Ultrasound-Guided Cervical Nerve Root Injections: Safety and Outcomes

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Ultrasound (US) provides direct visualization and imaging of various soft tissues without radiation exposure. Therefore, it is a very appealing option when performing neck injections, where there is a magnitude of critical soft tissue structures in a compact, very vascular area.

Moreover, US imaging allows real-time needle advancement and monitoring of the spread of injectate, which improve the accuracy of the block and minimize the risk for intravascular injection.

An added benefit of US is that it helps in the diagnosis of associated pathology or aberrant anatomy that may contribute to the patient’s pain presentation (Figure 1).1

The application of US in the interventional management of neck pain has the potential to be safer and more efficacious than traditional approaches in the following procedures: brachial and cervical plexus blocks; lesser, greater, and third occipital nerve blocks; stellate ganglion blocks; scalene muscle intervention for thoracic outlet syndrome; cervical medial branch and facet injections; and cervical nerve root blocks.

There is no intervention in pain management surrounded by more debate than cervical transforaminal epidural steroid injection (CTFSI). This review will shed light on the safety of the US-guided approach. It also will provide new insight into the technique and the preference for an extraforaminal nerve root approach rather than the traditional transforaminal epidural approach, although the debate continues.

A 2010 American Society of Regional Anesthesia and Pain Medicine evidence-based medicine review of US-guided procedures in pain management showed only weak evidence that US is superior to computed tomography (CT) in lumbar facet intra-articular injections (1 small randomized controlled trial [RCT], evidence level Ib). At that time, the recommendations were: “Although we do have few reports suggesting that US-guided cervical injections have advantages over fluoroscopy-guided approaches, we don’t have RCT-driven data to support this.”2
Since that time, there have been quite a few publications on US-guided cervical nerve root injections, cervical medial branch blocks, and cervical facet injections. Most recently, 2 RCTs reported on the advantages of US-guided cervical nerve root block over the traditional fluoroscopy-guided and CT-guided approaches (evidence level Ib for both).3,4

US-Guided Cervical Nerve Root Injections

**LIMITATIONS OF THE FLUOROSCOPY-GUIDED TECHNIQUE**

Cervical transforaminal injections (CTFSI) have been performed traditionally with the use of fluoroscopy or CT. There have been a few reports of fatal neurologic complications as a result of vertebral artery injury or infarction of the spinal cord and the brain stem.5-11 The mechanism of injury in these cases is hypothesized to be either vasospasm or unintentional arterial injection of particulate steroid with embolus formation.7,8

Current guidelines for the CTFSI technique involve introducing the needle under fluoroscopic guidance into the posterior aspect of the intervertebral foramen just anterior to the superior articular process in the oblique view to minimize risk for injury to the vertebral artery or nerve root.12 Despite strict adherence to these guidelines, adverse outcomes have been reported. A potential shortcoming of the described fluoroscopy-guided procedure is that the needle may puncture a critical contributing vessel to the anterior spinal artery in the posterior aspect of the intervertebral foramen.13

In this case, ultrasonography may provide for new advantages, as it allows for visualization of soft tissues, nerves, and vessels, and the spread of the injectate around the nerve (all potentially advantageous to fluoroscopy). US allows real-time identification of the vessels before needle puncture; this is the most distinctive advantage over fluoroscopic guidance, wherein this complication can be recognized only after aberrant vascular uptake is noted with contrast agent injection. In other words, US can “prevent” intravascular penetration, whereas contrast fluoroscopy can “detect” intravascular injection after the fact.14

**Advantages of US-Guided Cervical Nerve Root Block**

**EXTRAFORAMINAL PERIRADICULAR VERSUS TRANSFORAMINAL SPREAD**

It is very important to identify the target in the US-guided technique. The target is the nerve root or more specifically the ventral ramus, in the transverse process groove between the anterior and posterior tubercles. Thus, with US, the procedure is an extraforaminal selective nerve root block. This is in contrast to the fluoroscopy-guided technique, in which the procedure is a transforaminal epidural injection.

As described, with US guidance the needle is intentionally placed extraforaminally to avoid the vascularity within the foramen; accordingly, it is not feasible to monitor the spread of the injectate through the foramen into the epidural space because of the bony artifact of the transverse process. We therefore refer to this approach as a cervical selective nerve root block rather than a CTFSI.15

![Figure 1. Short-axis sonogram (transverse) US image at the level of the Tp of C5 showing an enlarged C5 nerve root, or neuroma. Note that it looks larger than the CA. CA, carotid artery; IJV, internal jugular vein; Tp, transverse process; US, ultrasound](image)

<table>
<thead>
<tr>
<th>Study</th>
<th>Injections, N</th>
<th>Vascular Injection, %</th>
<th>With DSA, %</th>
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<tr>
<td>Smuck et al19</td>
<td>121</td>
<td>32.8</td>
<td>-</td>
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<td>Furman et al22</td>
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<td>McLean et al25</td>
<td>134</td>
<td>17.9</td>
<td>32.8</td>
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**Table 1. Incidence of Vascular Injections With Fluoroscopy-Guided Cervical Transforaminal Injections**  

DSA, digital subtraction angiography
Yamauchi et al monitored the efficacy and spread of injectate in US-guided cervical nerve root block in a clinical as well as a cadaveric study. All target nerve roots in the 12 patients and 10 cadavers were correctly identified by US. This study suggested that there is no difference in the analgesic effects after US-guided injections, although the injectate spread tends to be mainly extraforaminal compared with the conventional transforaminal fluoroscopic technique.16

Lee et al compared the technical differences and clinical outcomes between US-guided cervical periradicular steroid injection (US-CPSI) and conventional fluoroscopy-guided transforaminal epidural injection for the treatment of cervical radicular pain. Their data suggested that US-CPSI can provide an adequate local spread pattern and tissue penetration for the treatment of cervical radicular pain.17

**Identification of Small Critical Vessels**

Narouze et al reported a pilot study of 10 patients who received cervical nerve root injections using US as the primary imaging tool with fluoroscopy as the control.15

The researchers were able to identify vessels at the anterior aspect of the foramen in 4 patients, and 2 patients had critical vessels at the posterior aspect of the foramen; in 1 patient, this artery continued medially into the foramen most likely forming or joining a segmental feeder artery. In these 2 cases, such vessels could have been injured easily in the path of a correctly placed needle with fluoroscopy (Figure 2).

Jee et al evaluated the efficacy and safety of US-guided cervical nerve root block compared with fluoroscopy-guided injection in a prospective RCT. A total of 120 patients were randomly assigned to either fluoroscopy or US. The treatment effects and functional improvement after the nerve root block were compared at 2 and 12 weeks. There were no statistically significant differences between the 2 groups.18

The authors of this study reproduced the findings of Narouze et al, but in a larger cohort of patients. In 21 patients in the US group, vessels were identified at the anterior aspect of the foramen. Eleven patients had a critical vessel at the posterior aspect of the foramen and 5 had an artery continue medially into the foramen. In the fluoroscopy group, 5 cases of intravascular injections were observed.

Obernauer et al also evaluated the accuracy, time savings, radiation doses, safety, and pain relief after US- versus CT-guided cervical nerve root injections in a prospective RCT. The accuracy of US-guided injections was 100%. The mean time to final needle placement in the US group was 2.21±1.43 minutes versus 10.33±02.30 minutes in the CT group. Both groups showed the same significant improvement in visual analog scale pain score.19

**Why Ultrasound?**

**Radiation-free imaging.** This is especially important with cervical injections where there is increased scattered radiation from the C-arm.18

**Short procedure time compared with CT.** Fluoroscopy time was reported to be significantly increased when a vascular injection is identified.4,19

**Ability to identify and avoid vessels in the trajectory of the needle.** The incidence of vascular injection in fluoroscopy-guided CTSFIs is significantly high (Table 1).19-23 This led to concerns about the safety of the procedure.

However, there were no vascular injections in the

![Figure 2. Short-axis sonogram (transverse) US image at the level of the transverse process and AP of C6 showing a critical artery crossing the AP on its way to the neuroforamen. Also note the small vessels in the vicinity of the neuroforamen.](image)

| Table 2. Incidence of Vascular Injections With US-Guided Cervical Nerve Root Injections |
|---------------------------------|-----------------|------------------|------------------|
| Study                          | Injections, N   | Vascular Injection With US, % | Vascular Injection With Fluoroscopy Control, % |
| Narouze et al                  | 10              | 0                        | 20              |
| Jee et al                      | 60              | 0                        | 9               |
| Obernauer et al                | 20              | 0                        | NA              |
| US, ultrasound                 |                 |                           |                 |

AP, articular pillar; at, anterior tubercles; pt, posterior tubercles; US, ultrasound
Caution Needed

In previous reports, US-guided cervical nerve root injection was compared with fluoroscopy with real-time contrast injection; however, none of the studies used digital subtraction technology, which might increase the sensitivity of detecting small critical vessels.

I believe that visualization of such small vessels may be challenging, and that it requires special training and expertise. No system is perfect, and not seeing a small blood vessel does not necessarily mean it does not exist. It could be either the limitation of US resolution or the limitation of the operator’s experience.

Depending on the experience of the operator, real-time fluoroscopy with contrast injection and digital subtraction—when available—still should be used, with US as an adjunct to help identify blood vessels in the vicinity of the foramen.

Pearls for Improving the Safety of Cervical Nerve Root Injection

- Real-time contrast fluoroscopy
- Digital subtraction angiography (when available)
- US guidance
- Blunt-tip needle
- Test dose
- Diagnostic block with local anesthetic only
- Therapeutic block with nonparticulate steroids

Conclusion

US guidance for cervical spine procedures is evolving rapidly. There are now several RCTs reporting the advantages of US in performing cervical nerve root injections compared with fluoroscopy and CT.

The future for US-guided cervical procedures is bright because these techniques offer many visual advantages that are not found in fluoroscopy-based techniques.