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FactFinders

FACTFINDERS FOR PATIENT SAFETY: Minimizing risks with cervical epidural injections

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A B S T R A C T

This series of FactFinders presents a brief summary of the evidence and outlines recommendations to minimize risks associated with cervical epidural injections. Evidence in support of the following facts is presented.

Minimizing Risks with Cervical Interlaminar Epidural Steroid Injections – 1) CILESIs should be performed at C6-C7 or below, with C7-T1 as the preferred access point due to the more generous dorsal epidural space at this level compared to the more cephalad interlaminar segments. This reduces the risk of the minor complication of dural puncture and the major complication of spinal cord injury due to inadvertent needle placement. 2) LF gaps are most prevalent in the midline cervical spine. This can result in diminished tactile feedback with loss of resistance (LOR), increasing the risk for inadvertent dural puncture or spinal cord injury. Based on current evidence, needle placement in the paramedian portion of the interlaminar space is safest to avoid LF gaps. 3) An optimal AP trajectory view and the physician's ability to discern engagement in the LF and subsequent LOR are crucial. Confirmation of minimal needle insertion depth relative to the ventral margin of the lamina with either a lateral or contralateral oblique (CLO) safety view is critical to minimize the risk of inadvertently inserting the needle too ventral. 4) There have been closed claims and case reports of patients who have suffered catastrophic neurologic injuries while receiving CILESIs under deep sedation. If sedation is administered, the least amount necessary should be utilized to ensure the patient can provide verbal feedback during the procedure. 5) CILESIs are an elective procedure; therefore, necessity and likelihood of benefit must be foremost considerations. Current guidelines recommend holding ACAP therapy before CILESIs due to the potentially catastrophic complications associated with epidural hematoma (EH) formation. However, there is also a risk of severe systemic complications with ceasing ACAP in specific clinical scenarios. The treating physician is obligated to determine if the procedure is indicated and can ultimately decide to delay the intervention or not perform the procedure if the benefit does not outweigh the risks.

Minimizing Risks with Cervical Transforaminal Epidural Steroid Injections – the Role of Preprocedural Review of Advanced Imaging – Variations in vascular anatomy may warrant a modified approach to CTFESI. Preprocedural review of cross-sectional imaging can provide critical information for safe injection angle planning specific to individual patients and may help to decrease the risk of unintended vascular events with potentially catastrophic outcomes.

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Safety of Multi-level or Bilateral Fluoroscopically-Guided Cervical Transforaminal Epidural Steroid Injections – Safe performance of a CTFESI procedure requires the ability to detect inadvertent arterial injection. Contrast medium placed into the epidural space and/or along the exiting spinal nerves during an initial CTFESI may obscure the detection of inadvertent cannulation of a radiculomedullary artery by a subsequent CTFESI. While no available literature directly addresses the potential risk that exists with a multi-level or bilateral CTFESI, caution is still warranted.

Minimizing Risk with Cervical Interlaminar Epidural Injections: Five Key Considerations.

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Introduction

A cervical interlaminar epidural steroid injection (CILESI) involves passing a needle within an interlaminar window through the ligamentum flavum (LF) to allow for sufficient needle tip access of the dorsal cervical epidural space for safe delivery of medication [1]. The indication for CILESI is to treat cervical radicular pain, most commonly caused by cervical osteoligamentous degenerative changes and intervertebral disc herniations resulting in nerve root impingement [2]. CILESIs are utilized more commonly than cervical transforaminal epidural injections (CTFESIs) for the therapeutic management of cervical radicular pain [3].

There is a risk of complications with either approach that, in rare circumstances, may result in serious morbidity and even mortality. Analysis of the American Society of Anesthesiologists' closed claim database from 2005 to 2008 identified 20 cases of spinal cord injury attributed to CILESIs [4]. Furthermore, while CILESIs are generally regarded as safe with appropriate procedural planning and technique, there always remains a small risk of epidural hematoma [1].

Anatomical considerations and needle access

Myth #1: There is no intrinsic difference in risk when performing CILESIs in the upper versus lower cervical spine.

Fact: CILESIs should be performed at C6-C7 or below, with C7-T1 as the preferred access point due to the more generous dorsal epidural space at this level compared to the more cephalad interlaminar segments. This reduces the risk of the minor complication of dural puncture and the major complication of spinal cord injury due to inadvertent needle placement.

The epidural space in the cervical spine is less capacious than in the thoracolumbar spine [1]. As one ascends the cervical spine, the anatomic proximity of the dural sac and spinal cord to the point of interlaminar needle access narrows, reducing the margin for error and increasing procedural risk [1,5–7]. Even at C7-T1, the normal depth of the posterior epidural space is less than 2–3 mm [1]. Cross-sectional imaging should be performed and reviewed before any CILESI to confirm sufficient epidural space for appropriate needle placement [7].

Although some authors have documented the safety of performing CILESI above the level of C6-C7 [8], current recommendations are that CILESIs should be performed at the C7-T1 level ideally and not higher than the C6-C7 level [1,5–7]. One argument for attempting a CILESI at a higher cervical level is to ensure coverage of the medication at the site of pathology. However, evaluation of cervical radiculopathy distribution patterns has shown that involvement of the C7 nerve root in isolation is most common, followed by C6 and a combination of C5 and C6 [2]. In one study, a 5 mL volume injected at C7-T1 spread cephalad to the C5 vertebral level 100 % of the time, the C4 vertebral level 92.9 % of the time, and the C2 vertebral level 69.1 % of the time, justifying the utility of the C7-T1 approach [9]. Epidural catheters have been used to reach higher cervical levels; however, this practice appears to be no more effective than standard C7-T1 ILESI and may confer an increased risk of epidural hematoma with catheter placement and removal [10,11].

Myth #2: Ligamentum flavum (LF) gaps are uncommon in the cervical spine and are not a risk factor for CILESI aberrant needle placement.

Fact: LF gaps are most prevalent in the midline cervical spine. This can result in diminished tactile feedback with loss of resistance (LOR), increasing the risk for inadvertent dural puncture or spinal cord injury. Based on current evidence, needle placement in the paramedian portion of the interlaminar space is safest to avoid LF gaps.

Cadaveric studies have shown that gaps in the LF are consistently localized to the midline and preferentially affect the cervical spine [12–16]. Cadaveric studies have also illustrated variable rates of midline gaps. One study determined that the rates of midline LF gaps in the lower cervical spine (C5-C6 to C7-T1) ranged from 51 to 74 % [16]. Another cadaveric study determined that the incidence of midline gaps in the LF from C3-T2 ranged from 87 to 100 % [14].

Similarly, *in-vivo* MRI characterization of the lower cervical spine (C5-C6 to C7-T1) confirmed that all LF gaps were localized to the midline with varying partial to full-thickness LF gap morphologies [13]. Cadaveric and MRI *in-vivo* analyses have demonstrated that LF gaps occur more commonly in the caudal and middle thirds of the midline interlaminar space than in the cephalic third of the interlaminar space [13–15].

MRI evaluation with axial T2-weighted spin echo sequences has demonstrated that the highest rate of full-thickness midline LF gaps occur at the C7-T1 level: 53 % in the cephalic portion and 71.4 % in both the middle and caudal portions [13]. For comparison, the rate of full-thickness midline LF gaps at the C6-C7 level was 28 % in the cephalic portion and 24 % in the middle and caudal portions [13]. Partial-thickness LF gaps were more common than full-thickness midline LF gaps at the C6-C7 level, unlike the C7-T1 level, where full-thickness midline gaps predominate [13].

Additionally, the average width of full-thickness midline LF gaps is most pronounced at the C7-T1 level [~1.7 mm (SD 0.64 mm)] as compared to C6-C7 [~1.29 mm (SD 0.58 mm)] [13]. Based on the best evidence, a paramedian approach, rather than accessing the midline portion of the interlaminar space, is a safer approach to avoid LF gaps [13–16].

Myth #3: The anteroposterior (AP) view and loss of resistance (LOR) technique allow for reliably safe needle placement.

Fact: An optimal AP trajectory view and the physician's ability to discern engagement in the LF and subsequent LOR are crucial. Confirmation of minimal needle insertion depth relative to the ventral margin of the lamina with either a lateral or contralateral oblique (CLO) safety view is critical to minimize the risk of inadvertently inserting the needle too ventral.

Multiplanar imaging minimizes procedural risk. Initial needle

placement necessitates an ideal AP trajectory view that optimizes the interlaminar access window and allows for coronal plane recognition of midline versus right or left paramedian needle placement. LOR provides the physician crucial tactile feedback that the needle has traversed the LF and entered the epidural space. In the cervical spine, the LF is less robust than in the lumbar spine, requiring the physician to be keenly aware of subtle tactile changes indicating epidural access [1,13]. As discussed, LF deficiencies are common in the cervical spine. It has been previously shown that there is a 53 % false LOR rate when relying solely on LOR and not utilizing a depth view to confirm needle placement before injecting contrast [17]. Thus, true lateral (90° oblique) or CLO (oblique opposite the needle tip) views are considered necessary "safety" views to confirm appropriate needle depth throughout the procedure, including before injecting contrast medium or medication [18].

The use of a true lateral versus CLO view often depends on several factors, including physician training and preference. Several studies have illustrated the superiority of the CLO view [19–21]. If the needle tip epidural access point is midline (within lateral margins of the spinous process), a lateral view may prove adequate to gauge depth [1]. However, poor visualization of the needle tip in lateral view in the lower cervical spine is common, and the CLO view is often necessary to confirm appropriate depth of needle placement [20,21].

A CLO safety view is generally recommended, especially when the needle tip lies lateral to the midline or if the lateral view is obscured by the silhouette of the shoulders [1]. It has been demonstrated that using the CLO view, first-attempt procedural success rates are significantly higher with fewer needle passes, and the view also allows for better needle tip visualization than the lateral view [19]. The CLO view provides a reliable radiographic landmark, and the epidural needle tip position is most consistently visualized at or just beyond the ventral laminar margin at the ventral interlaminar line, which reduces procedural risk [19,20]. Due to these factors, the CLO view instead of the lateral view is favored to mitigate the risk of aberrant needle placement in most circumstances [5,19–21].

Sedation

Myth #4: CILESI is safe to perform on patients receiving deep sedation.

Fact: There have been closed claims and case reports of patients who have suffered catastrophic neurologic injuries while receiving CILESIs under deep sedation. If sedation is administered, the least amount necessary should be utilized to ensure the patient can provide verbal feedback during the procedure.

Analysis of closed claims and multiple case reports have demonstrated that there is an association between spinal cord injury and patients undergoing cervical epidural injection under deep sedation [4,12,22,23]. Patient feedback regarding any unusual sensations, traveling symptoms, worsening pain, or paresthesia is paramount to procedural safety and may be compromised with deep sedation. Reports of such symptoms should warrant pause, re-evaluation of needle positioning, and consideration for abandoning the procedure [1]. If symptoms do not subside but persist, the procedure should be abandoned [1]. Two reported cases illustrate the catastrophic effect of spinal cord damage during CILESIs initially performed at C5-C6 (repositioned to C6-C7) in patients receiving IV sedation, with both patients suffering permanent neurologic injury [22]. Similarly, a patient underwent a C5-C6 ILESI under deep sedation, resulting in the patient's inability to provide feedback, and unfortunately, an intramedullary injection was performed. This resulted in hemiparesis and facial sensory loss [23]. Analysis of malpractice claims data from 2005 to 2008 has shown general anesthesia or sedation was used in 67 % of cervical procedure claims with spinal cord injuries [4]. Conversely, a retrospective study of 2494 cases found no statistical difference in the frequency of adverse events between patients who received moderate (conscious) sedation and no sedation, suggesting mild to moderate sedation is associated with low rates of adverse events when following established protocols [24].

International Pain and Spine Intervention Society (IPSIS) and American Society of Anesthesiologists guidelines state that routine use of sedation is not indicated [1,25]. A combined consensus opinion from a multidisciplinary working group and national organizations reached complete consensus from all 13 participating organizations that "moderate-to-heavy sedation is not recommended for ESIs, but if light sedation is used, the patient should remain able to communicate pain or other adverse sensations or events" [7].

If sedation is to be utilized due to legitimate patient factors, the patient should be adequately alert to provide warning of any undue sensations throughout the procedure [1]. In extreme and rare cases, such as in patients incapable of remaining still due to a movement disorder, deep sedation may be required [1]. However, the risk/benefit profile should be heavily weighed, and the patient should be informed of the additional inherent risk. Additional information on IPSIS recommendations on this topic can be found in the "Conscious Sedation" FactFinder [26] and IPSIS guidelines 2nd edition [5].

Anticoagulants/antiplatelets

Myth #5: Anticoagulation and antiplatelet (ACAP) therapy should be withheld before CILESIs due to the increased risk of epidural hematoma (EH), regardless of the medical indication for the use of ACAP therapy.

Fact: CILESIs are an elective procedure; therefore, necessity and likelihood of benefit must be foremost considerations. Current guidelines recommend holding ACAP therapy before CILESIs due to the potentially catastrophic complications associated with EH formation. However, there is also a risk of severe systemic complications with ceasing ACAP in specific clinical scenarios. The treating physician is obligated to determine if the procedure is indicated and can ultimately decide to delay the intervention or not perform the procedure if the benefit does not outweigh the risks.

There is an inherent risk of EH whenever a CILESI is performed. The posterior spinal canal is a space of low pressure, and the epidural veins are plentiful [1]. As a result, there is a risk that even an appropriately placed needle may cause iatrogenic injury to the epidural veins and consequently result in an EH [1]. The EH could subsequently result in acute spinal cord compression with devastating neurologic effects. The risk of performing CILESI on patients taking ACAP therapy requires a "risk versus risk" assessment [27]. The incidence of EH due to CILESI is not known [6]. The risk of clinically significant EH after ILESI appears to be low; however, based on the available literature, it is estimated that continuing anticoagulants increases the risk of EH by a factor of three [1]. The clinical significance of this risk is potentially severe, including death [1,5,6,28]. Conversely, ceasing ACAP therapy raises the risk of ischemic thrombotic or embolic complications that could also be severe, including death, albeit the likelihood also appears low [1,5,27].

The evidence on handling this scenario is primarily based on expert opinion of society working groups utilizing the available sparse evidence. As indicated by the IPSIS guidelines, "any change in the patient's regimen of medication should be undertaken in consultation with the physician responsible for their prescription, in case there are insights, considerations or precautions of which the physician or patient is unaware" [1]. The prescribing physician may not understand the bleeding risks inherent to the specific spine intervention [27]. Likewise, the interventionalist may not have an appreciation of why continuation of the ACAP therapy is essential. Ultimately, the performing interventionalist should make all efforts to collaborate with the prescribing physician to be astutely aware of the nuances of each patient's clinical scenario to estimate most rationally what is safest for the patient based on the best current evidence. A well-informed discussion of all the potential risks and alternative options should be held with the patient. Several reports in the literature illustrate the catastrophic effects of EH

in patients after CILESI [28–34]; however, there remains a lack of evidence regarding the true incidence of clinically pertinent EH after CILESI [35]. Equally, there remains a lack of evidence regarding the true incidence of thromboembolic events with holding ACAP therapy for CILESIs.

The second edition of the *Interventional Spine and Pain Procedures in Patients on Antiplatelet and Anticoagulant Medications Guidelines* categorizes CILESI(s) as an intermediate risk for the potential of serious bleeding without the use of ACAP(s) [36]. If performed on patients on ACAP therapy, the working group advocates that CILESI should be considered high risk for serious bleeding [36]. These guidelines recommend holding all ACAP and fibrinolytic agents for specified timeframes before CILESI [36]. As it pertains to CILESIs and Non-Aspirins (ASA) NSAIDs/ASA use, these guidelines indicate that "consideration" should be given to the discontinuation of these medications due to "specific anatomical configurations (that) may increase the risk and consequences of procedural bleeding." If the decision is made to hold ASA, the length of discontinuation can be adjusted, depending on whether ASA use is for primary or secondary prevention, as specified in these guidelines. The IPSIS guidelines 2nd edition indicate that non-ASA NSAIDs/ASA do not need to be held [1].

Conversely, a recent retrospective study evaluated 591 patients taking ACAP(s) who received cervical or thoracic interlaminar epidural steroid injections (IL-CTESI) [31]. In this study, 351 patients stopped their ACAP therapy before the procedure, and 240 patients continued their ACAP medications. The authors found no clinically relevant incidents of EH in either group [1]. This study provides the largest cohort to date evaluating the risk of clinically relevant EH in patients undergoing CILESIs. However, the results of this study should be viewed cautiously since the number of injections included in the study is much lower than would be required to reliably capture and quantify this complication based on current estimates of the rate of EH after percutaneous epidural access (estimated at 1:190,000) [37]. Ultimately, the risk of ischemic embolic/thrombotic complications with holding ACAP versus the risk of EH with continuing ACAP in patients undergoing CILESI warrants continued investigation.

Summary

- CILESIs should only be performed at C6-C7 or below, with C7-T1 as the preferred access point based on an anatomic review of the cervical dorsal epidural space.
- Spinal LF gaps are most commonly found in the midline cervical spine. The gaps most commonly involve the middle and inferior thirds of the midline interlaminar LF.
- Based on the best evidence, a paramedian approach, rather than accessing the midline portion of the interlaminar space, is the better approach to avoid LF gaps.
- If LF engagement and LOR are not clearly appreciated and the epidural needle tip position appears at or just beyond the ventral laminar margin at the ventral interlaminar line, early contrast medium administration is recommended to confirm the location.
- Multiplanar fluoroscopic imaging is recommended to minimize procedural risk.
- The CLO view appears more reliable in providing better needle visualization than the lateral view.
- As indicated in the IPSIS guidelines 2nd edition and by the American Society of Anesthesiologists, routine use of sedation is not indicated.
- There have been closed claims and case reports of patients who have suffered catastrophic neurologic injuries while receiving CILESIs under deep sedation.
- If sedation is required due to patient-related factors, the least amount necessary should be utilized to allow the patient to provide verbal feedback during the procedure.
- CILESIs are elective procedures; therefore, necessity and the likelihood of benefit must be foremost considerations. Current guidelines recommend holding ACAP therapy before CILESIs due to the potentially catastrophic complications associated with EH formation. However, there is also a risk of severe systemic complications with ceasing ACAP in specific clinical scenarios. The treating physician is obligated to determine if the procedure is indicated and can ultimately decide to delay the intervention or not perform the procedure if the benefit does not outweigh the risks.
- When the interventionalist determines that ACAP medication should be held to achieve the safest outcome, documented input from the prescribing physician in agreement with this decision is recommended.

Mitigating Risks with Cervical Transforaminal Epidural Steroid Injections – the Role of Preprocedural Review of Advanced Imaging (MRI and CT).

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Myth: Strictly adhering to the conventional approach in performing a cervical transforaminal epidural steroid injection (CTFESI) will mitigate all potential vascular risks and is the safest choice for all patients.

Fact: Variations in vascular anatomy may warrant a modified approach to CTFESI. Preprocedural review of cross-sectional imaging can provide critical information for safe injection angle planning specific to individual patients and may help to decrease the risk of unintended vascular events with potentially catastrophic outcomes.

Cervical transforaminal epidural steroid injection (CTFESI) is an important adjunct to the management of cervical radiculopathy [38]. When cervical radicular symptoms are not well-controlled with conservative modalities, a cervical transforaminal injection or a spinal nerve block can provide therapeutic relief [39,40]. Additionally, a spinal nerve block can be utilized for preoperative planning for cervical spine surgery when non-operative management has failed [41,42].

However, CTFESI has been associated with catastrophic neurologic injury, including brain and spinal cord infarction secondary to the inadvertent arterial injection of potentially embolic medications [43–51]. Safety guidelines in performing CTFESI, such as utilizing non-particulate steroid [43–52] and injecting contrast under live fluoroscopy or digital subtraction fluoroscopy [53,54] have been previously discussed. The safe performance of CTFESI is optimized by utilizing available safety measures to mitigate the risk of unintentional puncture or injection into nearby arteries.

The vascular anatomy of the cervical spine, specifically in periforaminal regions, can be complex. The vertebral artery (VA) typically lies anterior to the neural foramen, entering through the transverse foramen at C6. However, the VA can enter the spine at levels other than the C6 transverse foramen about 20 % of the time [53,54]. The VA is also known to have variations, such as accessory vessels and anomalous loops [55,56]. A study revealed that in nearly 30 % of patients, the VA is located at the posterior foramen within 2 mm of the optimal needle entry point for transforaminal injections [57,58]. At the levels most frequently targeted for injections, from C4-5 to C6-7, this rate decreased to 18 % [58]. In patients with severe cervical degeneration, the VA is commonly displaced and partially or completely overlies the lateral opening to the neural foramen [59].

Additional significant anatomic variations in vascular supply have been described [56,60,61]. These include spinal segmental arteries

arising from the ascending cervical artery entering the foramen at variable locations to eventually supply the spinal cord, as well as spinal segmental or spinal medullary arteries arising from the VA to supply the spinal nerve root at variable locations. Such anatomic variants have been identified as a risk factor for complications of CTFESI [62]. A lack of awareness regarding the presence of an anatomic variant during cervical transforaminal injection may increase the risk of cannulation of the vertebral artery or perturbation of a small artery that provides critical reinforcing blood supply to the spinal cord. Awareness of the location of vascular structures allows the proceduralist to plan an angle of needle insertion to decrease the likelihood of inadvertent needle placement into the vertebral artery (Figs. 1–4). In each of the cases presented below, failure to observe relevant anatomy on pre-procedural imaging would have potentially resulted in serious complications should a CTFESI had been attempted.

The standardized technique for performing CTFESI has been previously described [57]. Key safety points in this technique include obtaining an oblique fluoroscopic trajectory image such that the angle of insertion is co-axial to the laminar angle, with the insertion point at one to two needle widths posterior to the foramen. The needle tip is then guided to the lateral margin of the foramen at the superior articular process (SAP), from where it is advanced to the midportion of the articular pillar. Specific angles to achieve this transforaminal positioning have been described for cervical levels [63]. However, while this approach has been implemented in countless successful procedures, it does not explicitly consider the intrinsic or acquired variation in vascular anatomy of individual patients [20,21,25].

Three recent studies investigated a modified approach based on the location of vascular anatomy viewed on advanced imaging. Karm et al. conducted a retrospective analysis of 312 patients with neck pain or cervical radiculopathy who underwent MRI scans [64]. These scans were analyzed to determine a safe, optimal needle entry angle to decrease the chance of an inadvertent arterial puncture. Each scan was analyzed with a conventional transforaminal approach line and a new modified transforaminal approach line, drawn parallel to the ventral margin at the midpoint of the superior articular process's ventral border.

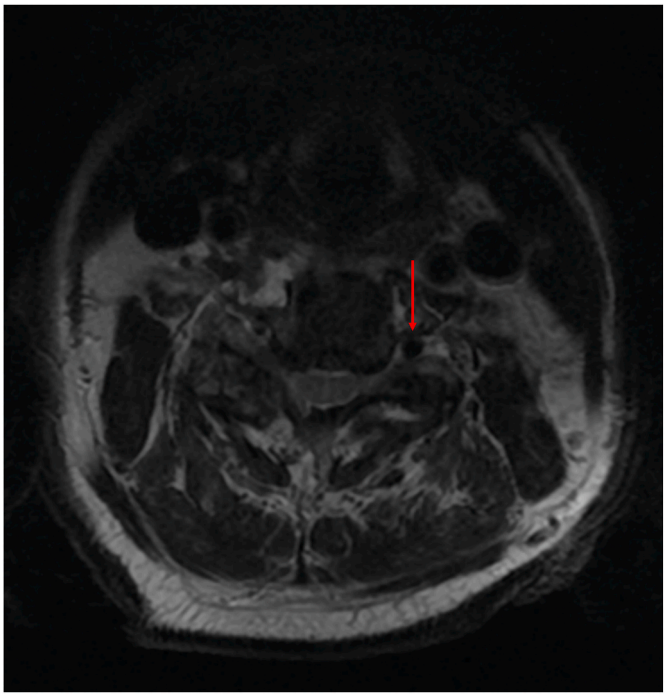

Fig. 1. Vertebral artery (red arrow) occupying the neural foramen. Image courtesy of Dr. Tiegs-Heiden.

These lines were examined to determine if they would intersect with the vertebral artery, internal carotid artery, and internal jugular vein. Differences between the angles of the lines were found at all levels examined. The new lines were farther from the vertebral artery at all levels and intersected a major vessel less frequently at all levels and sides with statistical significance. The conventional transforaminal approach line traversed the vertebral artery at the C5-6 level in 11 (3.5 %) instances on the right and 8 on the left (2.6 %); at the C6-7 level in 17 (5.4 %) instances on the right and 24 (7.7 %) on the left; and at the C7-T1 level in 14 (4.5 %) instances on the right and 25 (8 %) on the left. The new modified transforaminal approach line did not violate the vertebral artery at any of these levels. The authors concluded that the angle of the new line of approach (approximately 70°) is safer than the angle of the conventional approach (approximately 50°).

A follow-up study [65] examined the modified approach described by Karm et al. The study included 48 patients who underwent CTFESI using the conventional technique and 49 patients who underwent CTFESI using the modified and theoretically safer approach based on the patient's level-specific SAP ventral surface angle. This study demonstrated a higher rate of ideal epidural contrast flow patterns with the modified needle approach than with the conventional technique. A review of 973 CTFESI procedures using the modified approach (Fig. 5) showed no significant neurologic or vascular complications [66].

Although not available at all institutions, CT guidance may be considered for CTFESI, particularly in the presence of challenging or variant anatomy. This allows for real-time cross-sectional imaging of the needle position relative to critical structures and the target endpoint throughout the procedure. Multislice CT fluoroscopy clearly demonstrates the precise location of injected contrast media [67]. Retrospective studies have shown that CT guidance for CTFESI is a safe technique, with one study reporting a 4 % minor complication rate and no major complications in 403 procedures [68]. However, the amount of data available for CT guidance is relatively limited compared to fluoroscopy, and the safety profile for CT guidance is not fully established.

In performing CTFESI, the physician should minimize the risk of arterial injection and possible severe neurologic injury from the needle's path while ensuring accurate placement of the needle at the targeted foramina. Careful preprocedural review of individual patient anatomy on MRI or CT may decrease the potential of injury to critical vascular structures when performing CTFESI and reduce the incidence of catastrophic outcomes. A modified approach to long-held conventional angles of needle trajectory based on level-specific anatomy, as demonstrated on cross-sectional imaging, has been proposed and may also lead to a decreased incidence of catastrophic events.

Key points.

- Inadvertent arterial injections during CTFESI have led to documented reports of brain and spinal cord infarction. Therefore, it is of utmost importance to avoid associated vascular structures and to recognize when unintended cannulation of vasculature has occurred during the procedure.
- In addition to adhering to safety precautions discussed in prior FactFinder articles, such as using non-particulate steroid (15) and using contrast under live fluoroscopy or digital subtraction fluoroscopy (16,17), preprocedural cross-sectional imaging (CT or MRI) review is recommended.Preprocedural review of imaging can allow the interventionalist to plan an angle of approach relative to critical vascular structures for each case in order to decrease the chance of an inadvertent arterial injury.
- Preprocedural cross-sectional imaging review may also reveal anomalous vasculature, such as vertebral artery loops, segmental artery anomalies, and displacement of usual vasculature that can occur as a result of spinal degenerative changes and may preclude the performance of a transforaminal injection at that level.

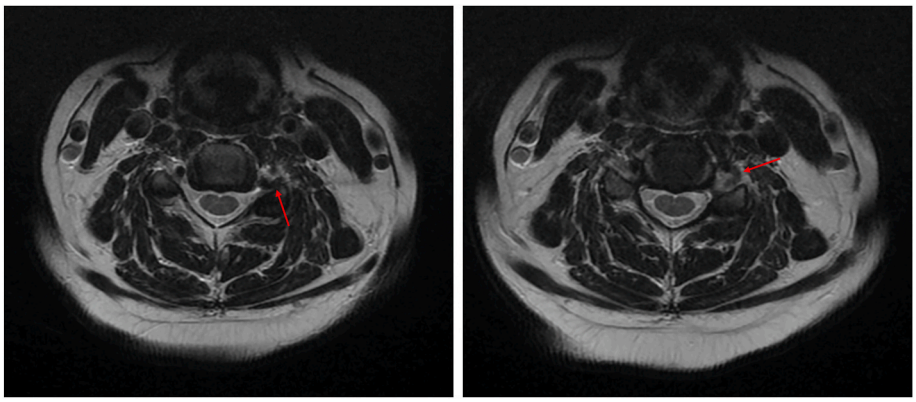

Fig. 2. Tortuous vertebral artery (red arrow) occupying the neural foramen. Image courtesy of Dr. Tiegs-Heiden.

Safety of Multi-level or Bilateral Fluoroscopically-Guided Cervical Transforaminal Epidural Steroid Injections.

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MYTH: There is no additional risk to performing a second-level or second-side cervical transforaminal epidural steroid injection (CTFESI).

FACT: Safe performance of a CTFESI procedure requires the ability to detect inadvertent arterial injection. Contrast medium placed into the epidural space and/or along the exiting spinal nerves during an initial CTFESI may obscure the detection of inadvertent cannulation of a radiculomedullary artery by a subsequent CTFESI. While no available literature directly addresses the potential risk that exists with a multi-level or bilateral CTFESI, caution is still warranted.

CTFESIs are commonly performed to treat cervical radicular pain [69–71] yet have unique complications and safety considerations [72]. The most serious complications of CTFESI are central nervous system (CNS) infarct and death. Numerous case reports of vertebrobasilar and spinal cord infarcts occurring after CTFESI have been published [73–82]. All report only a single-level injection being performed with particulate steroid. This implies that the incidence of the complication is rare, or the performance of multiple CTFESI in the same session is rare, or both.

The FDA Adverse Event Reporting System (FAERS) data cited in a 2014 briefing document [83] and narrative reviews [84] reported an additional 116 cases of significant neurologic complications involving the use of particulate steroids, compared to four reports of such complications with the use of non-particulate steroids [83]. An abundance of basic science and animal research supports that these complications are largely due to arterial injection of particulate steroid resulting in an embolic infarct of downstream CNS structures [85]. More recent evidence includes another potential source of embolism due to some medications or preservatives causing either deformation, spiculation, or aggregation of red blood cells as another possible mechanism for embolic infarction [86].

Another serious complication of CTFESI is seizure due to inadvertent arterial injection of anesthetic medication [87]. The use of an anesthetic injection before the injection of steroid may be used as a physiologic test to identify intra-arterial injectate deposition prior to administering corticosteroid, referred to as an anesthetic test dose [4,20]. An anesthetic injection is also requisite for a diagnostic spinal nerve injection [7,8]. Furthermore, a local anesthetic could inadvertently anesthetize surrounding structures, including the phrenic nerves traversing over the anterior scalene muscles on either side. This is a theoretical concern, particularly with a bilateral transforaminal approach, although no cases

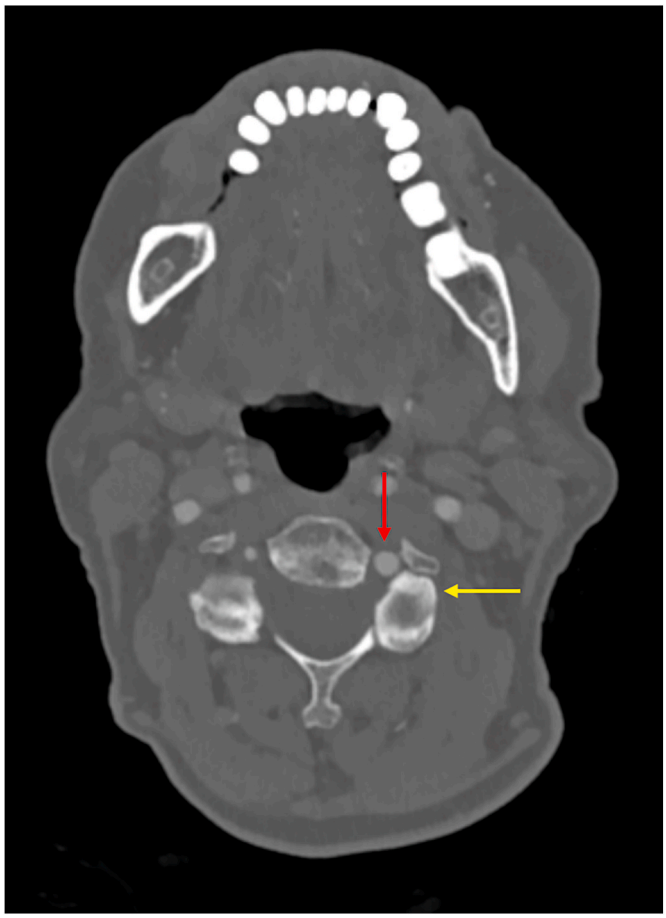

Fig. 3. Facet joint hypertrophy (yellow arrow) almost completely obscures the typical needle path for a transforaminal epidural injection, and the vertebral artery resides in the mouth of the neural foramen (red arrow). Image courtesy of Dr. Tiegs-Heiden.

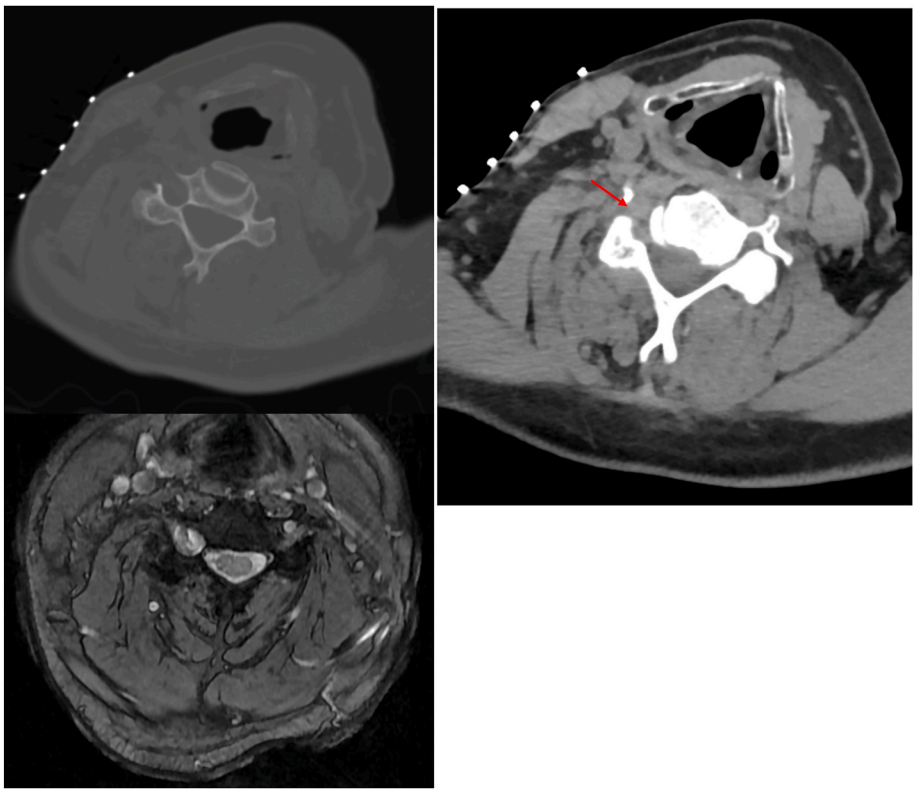

Fig. 4. The vertebral artery is ectatic, resulting in remodeling and expansion of the vertebral foramen (left images). Another image in the same patient (right), shows that the vertebral artery is located at the opening of the neural foramen (red arrow), resulting in very limited needle landing zone for a transforaminal epidural steroid injection. Image courtesy of Dr. Tiegs-Heiden.

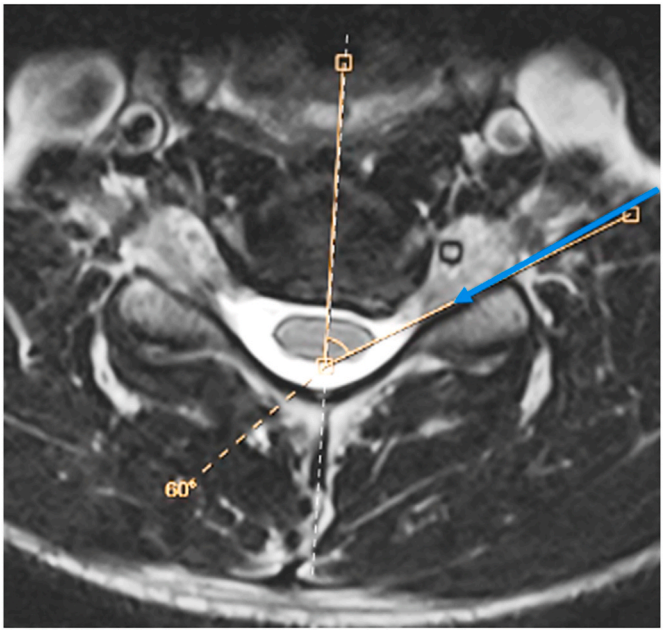

Fig. 5. T2 Axial MRI of C5/6 with planned needle trajectory based upon measured angle of the ventral surface of the C6 superior articular process from the sagittal midline. As this SAP measured 60° on MRI. The fluoroscopic oblique angle would be preset at 60° relative to the fluoroscopic AP. Credit: Levi et al. [65].

of phrenic nerve palsy have been reported in this setting.

Recommendations on the safe performance of CTFESI largely focus on avoiding inadvertent intra-arterial injection of potentially hazardous medication [4,20]. Specifically, the following recommendations were made in 2015 by the Multidisciplinary Working Group: all CTFESI should be performed by injecting contrast medium under real-time fluoroscopy and/or digital subtraction imaging (using an AP view) before injecting any substance that may be hazardous to the patient; particulate steroids should not be used in CTFESIs; and extension tubing should be used [72]. Placing the needle in the posterior foraminal space is also recommended to avoid the vertebral artery [88].

What is unknown is whether the performance of a multi-level or bilateral CTFESI increases the risk of this type of complication. During a CTFESI, contrast medium is introduced from the neural foramen into the epidural space, which may also spread in a cephalad or caudal direction. Thus, the presence of contrast medium within the epidural space could obscure the detection of a radiculo-medullary artery coursing through the same area. This should not limit the ability to detect flow within the vertebral artery, as it lies outside the epidural space. Based on previously published images, radiculomedullary arteries can be challenging to detect [89]. Detection of inadvertent intra-arterial injection is critical for safely performing CTFESI. Therefore, any technical aspect of the CTFESI procedure which (theoretically) impairs the maximal likelihood of detecting an inadvertent arterial injection should be avoided. CNS infarcts or other major complications following CTFESI are rare, and as a result, the magnitude of additional risk with a multi-level CTFESI is unknown.

There are other considerations. Firstly, the improved safety profile of CTFESI with the use of non-particulate steroid may mitigate the theoretical risk of a two-level or bilateral CTFESI as it pertains to embolic infarcts. However, the use of non-particulate steroid does not mitigate the risk of seizure due to arterial injection of anesthetic if an anesthetic is injected intra-arterially. Even if the detection of an artery is not significantly diminished by a two-level or bilateral CTFESI, there is still an inherently increased risk of arterial injection simply by placing two needles. Live digital subtraction imaging (DSI) increases the rate of vascular detection compared to live fluoroscopy and may be less

impacted in its ability to do so by previously administered contrast medium [90].

Conclusions and recommendations

There is no available literature directly addressing the potential risk, if any, with a multi-level or bilateral CTFESI. Catastrophic complications may occur when CTFESI is performed with improper technique even at a single level. Injection at an additional level increases the risk of complications; therefore, conducting CTFESI in accordance with the International Pain and Spine Intervention Society's (IPSIS) guidelines is critical for patient safety [88]. Beyond the use of non-particulate steroids in CTFESI, which is of paramount importance, safety recommendations are centered around detecting inadvertent arterial injection. In theory, injecting a second level after a technically successful first-level CTFESI may reduce the physician's ability to visualize a cannulated radiculo-medullary artery on live fluoroscopy due to the presence of contrast media in the epidural space. DSI can be used to improve visualization of any inadvertent vascular uptake; however, the DSI should be performed in a technically successful manner, capture high-quality images and avoid common pitfalls of DSI [91,92].

- All CTFESIs should be performed in accordance with current safety guidelines, including the use of a non-particulate steroid.
- There is an inherently cumulative risk when two injections via a multi-level or bilateral CTFESI are performed compared with a single injection.
- Caution is warranted if a multi-level CTFESI is being considered because of the potential risk of previously administered contrast medium obfuscating the ability to detect intra-arterial flow. If performed, consider the use of live digital subtraction imaging in addition to live fluoroscopy to identify radiculomedullary arterial flow.
- If symptomatic pathology exists bilaterally or at multiple cervical levels and a cervical epidural steroid injection is offered as a treatment, the treating physician might consider using an interlaminar approach at C6-7 or below if anatomically feasible. It should be noted, however, that the relative risk of major complications when comparing multi-level or bilateral CTFESI to ILESI remains unknown.
- The treating physician should make the ultimate choice of approach or technique (*i.e.,* interlaminar vs. transforaminal, multi-level, bilateral) by balancing potential risks and benefits with each technique for each patient.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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