Ultrasound Imaging for Cervical Injections

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Myth: Ultrasound imaging is a proven safe and effective alternative to fluoroscopy for cervical spine injections.

Fact: There is a paucity of literature evaluating the safety, accuracy, and effectiveness of ultrasound-guided cervical spine procedures, with available evidence suggesting inferior accuracy of ultrasound-guided needle placement. Fluoroscopy remains the best evidence-based image-guidance modality for the performance of cervical spine injections.

Ultrasound has been reported as an alternative image-guidance modality for cervical nerve root blocks, intra-articular facet injections, medial branch blocks, and radiofrequency ablation (1)(2)(3). Reported benefits of ultrasound include avoidance of radiation exposure to the patient, staff, and physician, as well as real-time direct visualization of soft tissue structures such as nerves and vessels. However, there are distinct safety considerations, concerns about accuracy of needle placement, and limited evidence assessing the effectiveness of ultrasound as opposed to fluoroscopically-guided cervical injections.

The incidence rate of complications related to the use of ultrasound for these procedures has not been defined as there are no published cohorts large enough to determine this. Currently, there is one available case report of spinal cord injury occurring during an ultrasound-guided C7 cervical medial branch block (4). Absence of additional case reports does not confer safety, however.

One proposed benefit of ultrasound is that it allows for visualization of vital soft tissue structures such as nerves and blood vessels. One study found that ultrasound evaluation of the C4-5, C5-6, and C6-7 neuroforamina reported the presence of a blood vessel (artery or vein) in 5.5%, 12.1%, and 13.5% of these foramina, respectively (5). Notably, these incidences are significantly lower than those obtained using cadaveric dissection to identify vulnerable arteries in the cervical neuroforamina, reported to be present 22.2% of the time (6). There is no available literature assessing how reliable ultrasound is in detecting vulnerable vessels. In theory, ultrasound evaluation may be specific, but lack sufficient sensitivity for identifying vulnerable vessels when performing cervical injections. Many ultrasound studies still rely on contrast injection during live fluoroscopic observation to rule out intra-vascular injection prior to depositing injectate (7)(8). In one study that compared ultrasound and fluoroscopic-guidance for cervical nerve root injections, intra-vascular injection was detected in 4/60 injections when fluoroscopy was used, compared to 0/60 when ultrasound was used (7). Similarly for cervical medial branch blocks, the current standard for detection of vascular uptake is injection of contrast media under live fluoroscopic observation, which has been shown to be more specific than other techniques such as negative aspiration (9). It cannot be assumed that the use of ultrasound is as effective as live fluoroscopy in the detection of vascular uptake during cervical medial branch blocks, an important consideration given the potential for false negative blocks during this diagnostic test if vascular uptake is undetected.

Another potential risk of ultrasound-guided injections occurs when the needle tip is not visualized. Visualization of the needle tip during the procedure, which is paramount for safety, is more challenging with ultrasound compared to fluoroscopy. Because of this, larger gauge needles are often needed. Without appropriate technique and skill, the lack of needle tip visualization may lead to catastrophic complications such as in the case report of spinal cord injury that occurred during a C7 medial branch block with ultrasound guidance (4). In addition, the theoretical capability of ultrasound to visualize vascular structures is irrelevant if the needle tip is not visualized.

There are multiple proposed techniques to properly identify the correct vertebral segment when performing an ultrasound-guided cervical injection. Some techniques, such as identifying where the vertebral artery enters a foramen, inherently lack sufficient specificity due to anatomic variability between patients. While

cephalad from this position may be more reliable, they all lack a means of saving an ultrasound image confirming that the appropriate vertebral segment was targeted. Standard fluoroscopy projections, on the other hand, quickly and reliably identify all relevant landmarks.

Ultrasound is also touted for its elimination of radiation exposure. While ultrasound does not expose the patient, staff, or physician to radiation, the radiation dose that a patient is exposed to during a typical spine injection is orders of magnitude less than the average annual exposure to background radiation (10).

The ultrasound-guided needle approach used for a cervical spine injection differs from that when fluoroscopy is used. For ultrasound-guided cervical nerve root injections, the target is in the intertubercular neural groove, which is outside of the neuroforamen (11). When comparing the final needle position under fluoroscopy after ultrasound guidance was used for needle placement for cervical nerve root injection, the needle was found to be exactly at the target point in 5 of 10 patients in the lateral oblique view and in only 3 of 10 patients in the AP view (2). A similar study found that the ultrasound-guided needles were identified by fluoroscopy exactly at the target points in 28/55 patients from the lateral oblique view and in 26/55 patients from the AP view (7). Unsurprisingly, achieving epidural spread in ultrasound-guided cervical nerve root injections is less likely. One study found that with 1 cc of injectate, epidural spread occurred in 0/53 ultrasound-guided injections. With 4 cc of injectate, "intraforaminal epidural" flow was detected in 24.5% of cases (12). Another study found that 10/12 injections resulted in spread along the nerve root in an "extra-neural" pattern and along the scalene muscle in 2/10 injections (13). In a cadaveric study, 30/30 ultrasound-guided injections resulted in dye spread surrounding the nerve root outside of the intervertebral foramen; in other words, none achieved epidural spread (13). Accordingly, when these injections are performed with ultrasound, they are referred to as cervical nerve root injections instead of epidural injections.

In a cadaveric study assessing the feasibility of cervical facet intra-articular injections, 78% (31 of 40) of ultrasound-guided facet joint injections were successful, with the authors concluding that substantial obstacles may prevent their routine use(14).

For medial branch nerve injections, accurate and precise needle placement is essential for an accurate and reliable block or subsequent effective neurotomy. One study that used ultrasound to perform a cervical medial branch nerve block and then used fluoroscopy to confirm placement found that 82 of 107 (77%) attempts resulted in correct placement (3). While further studies are needed, a miss rate of greater than 20% is prohibitively high for accuracy to be maintained for this diagnostic injection. In the only study that evaluated the accuracy of ultrasound for placement of a radiofrequency probe, the target was missed in 4/34 cases (1). Accuracy of radiofrequency probe placement is further complicated by which technique (perpendicular vs. parallel) is utilized.

Finally, procedural risk must be balanced against documented effectiveness. There are no studies demonstrating clinical accuracy of ultrasound-guided cervical medial branch nerve blocks or effectiveness of ultrasound-guided cervical medial branch radiofrequency neurotomy. The only study comparing ultrasound-guided cervical nerve root steroid injections to fluoroscopically-guided transforaminal epidural steroid injections found equal improvement in pain scores between groups, with mean VAS improving from 6.1 to 2.6 at 12 weeks in both groups (7). A cohort of patients undergoing ultrasound-guided cervical nerve root steroid injection reported that the average pain relief was 53% at 7 days and 13% relief at 30 days (13). Another cohort study reported that of 59 patients, 46 (78%) reported 50% or more improvement in cervical radicular pain at 3 months (8). There are no comparative effectiveness or placebo-controlled studies of ultrasound-guided cervical nerve root steroid injections.

Recommendations

- If ultrasound use is planned, until better evidence is presented, it is recommended to combine it with fluoroscopy.
  - Retain fluoroscopic images to document that the proper vertebral level was targeted, and final needle tip position.
  - Use real-time fluoroscopy to confirm the absence of intravascular injection.

- Clearly discuss with patients that evidence in support of the accuracy of needle placement and effectiveness of ultrasound-guided cervical injections is very limited and may not be equal to fluoroscopically performed injections.

- Discuss that the use of ultrasound confers unique risk profile.
  - Spinal cord injury during ultrasound-guided cervical medial branch block has been reported.

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