

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 (1). When cervical radicular symptoms are not well-controlled with conservative modalities, a cervical transforaminal injection or a spinal nerve block can provide therapeutic relief (2,3). Additionally, a spinal nerve block can be utilized for preoperative planning for cervical spine surgery when non-operative management has failed (4,5).

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 (6-14). Safety guidelines in performing CTFESI, such as utilizing non-particulate steroid (15) and injecting contrast under live fluoroscopy or digital subtraction fluoroscopy (16,17) 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 perforaminal 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 (18). The VA is also known to have variations, such as accessory vessels and anomalous loops (18,19). 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 (20,21). At the levels most frequently targeted for injections, from C4-5 to C6-7, this rate decreased to 18%. (21). In patients with severe

cervical degeneration, the VA is commonly displaced and partially or completely overlies the lateral opening to the neural foramen (22).

Additional significant anatomic variations in vascular supply have been described (19,23,24). 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 (25). 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 (fig 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 (20). 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 (26). 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 (27). 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. 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 (28) 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 (29).

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 (30). 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 (31). 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.

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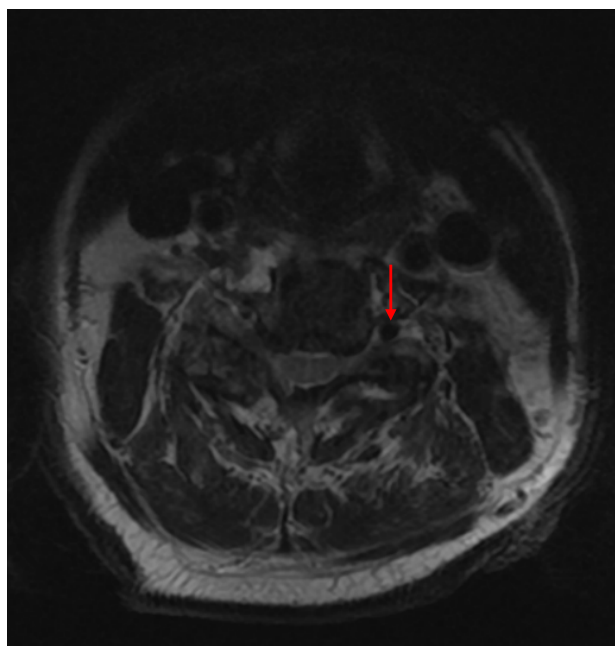


Figure 1: Vertebral artery (red arrow) occupying the neural foramen. Image courtesy of Dr. Tiegs-Heiden.

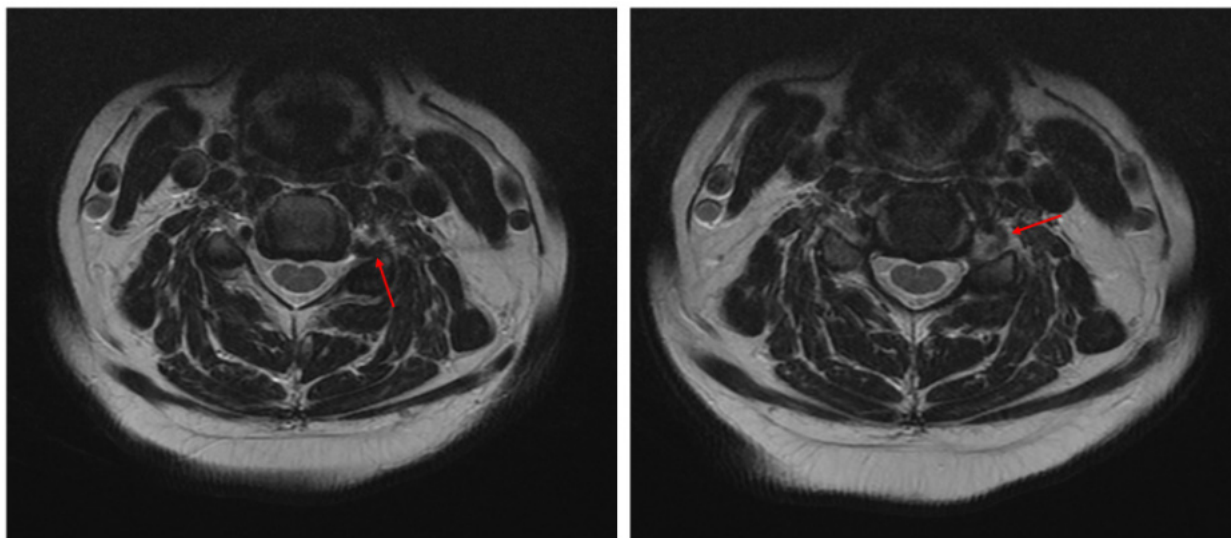


Figure 2: Tortuous vertebral artery (red arrow) occupying the neural foramen. Image courtesy of Dr. Tiegs-Heiden.



Figure 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.

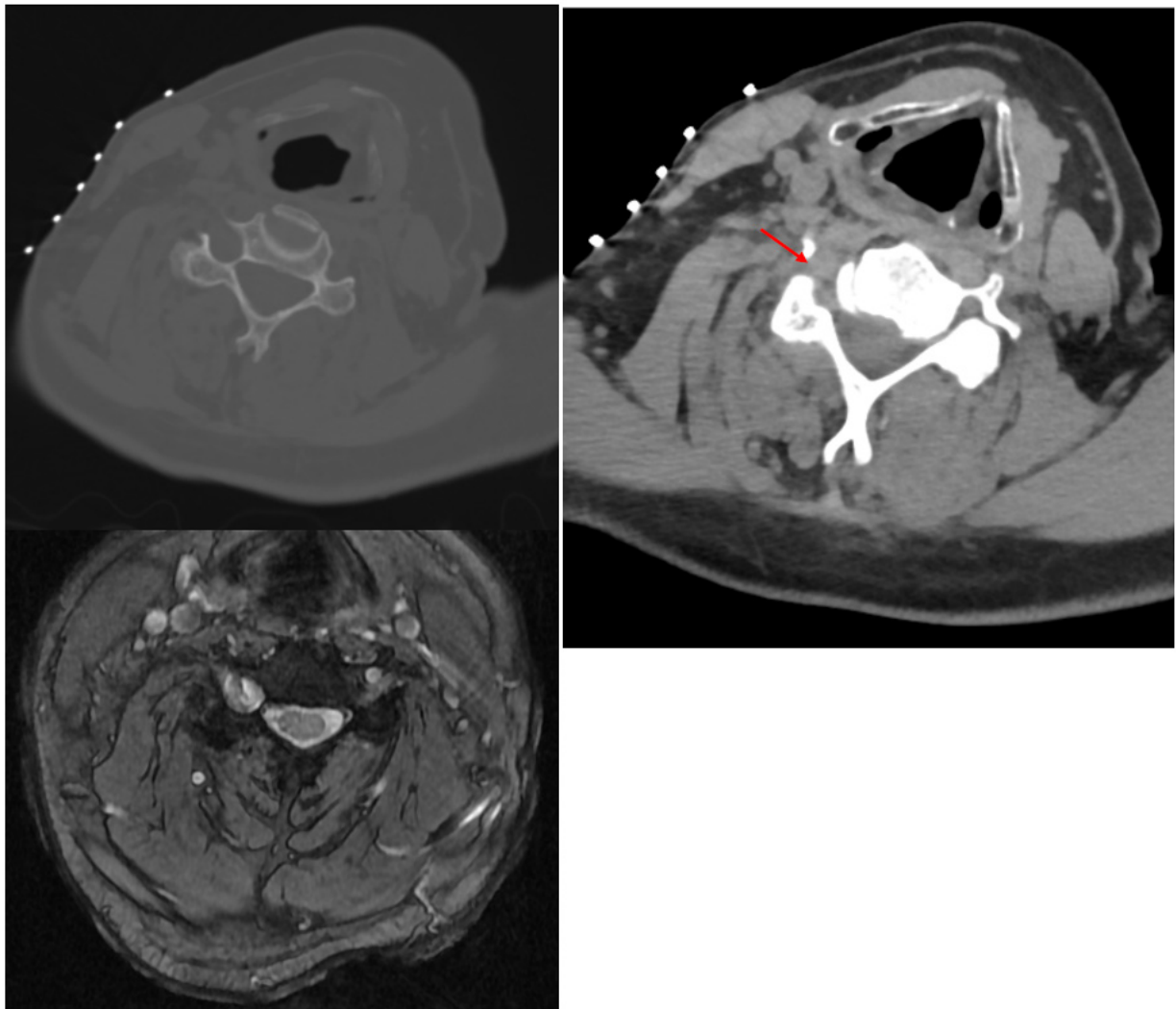


Figure 4: The vertebral artery is ectatic, resulting in remodeling and expansion of the vertebral foramen (left images). Another image in the same patient (right), shows that the vertebral artery is located at the opening of the neural foramen (red arrow), resulting in very limited needle landing zone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

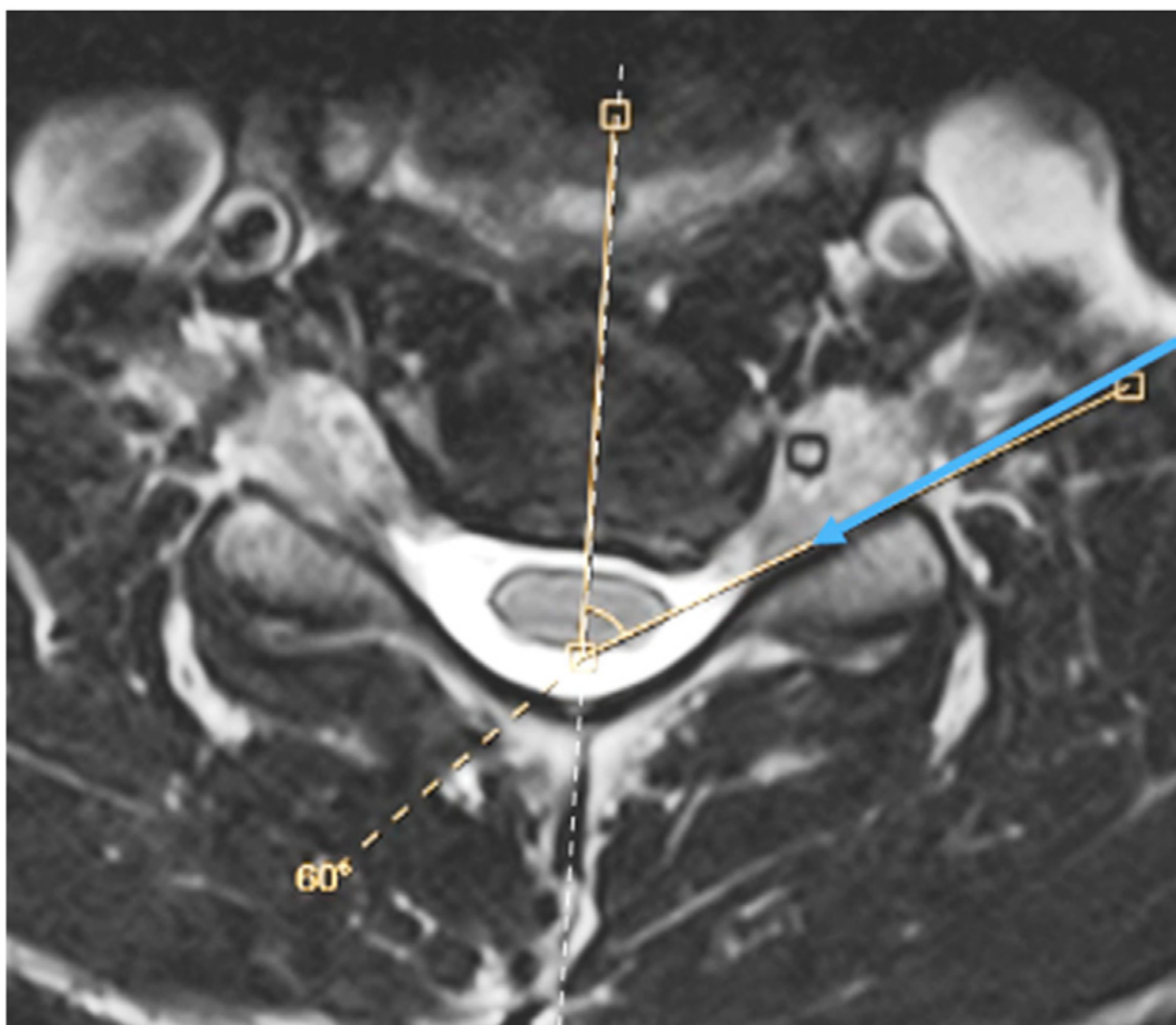


Figure 5: T2 Axial MRI of C5/6 with planned needle trajectory based upon measured angle of the ventral surface of the C6 superior articular process from the sagittal midline. As this SAP measured 60 degrees on MRI. The fluoroscopic oblique angle would be preset at 60 degrees relative to the fluoroscopic AP. Credit: Levi et al (28).