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SPINE SECTION

Original Research Articles

Anomalous Location of the Vertebral Artery in Relation to the Neural Foramen. Implications for Cervical Transforaminal Epidural Steroid Injections

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Abstract

Objectives. Evaluate the prevalence of an anomalous posterior vertebral artery (VA) in the neural foramen and to see if any factors might correlate with proximity of the VA to needle location in a cervical transforaminal epidural steroid injection (CTFESI).

Methods. A radiologist with subspecialty training in neuroradiology documented VA location in relation to the neural foramen on axial views of 198 consecutive computed tomography angiograms done for various reasons, 11 were excluded because of poor imaging or occluded VA. The levels of C2-3 through C6-7 were evaluated, where the VA courses within the foramen. The distance was measured from VA to ideal needle location for a CTFESI. Other data were collected including severity of foraminal stenosis, loss of disc height, and medical history. Analysis was done to see if any factor correlated with anomalous VA location.

Results. The VA was in the posterior foramen and within 2 mm of ideal needle location in at least one location in 29% of patients. When looking at the more commonly injected levels of C4-5 through C6-7, the prevalence was 18%. Severity of foraminal stenosis and loss of disc height correlated with VA proximity to typical needle location (both with $P < 0.0001$).

Conclusion. The VA can sometimes be in close proximity to the typical target location of a CTFESI. This proximity correlates with severity of foraminal stenosis and loss of disc height. Physicians should be mindful of this and evaluate the T2 axial magnetic resonance imaging before doing CFTESIs.

Key Words. Cervical; Epidural; Spine; Vertebral Artery; Safety; Steroids

Background

In recent years, significant complications have been reported after cervical transforaminal epidural steroid injections (CTFESIs). These have been catastrophic complications including spinal cord injury, stroke, and death [1–5]. These complications are very unfortunate in an elective procedure such as a CTFESI.

It is hard to know how common these complications are, but a survey of pain physicians revealed a total of 78 reported neurologic complications following cervical transforaminal injections. Among these were 16 vertebrobasilar brain infarcts, 12 cervical spinal cord infarcts, and two combined brain and spinal cord infarcts. Thirteen cases resulted in death: five with brain infarcts, one with combined brain and spinal cord infarcts, one following high spinal anesthesia, one associated with seizure, and five of unspecified etiology [6].

Anatomical studies suggest that the size of particles or the aggregation of particles in commonly used steroid preparations like triamcinolone (Kenalog, Bristol-Myers Squibb

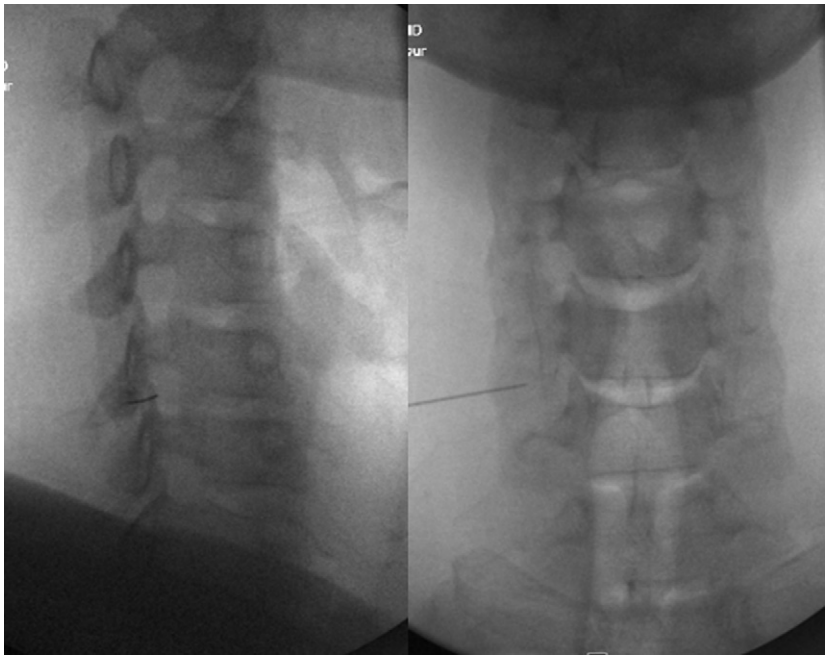

Figure 1 Needle in the posterior foramen and approaching the midline of the articular pillar.

Company, New York, NY, USA), methylprednisolone (Depo-Medrol, Pfizer Inc., New York, NY, USA), and betamethasone (Celestone, Soluspan, Merck & CO., Inc, Whitehouse, NJ, USA) may equal or exceed the caliber of red blood cells [3,7]. This could lead to potential embolic microvascular occlusion.

Thus, injection of particulate steroids into the vertebral artery (VA) or spinal radicular arteries and resulting embolic infarcts is suspected to be a major cause of these catastrophic complications [5,8]. Additionally, direct needle trauma to the VA has been reported as a cause of death with perforation of the VA [2].

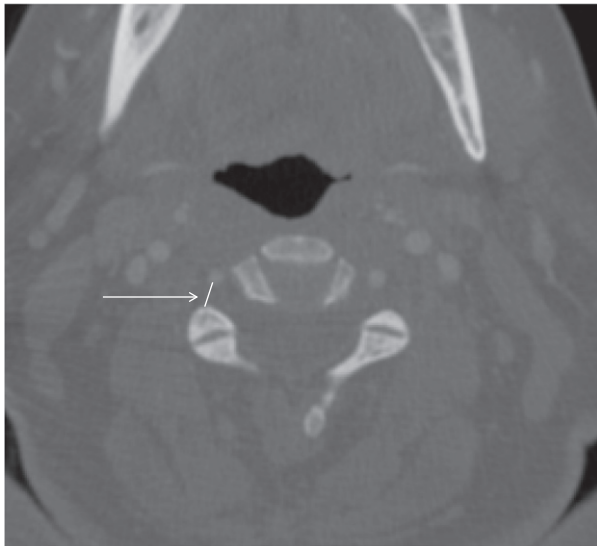

Figure 2 Example of measurement taken from midarticular pilar to vertebral artery on computed tomography angiogram. White arrow pointing to measurement line.

It has been thought that the VA should not be encountered in CTFESIs when the needle is placed in an ideal location in the posterior aspect of the foramen. Experts [9] have stated, "The vertebral artery lies outside the cervical intervertebral foramina and should not be encountered in a carefully executed transforaminal injection. Yet it has often been implicated in cases of neurological complications." But findings from Wells and Petersen [10] in 2010 suggest that the VA can sometimes be located in the posterior foramen, which is the target point for these injections.

Objectives

The objective of this study is to evaluate and further clarify the prevalence of an anomalous posterior VA in the neural foramen and to see if any factors might correlate with proximity of the VA to needle location in a CTFESI.

Methods

A radiologist with subspecialty training in neuroradiology documented VA location in relation to the neural foramen on axial views of 198 consecutive computed tomography (CT) angiograms done for various reasons at a university hospital. Eleven scans were excluded because of poor imaging or occluded VA. The levels of C2-3 through C6-7 were evaluated, where the VA courses within the foramen, with a focus on commonly injected levels of C4-5 through C6-7. The VA initially enters the foramen transversarium at C6 and occasionally at C7. At C7-T1, the VA is well anterior to the neural foramen and no measurement was done at this level.

If the VA was found to be in the mid to posterior aspect of the foramen, a distance was measured to the ideal needle location for a CTFESI. The reason for this measurement was because a posterior VA might also be located medially, some distance from the typical needle location for a CTFESI. Thus, a measurement was thought to be more clinically meaningful than just to classify location as anterior, mid, and posterior.

Additional documentation was made if the VA was located within 2 mm of the ideal needle location for a CTFESI. Although this distance is a bit arbitrary, it was felt to be close enough in proximity to be "at risk." The diameter of a 25-gauge needle is approximately 0.5 mm. Thus, 2 mm is quite close to the posterior target location of a CTFEFSI.

According to the International Spine Intervention Society Guidelines [11], the ideal needle location for a CTFESI is in the posterior foramen and "the tip of the needle should lie opposite the sagittal midline of the silhouettes of the articular pillars." This location was used when taking measurements (Figures 1 and 2).

Other data were collected including severity of foraminal stenosis, loss of disc height, side of VA dominance, and medical history. Foraminal stenosis and disc height were classified as severe (0–33% of normal diameter), moderate (34–66% of normal diameter), mild (67–99% of normal diameter), or normal. The medical history included things that conceivably might be associated with a tortuous VA such as hypertension, diabetes, smoking status (pack year history), and body mass index. A chi-square test was used to check the association between any two categorical variables. A Wilcoxon signed-rank test (or Kruskal–Wallis test) was done to see if any numerical factor correlated with VA proximity to the ideal needle location with CTFESIs.

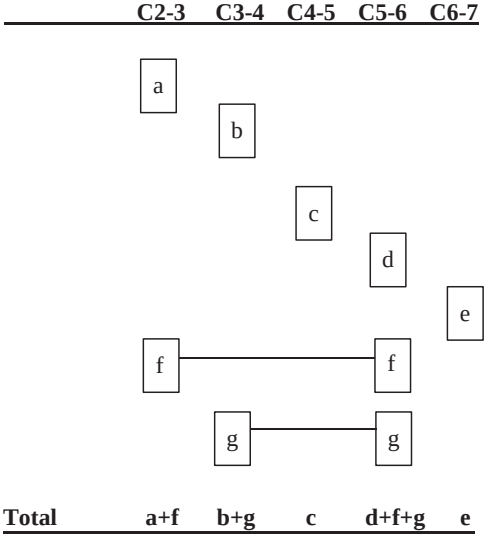

Figure 3 Calculation by level.
Letters a–g indicate instances of a verebral artery (VA) that was posterior and within 2 mm of the target point. A single box refers to subjects in which a proximate VA occurred only at one level. Connected boxes indicate a proximate VA at more than one level in a single patient. The total shows how the prevalence was calculated for each cervical level.

Table 1 Foraminal stenosis as it relates to proximity (distance of <2 mm) of vertebral artery and target needle location for a cervical transforaminal epidural steroid injection

Foraminal Stenosis	<2 mm (Needle Location to Vertebral Artery)	
Normal	37/1260 (2.9%)	$P < 0.0001$
Mild	10/290 (3.4%)	
Moderate	33/185 (17.8%)	
Severe	34/124 (27.4%)	

Table 2 Loss of disc height and correlation of vertebral artery proximity (<2 mm or ≥2 mm) to the needle location in a cervical transforaminal epidural steroid injection. This is cumulative data for all cervical levels (Fisher's exact test)

Disc Height Loss	<2 mm	≥2 mm	*P* Value
Normal	36/488 (7.4%)	452/488 (92.6%)	<0.0001
Mild	18/218 (8.3%)	200/218 (91.7%)	
Moderate	27/124 (21.8%)	97/124 (78.2%)	
Severe	26/99 (26.3%)	73/99 (73.7%)	

Results

The VA was located in the posterior foramen and within 2 mm of ideal needle location in 29.4% (55/187) of patients in at least one location. Some patients had a VA in this anomalous location at more than one level or on both sides, but 29.4% had this finding in at least one location. In the more commonly injected levels of C4-5 through C6-7, 18.2% of patients had a posteriorly located VA that was also within 2 mm of ideal needle location in at least one location.

The most common levels for VA to be located posteriorly and within 2 mm of ideal needle location were C3-4 (13.3%), C4-5 (10.2%), and C5-6 (8.0%). The least common level was C6-7, where only 1.1% of patients were found to have the VA in the posterior foramen and within 2 mm of needle location. Again, it should be noted

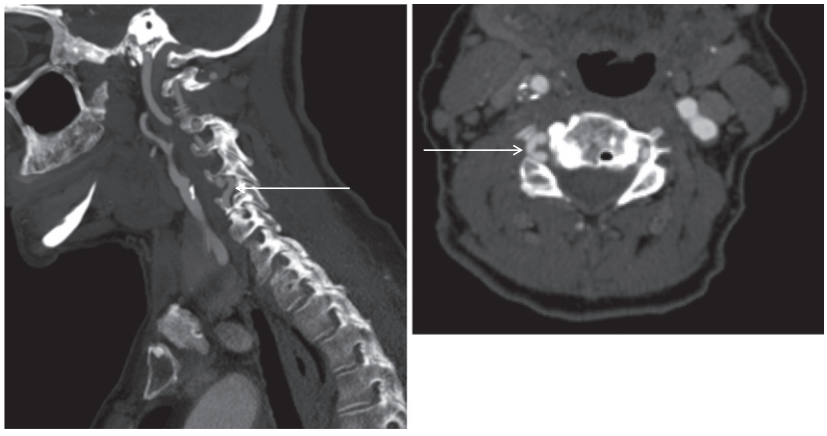

Figure 4 Left C4-5 vertebral artery loop in the posterior foramen.

that some patients had this anomalous location at more than one level, which is included in these percentages (Figure 3).

Severity of foraminal stenosis correlated with VA proximity to typical needle location ($P < 0.0001$). Looking at all levels without foraminal stenosis, only 2.9% of the time was the VA found within <2 mm of needle location. If there was severe foraminal stenosis, 27% of the time the VA was <2 mm from the ideal needle location (Table 1).

Furthermore, loss of disc height was associated with proximity of the VA to the needle location ($P < 0.0001$). If there was severe loss of disc height 26.3% of the time, the VA was within 2 mm of ideal needle location for a CTFESI (Table 2).

No other factors were found to be associated with both posterior location and being <2 mm from ideal needle location. This included other medical issues such as body mass index, smoking status (pack years of smoking), diabetes, hypertension, and side of VA dominance.

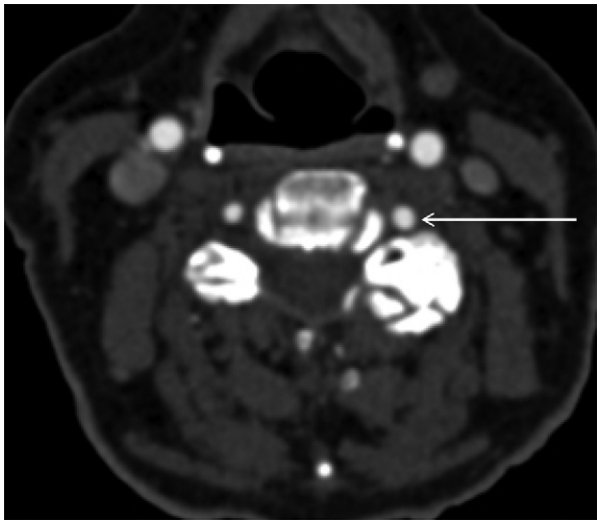

Figure 5 Bulky left C4-5 facet joint with posteriorly positioned vertebral artery.

Discussion

The VA can sometimes be in close proximity to the typical target location of a CTFESI, as seen in Figures 4–9. These findings are similar to prior findings of Wells and Petersen [10] and warrant caution when doing CTFESIs. Experts [9] in the spinal interventional field have stated "the vertebral artery . . . should not be encountered in carefully executed

Figure 6 Vertebral artery in the posterior foramen.

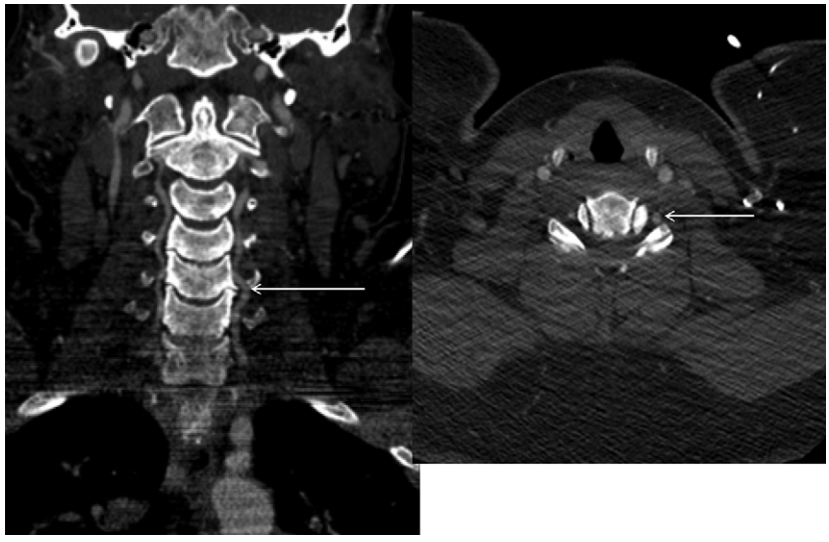

Figure 7 C5-6 left uncovertebral joint hypertrophy and a lateral displaced vertebral artery. It is also in the posterior foramen.

transforaminal injections. Yet it has often been implicated in cases of neurological complications." This appears to be incorrect and clinicians should be mindful of this.

The VA proximity to the typical target location for a CTFESI correlates with the severity of foraminal stenosis and loss of disc height. It should be noted that this study looked at bony foraminal stenosis seen on CT scans. Foraminal stenosis often correlates with the symptomatic level that is injected by the interventionalist. Physicians should be cognizant of this and evaluate the T2 axial magnetic resonance imaging (MRI) to check the location of the VA before doing CFTESIs.

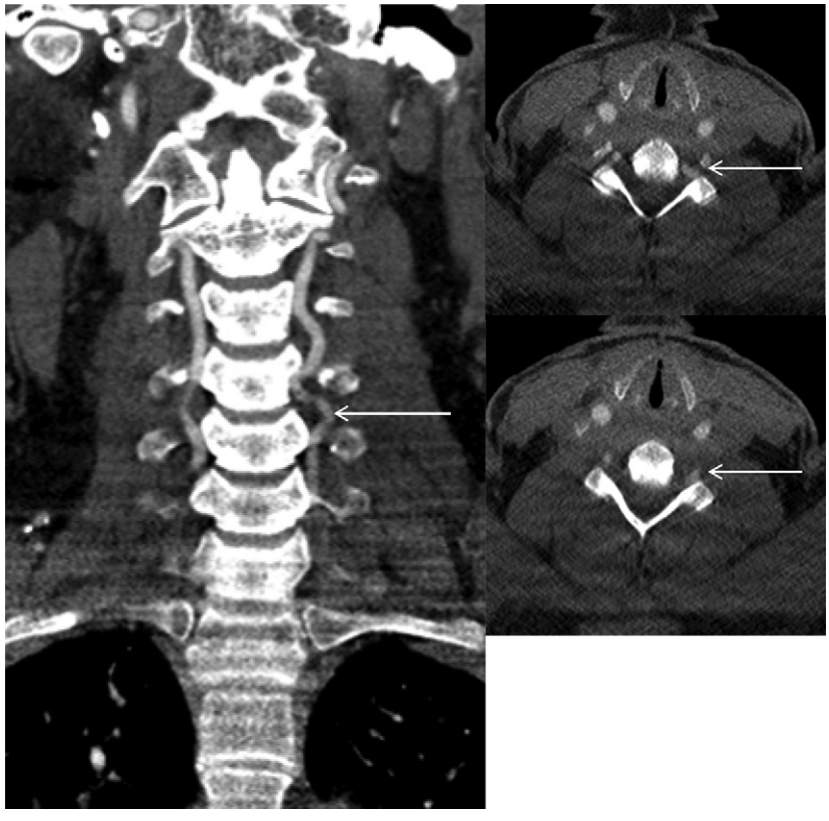

Figure 8 Posterior position of the vertebral artery.

Figure 9 C5-6 vertebral artery loop in a vulnerable position.

The more commonly affected levels were C3-4, C4-5, and C5-6. At C6-7, it was very uncommon for the VA to be located posteriorly. The VA comes off the subclavian artery and usually enters the foramen transversarium at C6, rarely at C7. The VA comes from an anterior position before coming into the foramen transversarium, thus explaining why the VA is very rarely in a posterior position at C6-7.

Other standard safety measures should still be employed. First, utilizing live fluoroscopy with contrast administration is key in picking up vascular uptake. Contrast should be administered in the anteroposterior (AP) view and target area kept in the center of the screen. There has been more than one case of paraplegia after transforaminal injections when the needle was at the upper end of the screen, making it difficult to pick up vascular flow [12,13]. Digital subtraction angiography has been shown to be more sensitive at picking up vascular flow of the small radicular arteries [14], but the VA is large enough that it should be apparent on live fluoroscopy. Test doses of local anesthetics have been recommended. In one case report of a CTFESI, a patient developed temporary quadriparesis following the injection of a test dose of local anesthetic despite appropriate needle placement. The injection was aborted and no permanent injuries occurred [15].

Use of a nonparticulate steroid is probably the most important thing that can be done to prevent complications. This is supported by an animal study that compared particulate and nonparticulate steroid injections into the VA of pigs under general anesthesia. Those injected with particulate steroids never regained consciousness. Subsequent MRIs revealed upper cervical cord and brain stem edema, and histological analyses showed ischemic changes. The animals injected with nonparticulate steroids did not have ischemic events and recovered without apparent adverse effects. MRIs and subsequent histological analysis were later normal in this group [16].

It should be noted that there can often be a funnel-shaped contour of the peripheral foramen, with the consequence that the posterior bony margin seen on an oblique fluoroscopic image (Figure 1) may be close to the mid foramen on the AP view (Figure 2). Thus, if the needle is advanced in the oblique view until periosteum is encountered, the needle can sometimes be close to the middle of the foramen, not the lateral margin.

Limitations of this study include that this is a retrospective study from a single academic center. These CT angiograms of the neck were done for various reasons, but primarily for patients who were being evaluated for a stroke, carotid stenosis, or carotid dissection. It is unknown if these factors may predispose a patient to having a more tortuous or anomalous location of the VA.

Summary

The VA can sometimes be in close proximity to the typical target location of a CTFESI. This proximity correlates with the severity of foraminal stenosis and loss of disc height. Physicians must be mindful of this. Evaluating the T2 axial MRI before doing CFTESIs is recommended to avoid potential complications.

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