Pain Physician 2024; 27:E157-E168 • ISSN 2150-1149

Cadaveric Study

# A Comparison of Precision and Safety using Three Recognized Ultrasound-Guided Approaches to Cervical Medial Branch Blocks: A Cadaver Study

Agnes R. Stogicza, MD[1], Alan Berkman, MD[2], André Marques Mansano, MD, PhD[3], Thiago Nouer Frederico, MD[3], Raja Reddy, MD[4], Charles Oliveira, MD[5], Wesley Chih-Chun Chen, MD[6], Christ Declerck, MD[7], Stanley Lam, MBBS[8], Micha Sommer, MD, PhD[9], Edit Racz, MD[1], Fabricio Dias Assis, MD[2], Andrea M. Trescot, MD[10], Javier de Andrés Ares, MD, PhD[11], María Luz Padilla del Rey, MD[12], and Sander van Kuijk, PhD[9]

From: [1]Saint Magdolna Private Hospital, Budapest, Hungary; [2]St Paul's Hospital, University of British Columbia, BC, Canada; [3]Hospital Israelita Albert Einstein, São Paulo, Brazil; [4]Medway National Health Service Trust United Kingdom; [5]Sinpain – Pain Management Center, Campinas, Brazil; [6]Purple Sun PM&R, Spine and Joint Center, Taipei, Taiwan; [7]Saint John's General Hospital Bruges, Belgium; [8]The Hong Kong Institute of Musculoskeletal Medicine, Hongkong, The Chinese University of Hong Kong, Hong Kong; [9]Maastricht University, The Netherlands; [10]Physician Partners of America (PPOA), Jacksonville, FL; [11]Hospital Universitario La Paz, Madrid, Spain; [12]Complejo Hospitalario Universitario de Cartagena, Murcia, Spain

Address Correspondence:
Agnes R Stogicza, MD
Department of Anesthesiology and Pain Medicine,
Saint Magdolna Private Hospital
Budapest, Hungary
E-mail: stogicza@gmail.com

Disclaimer: This research was supported by Semmelweis University, Department of Pathology, Forensic, and Insurance Medicine.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 04-22-2023

**Background:** Ultrasound (US) guidance is widely used for needle positioning for cervical medial branch blocks (CMBB) and radiofrequency ablation, however, limited research is available comparing different approaches.

**Objective:** We aimed to assess the accuracy and safety of 3 different US-guided approaches for CMBB.

**Study Design:** A cadaveric study divided into ultrasound-guided needle placement and fluoroscopy evaluation stages.

**Setting:** Department of Pathology, Forensic, and Insurance Medicine, Semmelweis University.

**Methods:** Sonographically guided third occipital nerve (TON), C3, C4, C5 and C6 medial branch injections and radiology evaluations were performed.

The 3 approaches compared were:
1. ES (published by Eichenberger-Siegenthaler): US probe in the coronal plane to visualize the cervical articular pillars, needle approach out of the plane, from anterior to posterior.
2. Fi (published by Finlayson): US probe in the transverse plane to visualize a cervical articular pillar and its lamina, needle approach in the plane, from posterior to anterior.
3. FiM (Modified Finlayson approach): Needles are placed as in Fi, but then adjusted with a coronal view of the cervical articular pillars.

Fluoroscopy images were taken and later evaluated, for "crude", "high precision" and "dangerous" placement.

**Results:** One hundred and fifty-five needle placements were assessed (10 were excluded, as no anterior-posterior fluoroscopy images were saved). Interobserver agreement on position of needle placement between the 5 observers was very high; the Fleiss' Kappa was 0.921.

For crude placement, no significant differences were identified between various approaches; (77.6%, 79.5%, and 75.6% for the ES, Fi, and FiM respectively). However, for placement in predefined high-precision zones, ES resulted in significantly more success (ES: 42.9%, Fi: 22.7%, and FiM: 24.4%, $P = 0.032$). Fi and FiM resulted in no dangerous placements, while ES led to the potential compromise of the exiting nerve root and vertebral artery on three occasions. In 10% of the placements, the levels were identified wrongly, with no difference between the various approaches.

**Limitations:** Feedback from a live patient, may prevent some existing nerve root injections, unlike in a cadaver. Though a higher number of needles were placed in this study than in most available publications, the number is still low at each individual medial branch level.

Revised manuscript received: 07-11-2023
Accepted for publication: 09-13-2023

Free full manuscript: www.painphysicianjournal.com

**Conclusion:** Fi proved safer than ES. Fi was equally successful in targeting the articular pillar, however, ES proved the most successful in placing the needle in the center of the articular pillar. Adding another, (coronal) US view to check needle position in FiM did not improve safety or precision. Identifying CMB levels with the US is challenging with all approaches, therefore we still recommend using fluoroscopy for level identification. While there were pros and cons with either procedure, the efficacy findings of previous papers were not replicated on elderly cadavers with arthritic necks.

**Key words:** cervical facet, medial branch block, safety, accuracy, ultrasound, fluoroscopy

**Pain Physician 2024: 27:E157-E168**

Cervical facet joints are considered to be the primary source of pain in 26-70% of patients with chronic neck pain, shoulder pain, or cervicogenic headaches (1-5). Medial branch diagnostic injections followed by radiofrequency denervation are validated approaches in the diagnosis and treatment of neck pain (3). Cervical facet joints are dually innervated by the medial branches of the dorsal rami of the cervical nerves (4,7).

Ultrasound (US) is increasingly used for pain procedures due to benefits like soft tissue and needle visualization, accessibility, affordability, and safety. However, it has limitations, such as inadequate orientation, lower image quality in high body mass index (BMI) patients, and inability to assess injectate spread precisely. Fluoroscopy remains the gold standard, and the US is an experimental modality for reimbursement by United States health insurers.

The currently published and practiced US-guided cervical medial branch block (CMBB) methods that are taught by various anesthesia and pain societies have only been validated in a few cadaveric and clinical studies, mainly by 2 groups: the Finlayson group and the Eichenberger-Siegenthaler group. Clinical studies on efficacy are emerging, but the literature is still missing data on safety and efficacy.

Cervical injections are high-risk procedures, and various devastating complications, including direct spinal cord injury, spinal cord compression due to hematoma, anterior spinal cord syndrome, brain stem, and cerebellum ischemia due to inadvertent vertebral artery compromise have been published (8-13). In 2017 an US-guided CMBB resulted in a spinal cord injury (14).

### Objective

To assess and compare the precision and safety of the commonly performed US-guided CMBB techniques (as published by Finlayson and Eichenberger-Siegenthaler) using fresh cadavers.

### Study Design

A cadaveric study divided into 2 stages. The first stage comprised 8 physicians performing US-guided medial branch blocks, and the second stage comprised 5 physicians assessing the needle placements on the previously saved fluoroscopy images.

### Setting

Department of Pathology, Forensic and Insurance Medicine, Semmelweis University.

## Methods

### Cadavers

After obtaining approval from the Institutional Review Board of Semmelweis University, we included 3 male and 2 female fresh, full, undissected cadavers selected randomly. Their ages ranged from 42 to 72 years old, with a mean age of 67. Their BMI ranged from 19 to 26, with a mean of 23.2. Three of the cadaver necks were deemed arthritic by the sonographers.

A Sonosite Edge 2® Ultrasound System (Fujifilm Ltd) with a 13-6-MHz high-resolution linear transducer and BRAUN 20G 50mm echogenic needles were used.

### Study Participants

The study participants consisted of 8 ultrasound proceduralists (RR, ARS, AMM, CO, SL, WC, TN, CD) performing the procedures, with 2 physician observers (AMT, ER) during needle placement to watch for harm and, subsequently, 5 fluoroscopy image evaluators (FDA, MS, AB, MLP, JA) assessing the needle placements on the fluoroscopic images captured.

The US proceduralists were experienced interventional pain physicians with Certified Interventional Pain Sonologist certification and 5-20 years of experience in performing and teaching US-guided procedures. The average experience in performing and teaching US-guided procedures was 10.8 and 5.2 years, respectively.

All proceduralists performed at least 50 medial branch blocks previously with the techniques assessed.

Similarly, the evaluators were experienced, internationally recognized interventional pain physicians with a mean of 9.4 years since their Fellow of Interventional Pain Practice certification and 9 to 36 years of experience in performing and teaching fluoroscopy-guided procedures.

## Test Under Investigation

### *Three Different Approaches to Ultrasound-Guided Needle Placement at the Third Occipital Nerve (TON), and C3-C6 Medial Branches*

Approach #1 (ES): US visualization of a series of cervical articular pillars (US probe in the coronal plane), with the needle approach out of a plane, from anterior to posterior), as described by Eichenberger and Siegenthaler (15-17).

Placing the cranial end of the transducer over the mastoid process allowed for visualization of the C1 transverse process after moving it slightly caudally and posteriorly. A slight rotation of the transducer made the C2 articular pillar and C2-3 joint line visible, while further sliding of the probe revealed the "hills" and "grooves" marking the location of the medial branch. Needles were inserted in TON, C3, C4, C5, and C6 in that order, from anterior to posterior, until the needle tip was visualized at the deepest point of the articular pillar. (Fig. 1a-d and 2a).

Approach #2 (Fi): US visualization of the cervical articular pillar and laminae (US probe in a slightly oblique transverse plane), needle approach in a plane, from posterior to anterior, as described by Finlayson (18) (Fig. 3a,b).

Moving the transducer cephalocaudally the joint lines, "hills", and "grooves" were visualized, marking the target point for MBB. Levels were identified by the characteristic tubercule/transverse process of C6 and C7. Needles were placed in the C6, C5, C4, and C3, TON order until bony contact was made at the deepest part

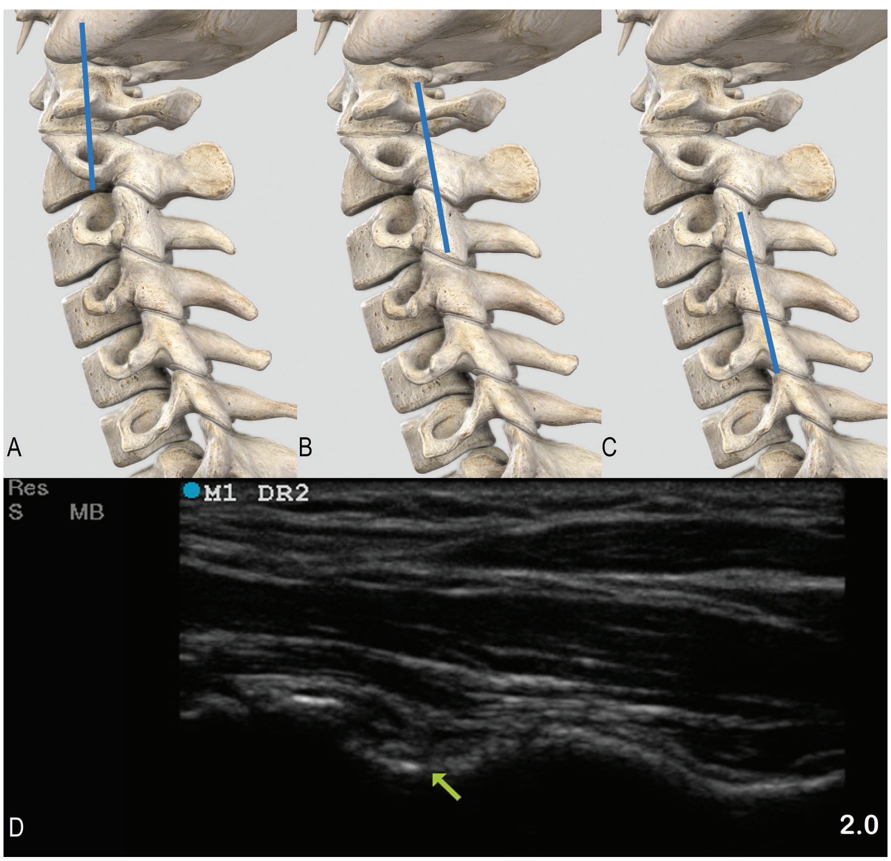


Fig. 1a, b, c and d. *ES approach. US probe positions to identify TON and CMBBs. The cranial end of the transducer is placed over the mastoid process (blue mark), then it is moved slightly caudally and posteriorly to allow visualization of the C1 transverse process (a). With a slight rotation of the transducer, the C2 articular pillar and the C2-3 joint line come into view, which marks the target point for the TON (b). Sliding the probe further caudally allows identification of the zygapophyseal joint openings, the "hills" and the deepest points of the articular pillars, and "grooves" marking the location of the medial branch (c). The typical wavy line of the articular pillar is visualized, the arrow marks the needle tip at C4 MB (d).*

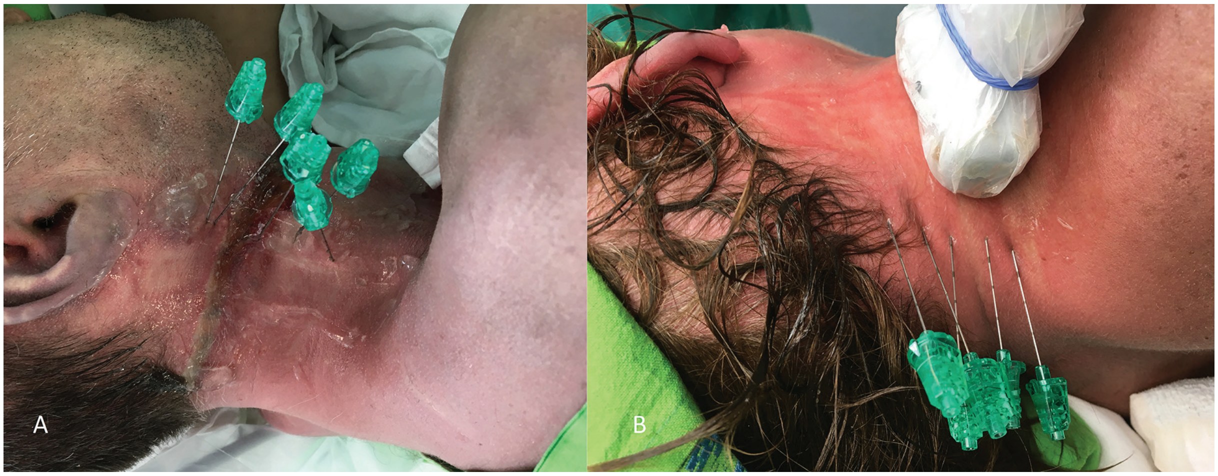


Fig. 2a and b. *ES, Fi, FiM approaches, needles were placed to the TON, C3, C4, C5, and C6 medial branches, until bony contact was made. ES approach: out-of-plane technique, from anterior to posterior. The footprint of the US probe is visible on the cadaver (a). Fi and FiM approach: in plane technique, from posterior to anterior (b).*

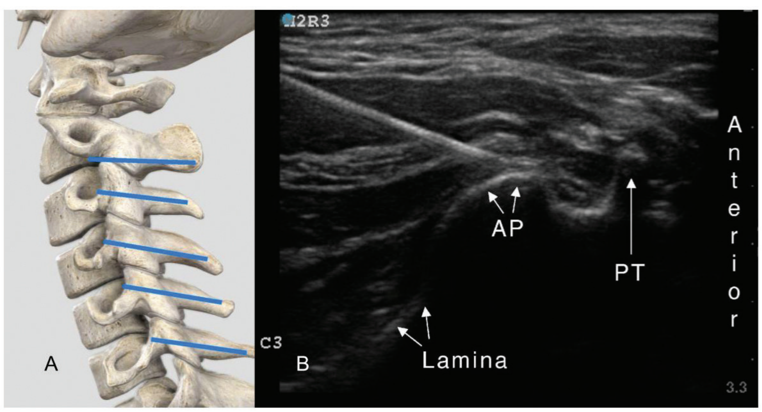


Fig. 3a and b. *Fi approach. US visualization of the cervical articular pillar and laminae (US probe in the transverse plane with a slight caudal rotation, blue mark) (a). Needles were placed in the C6, C5, C4, C3, TON needle approach in plane, from posterior to anterior (b). The lowest point of the articular pillar, the lamina, and part of the spinous process are visualized. Needle on target at C3 MB. AP = articular pillar, PT = posterior tubercule (c).*

of the articular pillar for C6-C3 and the C2-3 joint line for TON (Fig. 2b).

Approach #3 (FiM): Needle placement as in Fi, then needle tip adjusted with US visualization of the C-spine in a coronal view, as suggested by Finlayson for TON, C5, and C6 levels. We hypothesized that a combination of the two views might show more precision at other levels as well (19) (Fig. 4).

## Ultrasound-guided Procedure Description

Cadavers were positioned in lateral decubitus, optimal lateral, and anteroposterior x-ray imaging, with overlapping left and right articular pillars visible. After a 5-minute pre-scan, one practitioner placed needles at TON, C3-C6 medial branches using the ES approach, as well as Fi and FiM approaches. X-ray images were taken after each technique but not shown to the practitioner. This resulted in a total of 15 needles placed on one cadaver. No feedback was given between techniques. In total, 8 practitioners performed the procedure on 5 cadavers, leading to 165 needle placements.

## Fluoroscopy Evaluation

Both AP and lateral fluoroscopy images of each needle were then evaluated independently for precision and safety by 5 experts. The evaluators were blinded to the proceduralist's name and other evaluator's assessment. These 2 standardly used fluoroscopy views are sufficient to reconstruct the 3-dimensional image of both the bony spine less the minor calcifications and the needle. Typical needle placement appeared as in Fig. 5a,b for ES and Fig. 6a,b for Fi and FiM.

The specific questions evaluated were as follows:

1. "Is there a needle at the level, or is the level missed?"
   A missed level was defined as no needle tip identifiable on the lower portion of C2 or upper portion of C3 vertebrae for TON and on the corresponding vertebral levels for the C3, C4, C5, and C6 for MBB. If the level was missed, no further questions were asked.
2. "Is the needle in the joint line area (for TON)?" OR "Is the needle on the articular pillar (for C3, C4, C5, C6)?"
   For the crude target, the area in the lower portion of the C2 and upper portion of the C3 articular pillar was defined as acceptable for TON, and the corresponding articular pillar was accepted for C3, C4, C5, C6, marked by the black dashed parallelogram (Fig. 7).
3. "Is the needle within the green zone?"
   For precise placement assessment, the needle tip in the green dashed (5 mm side) rhombus was accepted (Fig. 7). We based this rhombus on the previously published papers by Siegenthaler et al. and the contrast spread at C2–C3 medial branch blocks studied by Barnsley et al (20). Finlayson also used the rhombus in his study to assess precise needle placement (17,21).
4. "Is the needle placement potentially dangerous?"
   Danger zones were defined as needles potentially compromising the spinal contents, the exiting nerve root, and/or the vertebral artery.
   In cases where there were 2 needles at one level, the needle in the better position was evaluated

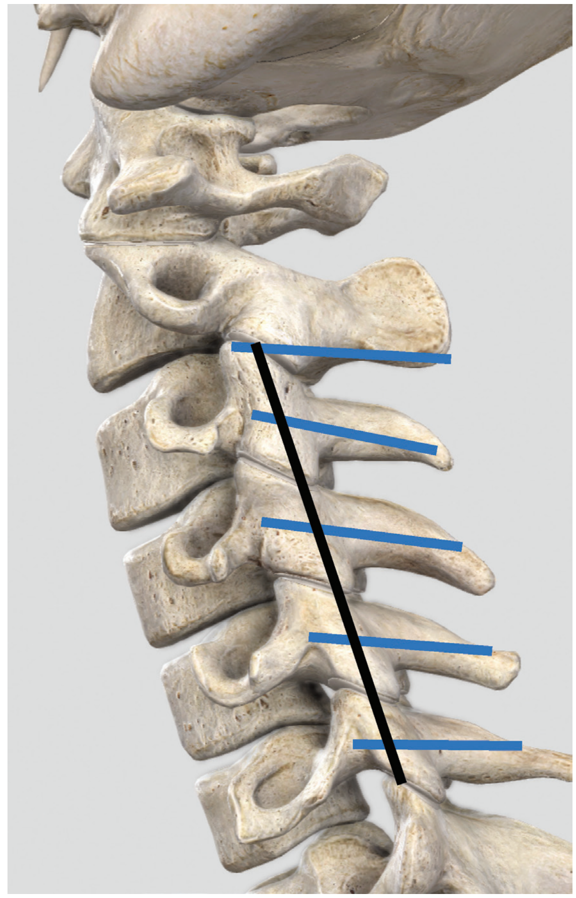

Fig. 4. *FiM approach. Target visualization and needle placement as in Fi (Fig 3), but then the needle tip was adjusted with US visualization of the C-spine in a coronal view (black mark).*

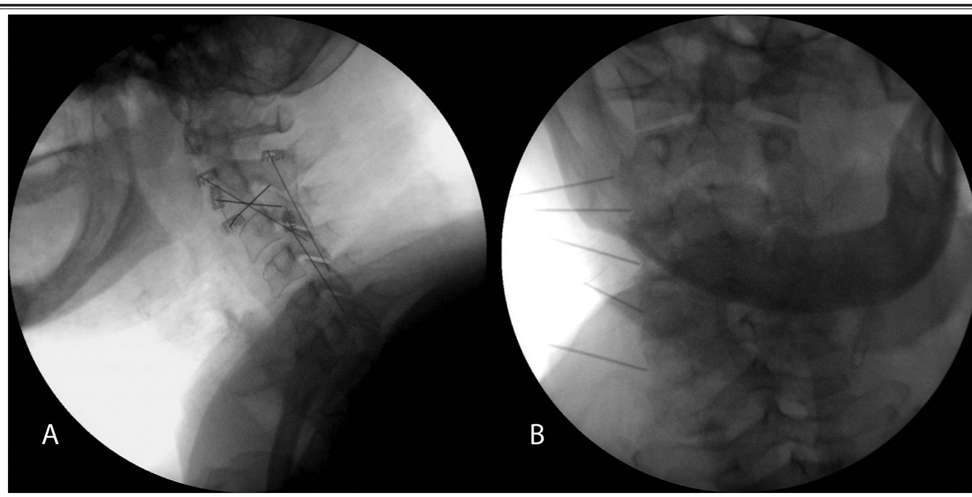


Fig. 5a and b. *Fluoroscopy images for needle placement appeared for ES.*

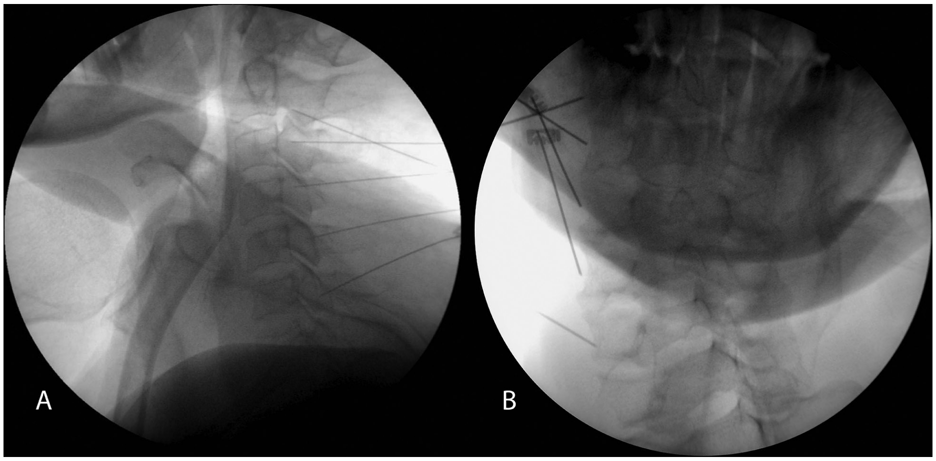


Fig. 6a and b. *Fluoroscopy images for needle placement appeared for Fi and FiM.*

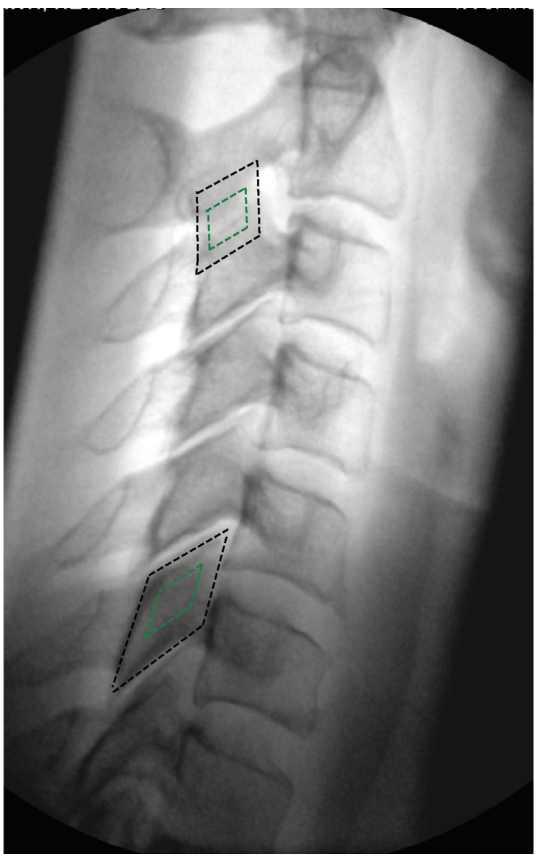

Fig. 7. *Evaluation of needle placement on the fluoroscopy images. For crude target, the area in the lower portion of the C2 and upper portion of the C3 articular pillar was defined as acceptable for TON, and the needle positioned on the corresponding articular pillar was accepted for C3, C4, C5, C6, marked by the black dashed parallelogram. For precise placement assessment, the needle tip in the green dashed parallelogram was accepted.*

for precision, but both needles were assessed for safety/danger.

## Results

A total of 5 cadavers were used for TON, C3, C4, C5, and C6 MB block procedures resulting in a total of 165 needle placements. Ten needle placements were excluded from the study, as the AP fluoroscopic views were not saved for further viewing. Therefore, a total of 155 needle placements were assessed.

### Statistical Analysis

Characteristics of cadavers were described as mean and SD for continuous variables, and absolute value and percentage for categorical variables.

As a measure of internal validity, we used the Fleiss' Kappa coefficient to compute agreement between observers who scored needle placements corrected for chance agreement. In case of disagreement between observers on needle placement, we took the most frequent binary score to end up with a single score within the procedure and location. For each method, we described the frequency of correct needle placement on the crude target, needle placement within the green zone, dangerous needle placement, and level/s missed. The various approaches were compared to each other concerning crude needle placement (dashed, black parallelogram), placement within the green zone, dangerous placement, and level missed using generalized linear mixed-effects regression to account for clustering of multiple procedures within cadavers.

### Interobserver Agreement

Interobserver agreement on the safety of needle

Table 1. *Characteristics of needle placement stratified by method for all locations combined and separate.*

| **All locations combined** | **ES-A n = 55** | **Fi-A n = 50** | **FiM-A n = 50** | ***P*-value** |
|---|---|---|---|---|
| Level missed | 6 (10.9%) | 6 (12.0%) | 5 (10%) | 0.948 |
| Correct crude needle placement | 38 (77.6%) | 35(79.5%) | 34 (75.6%) | 0.911 |
| Placement within green zone | 21 (42.9%) | 10 (22.7%) | 11 (24.4%) | 0.032 |
| Dangerous placement | 3 (5.5%) | 0 (0.0%) | 0 (0%) | 0.042 |
| **Third occipital nerve** | n = 11 | n = 10 | n = 10 | |
| Level missed (no needle at level) | 2 (18.2%) | 1 (10.0%) | 1 (10.0%) | |
| Correct crude needle placement | 3 (33.3%) | 4 (44.4%) | 5 (55.6%) | |
| Placement within green zone | 3 (33.3%) | 2 (22.2%) | 3 (33.3%) | |
| Dangerous placement | 2 (22.2%) | 0 (0.0%) | 0 (0.0%) | |
| **Medial branch C3** | n = 11 | n = 10 | n = 10 | |
| Level missed (no needle at level) | 1 (9.1%) | 0 (0.0%) | 1 (10.0%) | |
| Correct crude needle placement | 9 (90.0%) | 8 (80.0%) | 6 (66.7%) | |
| Placement within green zone | 3 (30.0%) | 3 (30.0%) | 3 (33.3%) | |
| Dangerous placement | 1 (10.0%) | 0 (0.0%) | 0 (0.0%) | |
| **Medial branch C4** | n = 11 | n = 10 | n = 10 | |
| Level missed (no needle at level) | 0 (0.0%) | 1 (10.0%) | 0 (0.0%) | |
| Correct crude needle placement | 11 (100%) | 8 (88.9%) | 8 (80%) | |
| Placement within green zone | 6 (54.5%) | 2 (22.2%) | 2 (20.0%) | |
| Dangerous placement | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| **Medial branch C5** | n = 11 | n = 10 | n = 10 | |
| Level missed (no needle at level) | 1 (9.1%) | 0 (0.0%) | 0 (0.0%) | |
| Correct crude needle placement | 8 (80%) | 10 (100%) | 8 (80%) | |
| Placement within green zone | 4 (40.0%) | 1 (10.0%) | 2 (20.0%) | |
| Dangerous placement | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |
| **Medial branch C6** | n = 11 | n = 10 | n = 10 | |
| Level missed (no needle at level) | 2 (18.2%) | 4 (40.0%) | 3 (30.0%) | |
| Correct crude needle placement | 7 (77.8%) | 5 (83.3%) | 7 (100%) | |
| Placement within green zone | 5 (55.6%) | 2 (33.3%) | 1 (14.3%) | |
| Dangerous placement | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |

Null hypothesis: all are the same.

placement between the 5 observers was very high; Fleiss' Kappa was 0.923. Table 1 shows characteristics of needle placement stratified by method (ES, Fi, and FiM) for all locations combined and for all locations separately.

## Precision

We did not find a significant difference in needle placements between the approaches on the crude target (joint line and articular pillar) zones (ES: 77.6%, Fi: 79.5%, and FiM: 75.6%, *P* = 0.911).

The ES resulted in significantly more needle placements in the predefined green zones (ES: 42.9%, Fi: 22.7%, and FiM: 24.4%, *P* = 0.032).

## Potentially Dangerous Placements

The total number of potentially dangerous needle placements was 3 with ES (needle potentially compromised both the exiting nerve root and the vertebral artery) (Fig. 8.a, b), 0 with Fi and FiM.

Overall, ES resulted in statistically significantly more dangerous placement than Fi and FiM approaches. (5.5% vs 0% vs 0% respectively, *P* = 0.042). Post-hoc analysis also revealed a significant difference between ES and Fi (*P* = 0.047), as compromising the vertebral artery and exiting nerve root only happened with ES.

## Target Level Missed

Target levels were missed 6 (10.9%), 6 (12.0%),

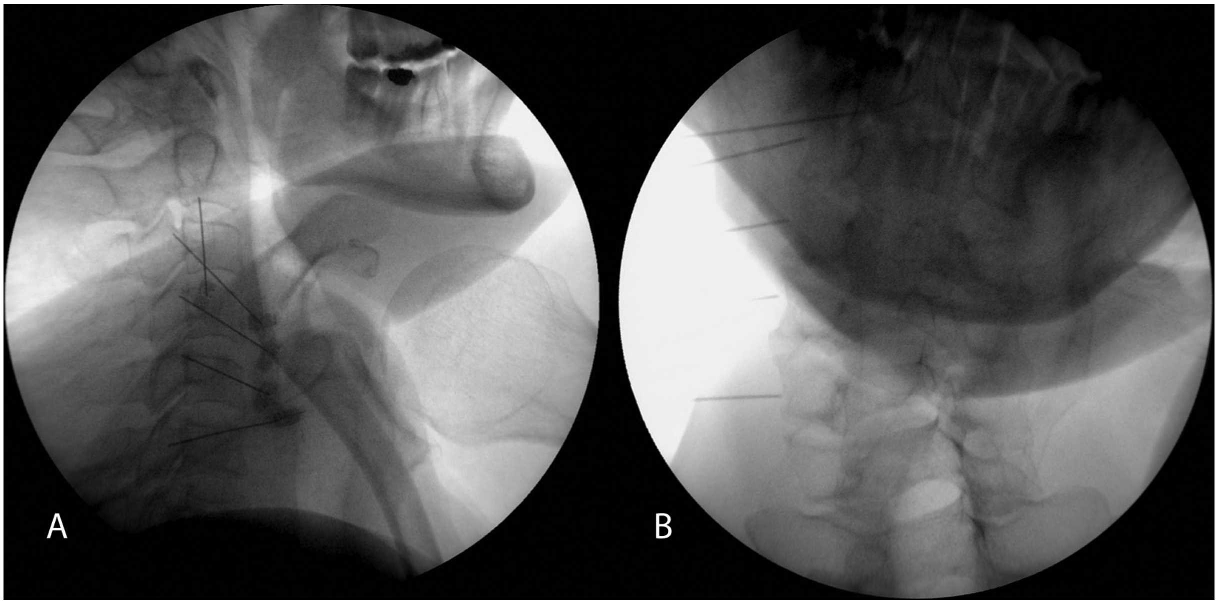


Fig. 8. *ES approach. Example of a needle placed more anterior than planned, and potentially compromised both the exiting nerve root and the vertebral artery.*

and 5 (10.0%) times with ES, Fi, and FiM, respectively. This difference between methods was not statistically significant. In a few cases, operators missed the most cephalad level (TON, ES approach), which resulted in all 5 needles placed one level caudad from the level intended (e.g., needles placed from C3-C7 instead of TON to C6), as the previously placed needle was used as reference. In cases like this, the data suggests only one level missed (TON); however, in real life, this would mean the operator would be wrong at each MBB. With that in mind, the total missed levels would have been 24.4%, 12.0%, and 10.0% with ES, Fi, and FiM, respectively.

## Discussion

Cervical medial branch injections are commonly used to treat headaches, neck pain, and shoulder pain. Precise injection is essential to optimize effectiveness and reduce potential complications, especially given the high-risk areas in the neck.

Two groups have made significant contributions to cervical facet approaches: the European Eichenberger-Siegenthaler group and the Canadian Finlayson group.

Eichenberger and Siegenthaler introduced the ES technique after injecting 14 healthy, low BMI volunteers, and showed 90% accuracy (15,16,22), then showed shortened fluoroscopy-guided radiofrequency (RF) procedure time when the MB was localized sonographically pre-procedure (3). Siegenthaler could successfully visualize the C3-C6 MBs in 39 (78%) of 50 patients. However, the visualization was not confirmed in any way, and patients were not injected. In his next study, he placed 107 US-guided needles to the C3-7 MB of healthy volunteers and showed a 77% accuracy rate (“green zone”) for needle position and 84% for contrast spread. However, the study population had lower age (median 25 years) and BMI (22) and likely no arthritic changes compared to the general neck pain population, which may impact the results.

The other remarkable group of papers that we rely on, came from Finlayson et al. He described the posterior to anterior an in-plane approach to the TON, C3-C7 MBB (18,21,23). In a randomized controlled trial, he compared US-guided TON procedures to fluoroscopy-guided procedures and found good numbness in the TON distribution area for 19 out of 20 patients.

In his paper on the US-guided C3-C6 MBB with fluoroscopy (lateral view only) confirmation he achieved 100% success in placing the needle onto the articular pillar of interest (“crude targeting” in our study); however, positioning it on the center (“green zone” in our study) was achieved in only 80.9% of the cases. Of these cases, 19.1% (mainly at C6 and C5 levels), the needle tip was located on the outer edges of the articular pillar, which he explained as due to degenerative changes. He also raised the idea that it would not matter, since, despite these positioning results, he achieved a better contrast spread (100% for C3, 97% for C4, but only 91.4% for C5 and 84.9% for C6) to the targeted area with 0.3 mL solution of contrast and local anesthetic (21). To improve the success rate, he developed the biplanar technique (FiM) and achieved a 100% success rate on 40 patients, confirmed by contrast spread (19). Of note, all these procedures were performed by 2 proceduralists throughout the publications.

In a randomized controlled trial, he compared US-guided TON procedures to fluoroscopy-guided procedures and found good numbness in the TON distribution area for 19 out of 20 patients.

In this study, we compared the 3 above-discussed approaches to US-guided CMBB, with a focus on safety and precision.

### Safety

The cervical spine has multiple structures of vital importance. Any errors during needle placement can lead to permanent damage or fatal consequences. Stroke, paralysis, spinal cord ischemia, vertebral artery compromise with cerebellar infarction, hematoma, high spinal anesthesia, and death have been reported (12). Based on the level of danger and the likelihood of occurrence during needle placement we focused on the most devastating consequences - a compromise of the intraspinal space, the vertebral artery, and the exiting nerve root. We found that ES is clinically and statistically significantly more dangerous than Fi and FiM (ES resulted in 3 exiting nerve root and vertebral artery compromise, whereas Fi and FiM led to none).

There may have been multiple reasons for this: 1) With ES the ideal needle trajectory is barely different than a needle placed in the neuroforamen or in the spinal canal, so a slight error in identifying the coronal plane or in needle trajectory combined with the loss of depth control can result in foraminal or spinal space breach; 2) Higher BMI, and arthritic neck can increase the chances of loss of depth control (Fig. 8. a,b). The cadaver necks were arthritic, making the landmarks harder to identify. This reflects real-life situations, unlike the way the ES was described on only healthy, young volunteers.

Also, one must observe the natural shape of the articular pillars: the characteristic waveform can be observed both from lateral (coronal US probe placement, Fig. 9a) and somewhat anterior (Fig. 9b). Without a thorough understanding of the C-spine topography, it is easy to aim more anteriorly, hence, to target the posterior portion of the neuroforamen, instead of the lateral part of the articular pillar. This puts the vertebral artery and exiting nerve root at risk.

Siegenthaler et al (15) suggested introducing the needle from anterior to posterior, as the vulnerable structures are situated more anterior to the facet joint line (i.e., vertebral artery and neuroforamen). In our opinion, nothing prevents the inexperienced proceduralist from placing the needle too anterior in the hunt for the target and the needle tip, especially in a patient with less ideal anatomy (shorter neck or higher BMI) which therefore exposes the vertebral artery, exiting nerve root and spinal cord to injury.

The posterior to the anterior approach of Fi has no vital structures in the needle trajectory, therefore it seems a safer approach, as also proven in our study.

In real life, an awake patient would report nerve root violation, reducing the risk of additional damage and risk of access to the spinal canal. Nevertheless, spinal cord injury has been reported, as stated above (14).

### Precision

For precision, we identified crude and precise positioning.

The lower C2 or upper C3 pillar for TON and the corresponding articular pillar for C3-6 MB were acceptable for crude targeting. This may result in sufficient local anesthetic spread to the medial branch as was shown by Finlayson (21). In our study, 77.6%, 79.5%, and 75.6% of the needles were acceptably placed for crude targeting in ES, Fi, and FiM approaches respectively, showing no significant difference. TON blocks had lower success rates, achieving only 33.3%, 44.4%, and 55.6% accuracy by ES, Fi, and FiM approaches. The success rate for the other levels with all approaches ranged between 77% and 100%.

We have found that ES resulted in significantly more needle placements in the predefined green zones, i.e. the centers of the articular pillars (42.9% compared to 22.7% and 24.4% for the ES, Fi, and FiM, respectively). Previous studies recommended that the needle tip be placed in the centroid of the articular pillar for diagnostic blocks, and parallel with the joint lines on the articular pillar for radiofrequency ablation for effective denervation (6). More recent measurements of the cervical medial branches suggest that medial branch size and location vary. The C5 MB occupies the lateral concavity of the articular pillar with varia-

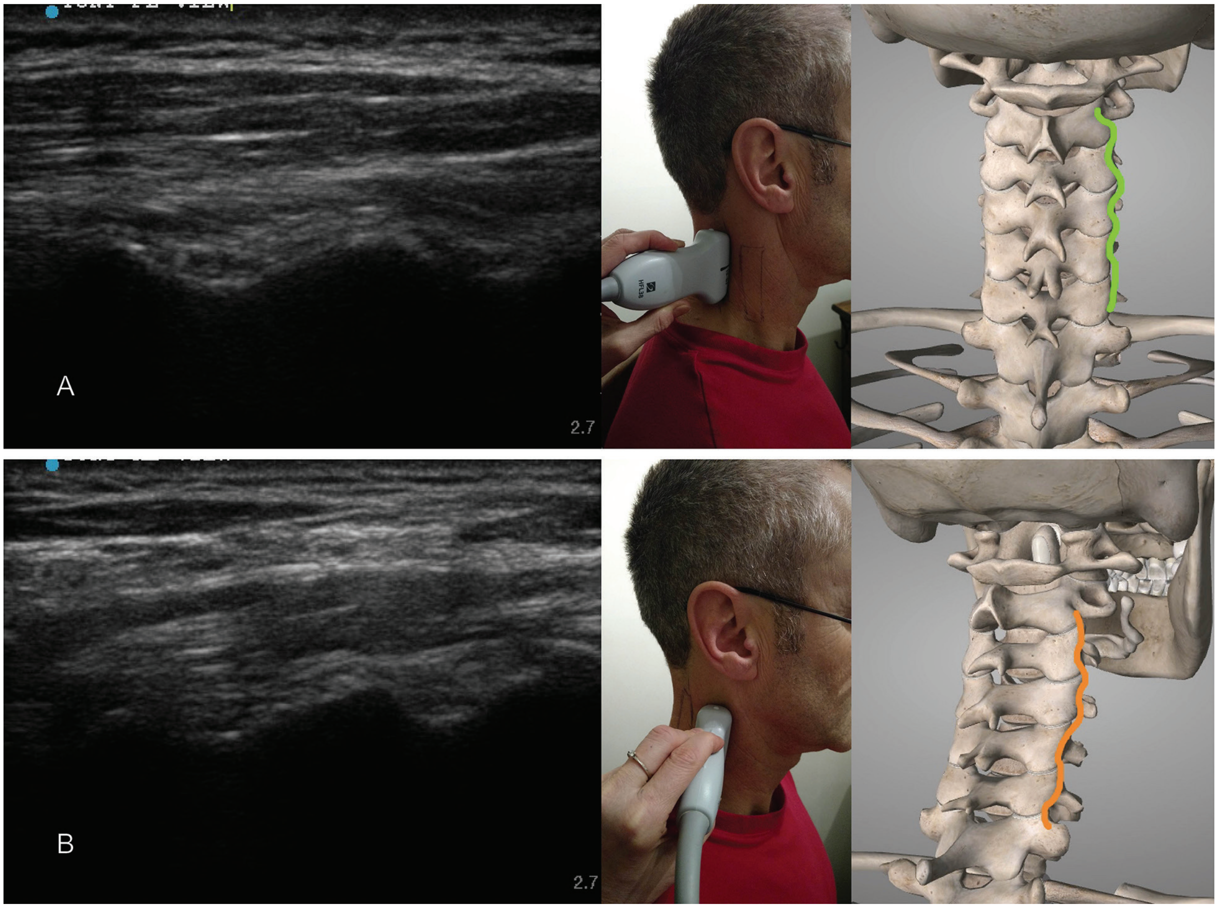


Fig. 9a and b. *The characteristic waveform utilized in ES can be observed both from lateral (green mark). (A) and somewhat anterior (orange mark). (B). The US probe positions for the corresponding US image are marked on the model's skin.*

tion becoming greater at levels further from C5 (24). In light of the variations of the MB positions relative to the bony articular pillars, the relevance of the green zone may become questionable. Furthermore, the usually injected 0.3 mL for diagnostic injection usually covers the entire articular pillar at the given level (25).

Approach #1: ES, is the most tempting for the novice proceduralist because the famous wavy line formed by the articular pillars can be reliably visualized with limited experience. This approach is not suitable for radiofrequency lesioning unless a special needle is used (tripod, bipod, cooled RF), as the small lesion at the tip of the needle is unlikely to incorporate the medial branch.

Approach #2: Fi is somewhat harder to learn for new sonographers because it entails understanding the C-spine sonoanatomy in more detail. Recognition of the different shapes of each cervical lamina, caudally slanted spinous processes, and caudal rotation of the US probe are essential. However, once incorporated into scanning, the technique is easier and safer. The needle is placed in-plane, ensuring meticulous positioning while maintaining needle tip visibility. Furthermore, Fi is also useful for radiofrequency ablation, where the goal is to place the needle tip along the pillar to increase the chances of incorporating the medial branch in the lesion.

Approach #3: FiM was expected to carry the benefits of both ES and Fi; however, our data indicates the contrary. Any manipulation of the needle without perfect visualization of the needle tip does not add to the precision. Before the start of his study on the C3-6 MBB, Finlayson had evaluated (and abandoned) the use of a coronal plane to verify the position of the needle after the latter had been placed with a transverse plane (21). As also noted by Lee et al (26), it is difficult to reliably visualize a static needle in its short axis. Later, Finlayson showed that the C5 and C6 MB precision placement improved with biplanar visualization (19).

In our study, the proceduralists misplaced the needle in more than 10 % of the cases, which may reflect poorly on the ability to judge the levels by the US. However, as by the nature of the needle placement method, one misplaced needle immediately results in missing the consecutive levels. Therefore, if all 5 needles were shifted caudally, we modified the score from 5 to 1. However, in real-life conditions, one can encounter a similar problem, when multiple needles are all placed to a different level than intended.

### Strengths and Limitations

Feedback from a live patient may prevent exiting nerve root injection, unlike in a cadaver.

Though a higher number of needles were placed in this study than in most available publications, the number is still low at each individual medial branch level.

The large number of US proceduralists (8) from 6 countries resembles a real-life situation with various levels of procedural proficiency.

## Conclusion

The currently taught and practiced CMBB methods both in-plane and out-of-plane (ES, Fi, and FiM) should yield a similarly successful block. However, the ES approach seems more helpful in placing the needle precisely on the centroid of the articular pillar, but it also leads to a greater number of dangerously placed needle tips.

The 3 approaches are equally inadequate in identifying cervical vertebral levels, so the aid of fluoroscopy is still recommended to prevent those errors.

Cervical procedures are dangerous, high-risk procedures even in experienced hands, and they may compromise patient safety if anatomy is challenging because of, for example, advanced arthrosis. Further studies are required, especially on elderly patients with arthritic changes to further confirm the safety and accuracy of the procedures. Until then we propose less experienced proceduralists to avoid the ES approach completely or use the Fi (posterior to anterior) approach.

Even though the US proceduralists were experts from all over the world, neither we collectively, nor any individual among us, was able to reproduce the previously published high level of precision and accuracy as reported (by Siegenthaler and Finlayson) in the papers above.

## References


1. Aprill C, Bogduk N. The prevalence of cervical zygapophyseal joint pain. A first approximation. *Spine (Phila Pa 1976)* 1991; 17:744-747.
2. Lord SM, McDonald GJ, Bogduk N. Percutaneous radiofrequency neurotomy of the cervical medial branches: A validated treatment for cervical zygapophysial joint pain. *Neurosurgery Quarterly* 1998; 8:288-308.
3. Narouze SN, Provenzano DA. Sonographically guided cervical facet nerve and joint injections. *J Ultrasound Med* 2013; 32:1885-1896.
4. Manchikanti L. Facet joint pain and the role of neural blockade in its management. *Curr Rev Pain* 1999; 3:348-358.
5. Manchikanti L, Singh V, Rivera J, Pampati V. Prevalence of cervical facet joint pain in chronic neck pain. *Pain Physician* 2002; 5:243-249.
6. Narouze SN, Provenzano DA, Vydyanathan A, et al. Sonographically guided cervical facet nerve and joint injections. *J Ultrasound Med* 2013; 32:1885-1896.
7. Bogduk N. The clinical anatomy of the cervical dorsal rami. *Spine J* 1982; 7:319-330.
8. Beckman WA, Mendez RJ, Paine GF, Mazzilli MA. Cerebellar herniation after cervical transforaminal epidural injection. *Reg Anesth Pain Med* 2006; 31:282-285.
9. Malhotra G, Abbasi A, Rhee M. Complications of transforaminal cervical epidural steroid injections. *Spine (Phila Pa 1976)* 2009; 34:731-739.
10. Ma DJ, Gilula LA, Riew KD. Complications of fluoroscopically guided extraforaminal cervical nerve blocks: An analysis of 1036 injections. *J Bone Jt Surg - Ser A* 2005; 87:1025-1030.
11. Rathmell JP, Benzon HT, Dreyfuss P, et al. Safeguards to prevent neurologic complications after epidural steroid injections: consensus opinions from a multidisciplinary working group and national organizations. *Anesthesiology* 2015; 122:974-984.
12. Bogduk N, Dreyfuss P, Baker R, et al. Complications of spinal diagnostic and treatment procedures. *Pain Med* 2008; 9:S11-S34.
13. Ludwig MA, Burns SP. Spinal cord infarction following cervical transforaminal epidural injection: A case report. *Spine (Phila Pa 1976)* 2005; 30:266-268.
14. Park D, Seong MY, Kim HY, Ryu JS. Spinal cord injury during ultrasound-guided C7 cervical medial branch block. *Am J Phys Med Rehabil* 2017; 96:e111-e114.
15. Siegenthaler A, Narouze S, Eichenberger U. Ultrasound-guided third occipital nerve and cervical medial branch nerve blocks. *Tech Reg Anesth Pain Manag* 2009; 13:128-132.
16. Eichenberger U, Greher M, Kapral S, et al. Sonographic visualization and ultrasound-guided block of the third occipital nerve prospective for a new method to diagnose C2-C3 zygapophysial joint pain. *Anesthesiology* 2006; 104:303-308.
17. Siegenthaler A, Mlekusch S, Trelle S, Schliessbach J, Curatolo M, Eichenberger U. Accuracy of ultrasound-guided nerve blocks of the cervical

zygapophysial joints. *Anesthesiology* 2012; 117:347-352.

18. Finlayson RJ, Etheridge JPB, Vieira L, Gupta G, Tran DQH. A randomized comparison between ultrasound- and fluoroscopy-guided third occipital nerve block. *Reg Anesth Pain Med* 2013; 38:212-217.
19. Finlayson RJ, Etheridge JPB, Tiyaprasertkul W, Nelems B, Tran DQH. A prospective validation of biplanar ultrasound imaging for C5-C6 cervical medial branch blocks. *Reg Anesth Pain Med* 2014; 39:160-163.
20. Barnsley L, Bogduk N. Medial branch blocks are specific for the diagnosis of cervical zygapophyseal joint pain. *Reg Anesth* 1993; 18:343-350.
21. Finlayson RJ, Gupta G, Alhujairi M, Dugani S, Tran DQH. Cervical medial branch block: A novel technique using ultrasound guidance. *Reg Anesth Pain Med* 2012; 37:219-223.
22. Siegenthaler A, Schliessbach J, Curatolo M, Eichenberger U. Ultrasound anatomy of the nerves supplying the cervical zygapophyseal joints: An exploratory study. *Reg Anesth Pain Med* 2011; 36:606-610.
23. Finlayson RJ, Etheridge JPB, Tiyaprasertkul W, Nelems B, Tran DQH. A randomized comparison between ultrasound- and fluoroscopy-guided C7 medial branch block. *Reg Anesth Pain Med* 2015; 40:52-57.
24. Kweon T, Kim J, Lee H, Kim M, Lee YW. Anatomical analysis of medial branches of dorsal rami of cervical nerves for radiofrequency thermocoagulation. *Reg Anesth Pain Med* 2014; 39:465-471.
25. Wahezi SE, Molina JJ, Alexeev E, et al. Cervical medial branch block volume dependent dispersion patterns as a predictor for ablation success: A cadaveric study. *PM&R* 2019; 11:631-639.
26. Lee SH, Kang CH, Lee SH, et al. Ultrasound-guided radiofrequency neurotomy in the cervical spine: sonoanatomic study of a new technique in cadavers. *Clin Radiol* 2008; 63:1205-1212.