident by osteophyte formation on C6–C7 levels [22]. She also had serial interlaminar CEI's every four to six months over a period of six years, which may have caused repetitive microtrauma on posterior vertebral ligaments, inducing scar tissue formation. While the etiology for ligamentum flavum hypertrophy remains elusive, mechanical stress and inflammation-mediated fibrosis have been implicated [23,24]. In addition, it is noted that patient oversedation in the perioperative window has a significant association with SCI due to lack of patient feedback of any abnormal sensation or pain [11,12]. The authors acknowledge the potential risk of minimal sedation during CEI in this case but consider it relative to other patient-specific factors, as the patient was immediately responsive to the initial exacerbation of pain, prompting the proceduralist to reposition the needle and complete the procedure. The combination of minimal sedation, previous ACDF, anatomic patterns precluding loss of resistance, repetitive microtrauma of posterior vertebral ligaments, and a narrow cervical epidural space may all have contributed to this patient's intrinsic cord injury. Furthermore, it is unknown whether pre-procedural imaging was reviewed in this case, which may have contributed to this catastrophic complication. Highlighting these factors may offer important clinical implications for healthcare professionals when developing the management strategy for chronic cervicalgia. Recommendations have been formed by various societies and national organizations to minimize epidural steroid injection complications. These safety measures include reviewing pre-procedural imaging, limiting or entirely avoiding perioperative sedation, obtaining appropriate lateral or oblique views for needle depth approximation, and limiting the injectate volume to 4mL maximum [8,11,12,21]. In addition to these recommendations, the authors suggest for patients with prior cervical spine surgery, providers should meticulously characterize the pain syndrome to define an appropriate evidence-based intervention, understand the previous surgery performed to tailor interventions accordingly, and focus interventions in the lower cervical spine, preferably at C7-T1. In any event where conditions are sub-optimal and there is an inability to obtain the necessary imaging to ensure safety, the procedure should be terminated for the safety of the patient [25].

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Declaration of competing interest

The authors declare no conflicts of interest.

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