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Ultrasound-guided cervical transforaminal injection and selective nerve root block

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Traditionally, cervical transforaminal injections have been performed under fluoroscopic guidance. Real-time fluoroscopy with contrast injection is necessary to minimize intra-arterial injections. But even with strict guidelines, multiple instances of inadvertent intra-arterial injections with resultant spinal cord injury have been reported. This has led some practitioners to question the use of this procedure and whether the benefits outweigh the risks.

The use of ultrasound (US) imaging to facilitate nerve blocks has increased recently. US allows visualization of soft tissues, as well as nerves and vessels, and also permits visualization of the injectate around the nerve. Unlike fluoroscopy and computed tomography, US does not expose the patients or personnel to radiation, and the image can be performed continuously while the injectate can be visualized in real time, thereby increasing the precision of injection.

US imaging can be used to obtain well-defined images of the cervical neural foramina with real-time visualization of the spinal nerves and vessels and may improve the safety of the technique. It may facilitate identifying anomalous critical vessels at unexpected locations relative to the intervertebral foramen and avoiding injury to such vessels, which is the leading cause of the reported complications from cervical nerve root injections.
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Anatomy

The cervical spinal nerve occupies the lower part of the foramen with the epiradicular veins occupying the upper part. The radicular arteries arising from the vertebral, ascending cervical, and deep cervical arteries lie in close approximation to the spinal nerve.[1]

Huntoon was able to show that the ascending and deep cervical arteries may contribute to the anterior spinal artery (not only the vertebral artery). More than 20% of the foramina dissected (21/95) had either the ascending or deep cervical artery or a large branch within 2 mm of the needle path for a cervical transforaminal procedure. One-third of these vessels were spinal branches that entered the foramen posteriorly, potentially forming a radicular or a segmental feeder vessel to the spinal cord, making it vulnerable to inadvertent injury or injection even during correct needle placement. Variable anastomoses between the vertebral and cervical arteries were found; therefore, it is possible to introduce steroid particles into the vertebral circulation via the cervical arteries.[2] Also, in a single cadaver dissection study, Hoeft and coworkers[3] showed that radicular artery branches from the vertebral artery lie over the most anteromedial aspect of the foramen, whereas those that arise from the ascending or deep cervical arteries are of greatest clinical significance as they must course medially, transversing the entire length of the foramen.

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Cervical transforaminal and selective nerve root block

The patient is placed in the supine position, and an oblique lateral view of the cervical spine is obtained. The C-arm is rotated obliquely ipsilaterally until the intervertebral foramen is maximally open. The radiologic target point is the posterior aspect of the intervertebral foramen just anterior to the superior articulator process (SAP) in the oblique view, and at the midsagittal plane of the articular pillars in the anteroposterior (AP) view.[1]

A blunt needle is then introduced under fluoroscopic guidance into the posterior aspect of the intervertebral foramen just anterior to the superior articular process in the oblique view to minimize the risk of injury to the vertebral artery or the nerve root. Then, an AP view is obtained, and the needle tip should not be advanced beyond the midsagittal plane of the articular pillars to avoid injury to the vertebral artery and the radicular branches. Real-time fluoroscopy with contrast injection is essential to minimize intra-arterial injections. After negative aspiration and appropriate contrast spread, 1-2 mL of local anesthetic with or without nonparticulate steroids is used.

Indications

Cervical nerve root block/transforaminal epidural injections are indicated in cervical radicular pain not responsive to conservative therapy. Although conservative therapy, using exercises and analgesics, has been shown to improve symptomatology, its success is variable.[4] Failure of conservative therapy warrants alternatives, either surgical or cervical epidural injections.

Cervical spine surgery has an approximately 4% incidence of serious acute complications apart from the perioperative hospital stay and its incident complications.[5] The alternative is cervical epidural steroid injections, which have good evidence for short-term relief of symptoms in these patients.[6] The low incidence of major complications (<1% as reported by the bone and joint decade 2000-2010 task force on neck pain and its associated disorders)[5] combined with ease of administration make them an attractive option.

Cervical epidural injections can be performed using an interlaminar or a transforaminal technique. As cervical radicular pain is frequently caused by foraminal stenosis, transforaminal steroid injections can maximize the concentration of steroid delivered to the affected nerve roots while reducing the volume of carrier required and have been shown to be effective in relieving symptoms.[7,8]

Limitations of the current technique

Examination of the literature on cervical nerve root block reveals a multitude of reported complications and resulting adverse central nervous system sequelae. Ma and coworkers,[9] in a survey of 1036 consecutive extraforaminal cervical blocks, showed a complication rate of 1.64%. They reported 6 patients with transient neurologic deficits and 1 patient with global amnesia. There have been reports of fatal complications in the literature because of vertebral artery injury[10,11] and/or infarction of the spinal cord and the brain stem.[12-16] The mechanism of injury was contended to be vasospasm or the particulate nature of the steroid injectate with embolus formation after inadvertent intra-arterial injection.[12,13] That is why some experts advocate using only local anesthetic or nonparticulate steroids when performing such injections.[1,17]

Furman and coworkers[18] showed a 19.4% incidence of inadvertent intra-arterial injections during transforaminal cervical epidural steroid injections. The use of aspiration of blood was only 45.9% sensitive for detection, and real-time contrast fluoroscopy was deemed necessary to detect inadvertent intravascular injections. But Baker and coworkers[13] reported an instance of intra-arterial injection of contrast that showed no runoff with conventional real-time fluoroscopy but was seen as intravascular after using digital subtraction angiography. So they concluded that even real-time contrast fluoroscopy may be insufficient and recommended digital subtraction angiography for detection of inadvertent intravascular injection. Wallace and coworkers,[10] in their report of vertebral artery dissections after cervical transforaminal steroid injections, have advocated the use of CT guidance to visualize the vascular structures with better resolution after contrast injection.

Currently, the guidelines for cervical transforaminal injection 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 the risk of injury to the vertebral artery or the nerve root.[1] Despite strict adherence to these guidelines, adverse outcomes have been reported.[12,13] A potential shortcoming to these current guidelines would be the presence of a critical feeder vessel to the anterior spinal artery in the posterior aspect of the intervertebral foramen that could be injured in the pathway of the needle.[2] Here, the ultrasonography may come to play, as it allows for visualization of soft tissues, nerves, and vessels and also facilitates visualization of the injectate around the nerve; thus, it may be advantageous to fluoroscopy.

Literature review of ultrasound-guided cervical nerve root block

Galiano and coworkers[19] described the use of ultrasound (US) in cadavers to visualize the middle and lower cervical spine for the purpose of performing periradicular injections. They used computed tomographic images for confirmation. Five of the 40 US examinations could not depict the spinal

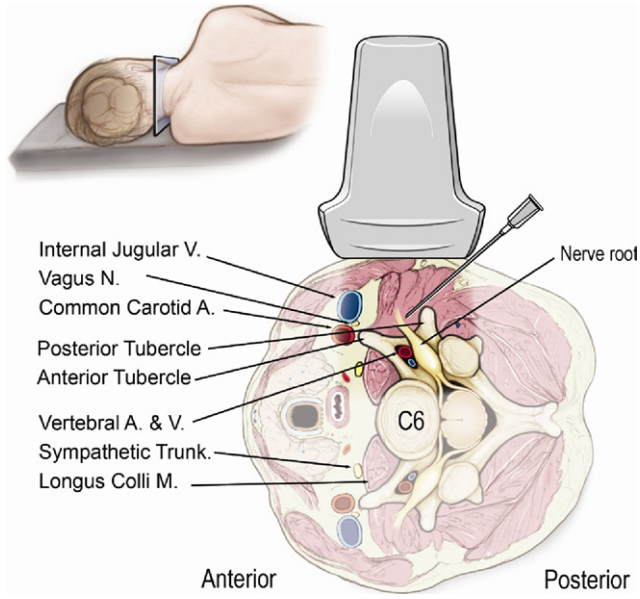

Figure 1 Illustration showing the orientation of the US transducer and the anatomy relevant to cervical transforaminal injection. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2008-2009. All Rights Reserved.) (Color version of figure is available online.)

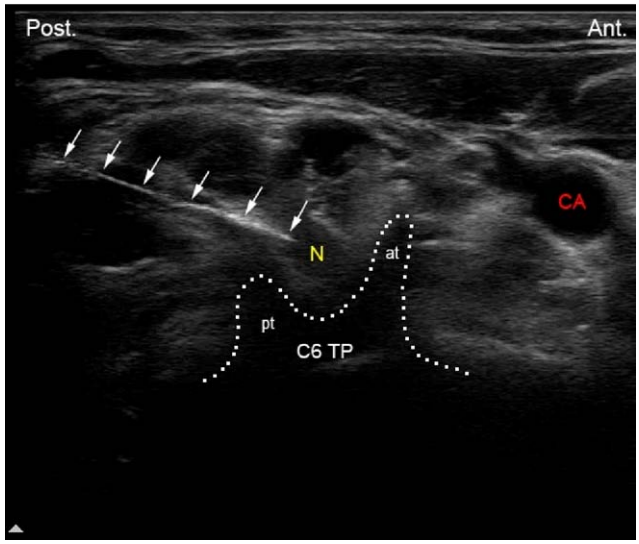

Figure 3 Short-axis transverse US image showing the sharp anterior tubercle (at) of the C6 transverse process (C6tp). N, nerve root; CA, carotid artery; pt, posterior tubercle. Solid arrows are pointing to the needle in place at the posterior aspect of the intervertebral foramen. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2008-2009. All Rights Reserved.) (Color version of figure is available online.)

nerve due to reduced imaging conditions, and the placed 8 needles were positioned within 5 mm dorsal to the spinal nerve. They were not able to comment on the relevant blood vessels in the vicinity of the vertebral foramen, and this raised some concerns about the safety of performing the procedure with US at that time.[20] Now, with the introduction of high-resolution US transducers and gaining more experience, we were able to visualize small critical arteries with ultrasonography.

Narouze and coworkers[21] 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. The radiologic target point was the posterior aspect of the intervertebral foramen just anterior to the SAP in the oblique view, and at the midsagittal plane of the articular pillars in the anteroposterior (AP) view.

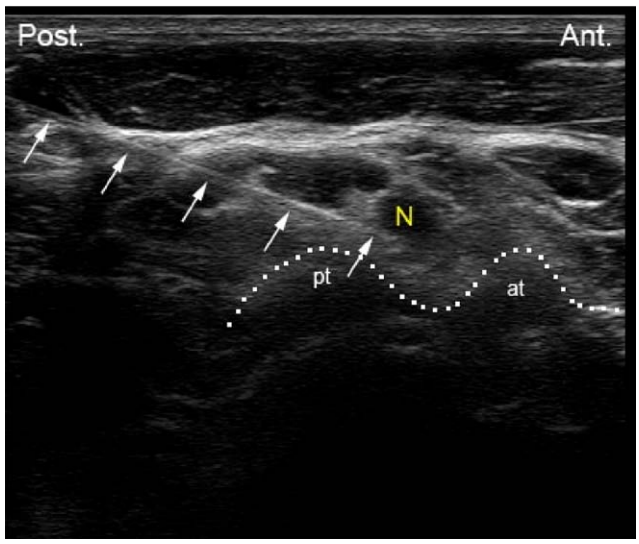

Figure 2 Short-axis transverse US images showing the anterior tubercle (at) and the posterior tubercle (pt) of the cervical transverse process as the "two-humped camel" sign. N, nerve root; CA, carotid artery. Solid arrows are pointing to the needle in place at the posterior aspect of the intervertebral foramen. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2008-2009. All Rights Reserved.) (Color version of figure is available online.)

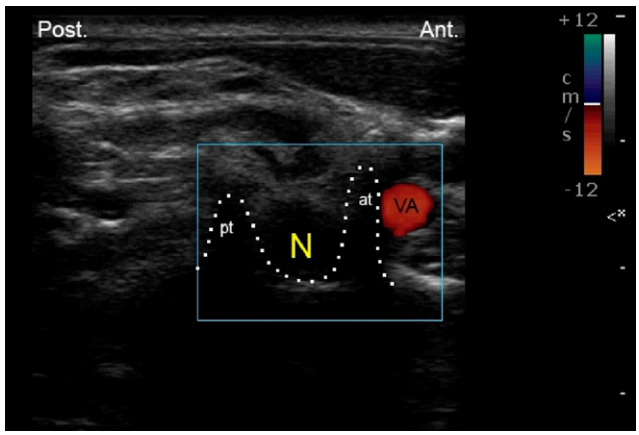

Figure 4 Short-axis transverse US image showing the sharp anterior tubercle (at) of the C6 transverse process and the vertebral artery (VA) is anterior. N, nerve root; CA, carotid artery; pt, posterior tubercle. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2008-2009. All Rights Reserved.) (Color version of figure is available online.)

The needle was exactly at the target point in 5 patients in the oblique view and in 3 patients in the AP view. The needle was within 3 mm in all patients in the lateral oblique view and in 8 patients in the AP view. In the other 2 patients, the needle was within 5 mm from the radiologic target.

In 4 patients they were able to identify vessels at the anterior aspect of the foramen, whereas 2 patients had critical vessels at the posterior aspect of the foramen. In one patient, this artery continued medially into the foramen, most likely forming a segmental feeder artery. In these 2 cases, such vessels could have injured easily in the pathway of a correctly placed needle under fluoroscopy.

Ultrasound-guided technique for cervical selective nerve root block

With patients lying in the lateral decubitus position, US examination is performed using a high-resolution linear array transducer. The transducer is applied transversely to the lateral aspect of the neck to obtain a short-axis view of the cervical spine (Figure 1). One can easily identify the cervical transverse process with the anterior and posterior tubercles as hyperechoic structures "two-humped camel" sign and the hypoechoic round or oval nerve root in between[21] (Figure 2). First, the cervical level is determined by identifying the transverse process of the seventh and sixth cervical vertebrae (C7 and C6). The seventh cervical transverse process (C7) differs from the above levels as it usually has a rudimentary anterior tubercle and one prominent posterior tubercle.[22] Then, by moving the transducer cranially, the transverse process of the sixth cervical spine comes in the image with the characteristic sharp anterior tubercle (Figure 3), and then after the consecutive cervical spinal level can be easily identified. Another way to determine the cervical spinal level is by following the vertebral artery, which runs anteriorly at the C7 level before it enters the foramen of C6 transverse process in about 90% of cases. However, it enters at C5 or higher in the remaining cases[23] (Figure 4).

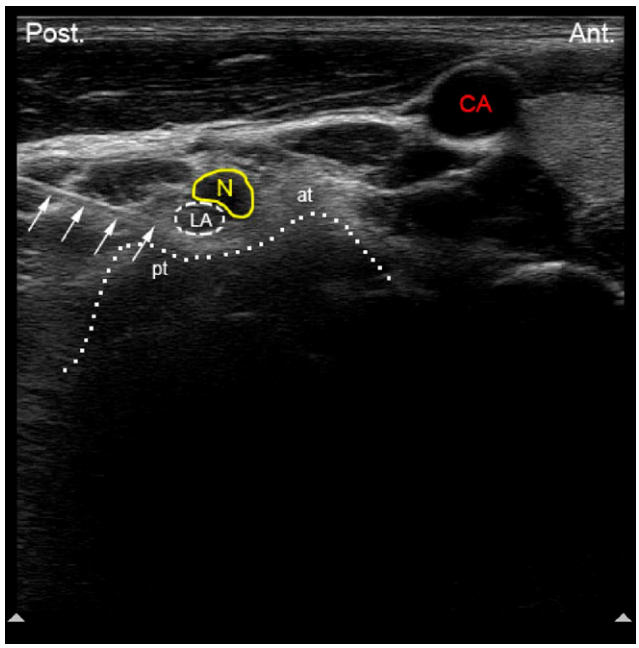

Figure 5 Short-axis transverse US image showing the spread of the local anesthetic (LA). N, nerve root; CA, carotid artery; at, anterior tubercle; pt, posterior tubercle. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2008-2009. All Rights Reserved.) (Color version of figure is available online.)

Once the appropriate spinal level is identified, a 22-gauge blunt-tip needle can be introduced just lateral to the lateral end of the transducer and advanced, from posterior to anterior, in-plane with the US beam (Figure 1) under real-time US guidance to target the corresponding cervical nerve root [from C3-C8] at the external foraminal opening. One can successfully monitor the spread of the injectate around the cervical nerve (Figure 5) with real-time ultrasonography; however, it is difficult to monitor the spread of the injectate through the foramen—if any—into the epidural space (because of the bony drop out artifact of the transverse process). We therefore refer to this approach as a "cervical selective nerve root block" rather than cervical transforaminal epidural injection.

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