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# Ultrasound-Guided Cervical Medial Branch Blocks: A Technical Review

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**Abstract**

Cervical medial branch blocks are commonly performed for the diagnosis and treatment of chronic neck pain and headaches. Although fluoroscopy constitutes the imaging standard for these procedures, recent evidence suggests that ultrasound guidance (USG) can provide similar accuracy coupled with shorter performance times. Moreover the ability to visualize soft tissue structures allows the operator to detect and avoid blood vessels, thus reducing complications related to vascular breach. In this review article, we discussed the technical considerations and evidence supporting the use of USG for cervical medial branch and third occipital nerve blocks.

## Introduction

Cervical medial branch blocks (CMBBs) are commonly employed for the diagnosis and management of facet-related pain [1]. The latter constitutes the most important cause of axial neck pain and has been implicated in 40% of all cases [2]. Well-defined pain referral patterns for each joint can help operators select the appropriate injection level [3,4]. The third occipital nerve (TON), found over the C2/C3 joint, innervates a small patch of skin in the suboccipital area and is the only medial branch with a reliable cutaneous distribution. Its clinical importance lies in the mediation of cervicogenic headaches, a common and disabling condition [5]. While CMBBs are often used to identify patients for thermo-radiofrequency procedures, they also possess an intrinsic therapeutic effect, providing pain relief for several weeks or months [6].

Fluoroscopy constitutes the current imaging standard for CMBB [7]. However, an emerging body of literature supports the use of ultrasound guidance (USG) [8-13]. In this review article, we will analyze the evidence pertaining to USG, discuss differences between the 2 imaging modalities and provide a comprehensive technical description of USG CMBB.

## Literature Review

Four prospective cohort studies and 2 randomized controlled trials (RCTs) have examined the use of USG for CMBB (Table 1). In a volunteer study, Eichenberger et al. [8] performed TON blocks in 10 subjects, using a transverse (short axis) view and an out-of-plane needling technique. They reported an accurate needle position over the C2/C3 joint in 82% of blocks (as controlled by fluoroscopy) as well as a 90%- success rate of (hypoesthesia in the suboccipital area). In another volunteer study (n=60), using USG, Siegenthaler et al. [9] placed needles and injected radiographic contrast in the centroid of the C3-C6 articular pillars (APs). For the TON and C7 medial branch, they targeted the C2/C3 joint and C7 superior articular pillar (SAP), respectively. A coronal (long-axis) view, with out-of-plane needling, was used and accuracy verified with fluoroscopy. Siegenthaler et al. [9] reported that 77% of needles were accurately positioned and that radiographic contrast reached the intended target in 84% of cases. The lowest accuracy was found at the C7 level. In a 2-phase study, Finlayson et al. [10] examined the accuracy of an in-plane needling technique using a transverse view in 53 patients undergoing CMBB from C2/C3 to C6. They found that needle tips were placed in the middle 2 quarters of the AP in 80.9% of subjects and contrast covered the targeted AP in 94.5% of injections. Again the lower cervical levels were associated with a higher failure rate. The same authors subsequently developed a bi-planar approach to increase the accuracy of C5 and C6 CMBB [11,12]. In 40 patients, needles were first positioned using the previously described transverse view/in-plane technique. Placement was then verified by scanning in a coronal plane and ensuring proper needle tip position in the centre of the AP. The bi-planar method was associated with greater accuracy, as radiographic contrast covered the targeted levels in 100% and 97.5% of C5 and C6 levels, respectively.

| Authors (year) | Study design | Results | Comments |
|---|---|---|---|
| Eichenberger et al. | 10 blocks in 14 volunteers, ultrasound guided visualization and injection of third occipital nerve; fluoroscopic confirmation of needle position | Third occipital nerve visualized in 27/28 (96%); 23/28 correct needle placement (82%) | Median third occipital nerve diameter 2 mm; third occipital nerve blocked in 90% |
| Siegenthaler et al. | Ultrasound-guided cervical medial branch block; 60 volunteers; 180 block; 0.2 ml of contrast dye injected; fluoroscopic confirmation | 180 needles placed; 73 needles purposely misplaced based on study design; 82/107 needles placed correctly (77% accuracy rate); 90/107 contrast dye reached bony | Level tested third occipital nerve to C7 medial branch; no adverse events reported; low accuracy at C7 |

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|---|---|---|---|
| | | target (84% success rate) | |
| Finlayson et al. | 2-phase study; 53 patients; 163 blocks; 0.3 ml of 1:1 local anesthetic and contrast dye injected | Phase 1:80.9% of needles placed correctly; phase 2: contrast covered appropriate area in 94.5% | Levels investigated C3-C6 medial branches |
| Finlayson et al. | Randomized controlled trial;40 patients randomized to fluoro- or ultrasound-guided third occipital nerve block | Ultrasound guidance associated with shorter procedure time (212.8 vs 396.5 s) and fewer needle passes (2 vs 4); no intergroup difference in preblock and postblock pain scores. Similar success rates (95-100%) | US-guided technique associated with superior outcomes; vascular breach occurred with fluoro-guided technique in 10%; third occipital nerve identified in 80% of US-guided procedure; no adverse events occurred with US-guided technique |
| Finlayson et al. | Prospective cohort; biplanar ultrasound-guided C5-C6 MBB; 40 patients, 0.3 ml of 1:1 local anesthetic and contrast dye injected; fluoroscopic confirmation | 100% and 97.5% appropriate contrast distribution at C5 and C6 | Visualized blood vessels crossing C6 articular pillar in 30% of cases |
| Finlayson et al. | Randomized comparison between ultrasound- vs fluoroscopic-guided C7 medial branch block; 50 patients | US-guidance associated to shorter performance time (233.6 vs 390 s) and fewer needle passes (2 vs 4); similar success rate; no intergroup difference in preblock and postblock pain scores | Blood vessels overlying target area and circumvented during needle insertion in 40% in the USG group; 20% intravascular and 4% intraarticular spread in fluoroscopic-guidance vs none in US |

**Table 1:** Studies examining ultrasound guided cervical medial branch and third occipital nerve blocks

Two randomized controlled trials have compared USG and fluoroscopy for CMBB. In the first study, Finlayson et al. [11] compared the 2 imaging modalities in 40 patients undergoing TON blocks. Success (hypoesthesia in the suboccipital area) was similar in the 2 groups (95-100%). However, performance times were significantly shorter with USG. Moreover no vascular breach occurred with the latter (compared to 10% for fluoroscopy). The same authors conducted a second RCT comparing the 2 imaging modalities for C7 medial branch blocks [13]. In the USG group, 2 injections were performed on the superior articular process of C7 using a bi-planar technique. Finlayson et al. [13] found that fluoroscopy was associated with significantly longer performance times, more needle passes and a higher incidence of vascular breach (20% versus 0%).

## Technical Commentary

Fluoroscopy has long been the imaging standard for spinal procedures, as it allows operators to reliably define bony structures while remaining impervious to the depth of overlying tissue [7]. Nonetheless several anatomic features unique to the neck offer an ideal canvas for USG. For instance, cervical targets are relatively shallow (usually ≤ 3 cm under the skin surface [14]): this falls within the range of high-resolution linear array probes. Another particularity of the cervical spine stems from the large number of critical soft tissue structures (blood vessels, nerves) in close proximity to the needle path [14]. Unlike fluoroscopy, USG allows the operator to visualize and avoid these structures during needle insertion. In turn this may reduce complication rates related to vascular breach [15,16]. Obtaining a true lateral view is critical for the safe performance of fluoroscopy-guided CMBB [7]. This can be challenging for the novice operator, as the cervical spine is quite mobile and frequent C-arm adjustments are required to compensate for small patient movements or pre-existing cervical misalignment. Failure to do so can result in potentially serious complications related to needle misplacement. In contrast, USG provides a view of the bony contours of the cervical spine and is relatively unaffected by patient position. This allows the operator to reliably differentiate the targeted AP from critical structures such as the neural foramen. Another advantage provided by USG relates to real-time needle visualization (in-plane technique); in contrast, fluoroscopy is handcuffed by intermittent viewing of needle positions thereby increasing the risk of misdirection [13].

## Sonoanatomy

Although the larger third occipital nerve can be insonated in most patients, the smaller medial branches (MB) at other levels are often difficult to visualize in clinical practice [17]. Therefore, the validated landmark-based technique relies on identifying target points on the bony contours of the cervical spine [10-13]. For C3 to C6 MBs, the centroid of the AP is targeted and a small injectate deposited between the periosteum and the tendinous insertions of the semispinalis capitis muscle (SSC) (Figures 1, 2A). This plane contains the MB [18] and small local anesthetic (LA) volumes can efficiently spread to cover the entire surface of the AP. The target points for TON and C7 MB blocks are the C2/C3 joint and C7 SAP, respectively.

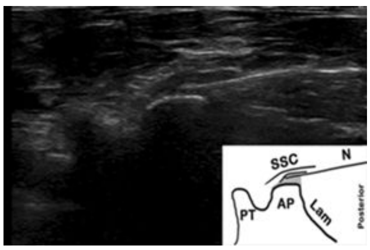


**Figure 1:** Transverse scan of the C4 articular pillar (AP) showing a needle in position after injection of 0.3 mL of local anesthetic. The injectate has spread along the anteroposterior aspect of the AP, lifting up the semispinalis capitis muscle (SSC). Posterior tubercle of transverse process (PT); needle (N); lamina (Lam).

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## Coronal (Long Axis) Scan

Coronal scans are used for level confirmation in both the upper and lower cervical spines. In the long axis, the APs appear as a series of peaks (zygapophyseal joints lines) and valleys (convex shapes of the APs). Above the C2-C3 joint, the slope of the inferior articular process of C2 creates a characteristic drop-off with the vertebral artery, which can be seen immediately cephalad to it (Figures 3, 2B). In the lower cervical spine, the transverse process (TP) of C7, which can be found anterior to the AP, provides a reference for needle positioning (Figures 4, 2C).

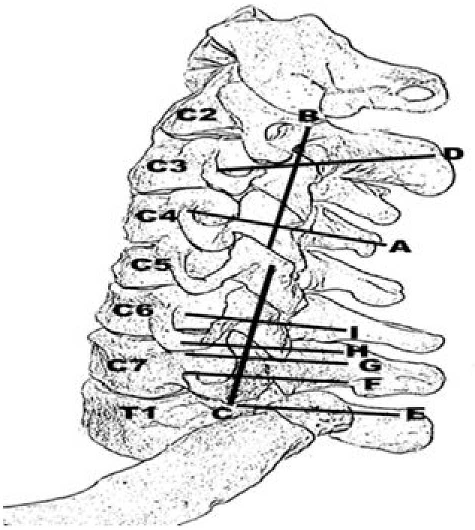


**Figure 2:** Cervical spine model showing the scan line depicted in the different figures. (A) figure 1; (B) figure 3 and figure 9; (C) figure 4; (D) figure 5; (E) figure 6A; (F) figure 6B; (G) figure 6C; (H) figure 6D; (I) figure 6E and figure 8.

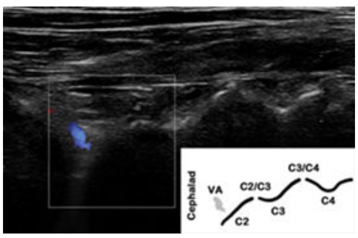


**Figure 3:** Coronal scan of the upper cervical spine along the anterior edge of the articular pillars with color power doppler mode engaged. The drop off at the C2/C3 level is confirmed by imaging the vertebral artery cephalad. Vertebral artery (VA); inferior articular process of C2 (C2); articular pillars (C3, C4); zygapophyseal joints (C2/C3, C3/C4).

## Transverse (Short Axis) Scan

Transverse scans are used for needle placement. The targets are the C2-C3 zygapophyseal joint (TON) (Figures 5, 2D) and the centroid aspect of the AP (C3-C6 MBs). The latter appears as a distinctive flat hyperechoic line that can be appreciated when moving the probe in a cephalo-caudal direction. It can be easily differentiated from the joint line, which is rounded and less echogenic. The tendinous insertions of the SSC can be identified just above the AP; they allow LA confinement to the periosteal plane, thus ensuring a successful block with small injectates. A useful landmark in the lower cervical spine is the narrow C7 TP, which possesses no anterior tubercle: this permits its differentiation from the TPs of other cervical levels as well as the wider square shape of the T1 TP (Figures 6A/2E, 6B/2F, 6C/2G, 6D/2H, 6E/2I, 2).

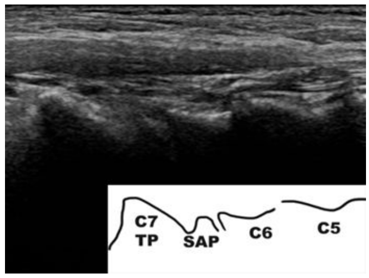


**Figure 4:** Coronal scan of the lower cervical spine. C7 transverse process (C7 TP); superior articular process of C7 (SAP); articular pillar of C6 (C6); articular pillar of C5 (C5).

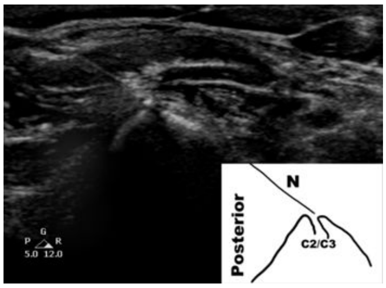


**Figure 5:** Transverse scan of the upper cervical spine at the level of the C2/C3 joint (C2/C3), demonstrating a needle (N) in position for third occipital nerve block.

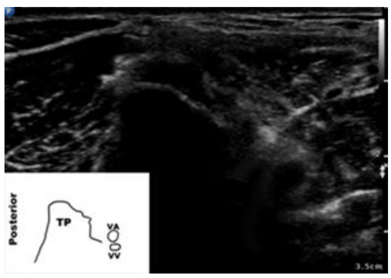


**Figure 6A:** Transverse scan of the lower cervical spine demonstrating the different sonoanatomic landmarks that would be visualized while scanning in a caudad to cephalad direction. Transverse process of T1 (TP) with vertebral artery (VA) and vertebral vein (VV) visible anteriorly.

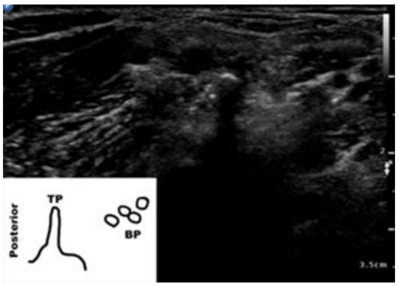


**Figure 6B:** Transverse scan of the lower cervical spine demonstrating the different sonoanatomic landmarks that would be visualized while scanning in a caudad to cephalad direction. Transverse process of C7 (TP) with brachial plexus (BP) visible anteriorly.

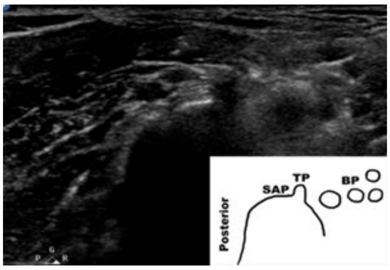


**Figure 6C:** Transverse scan of the lower cervical spine demonstrating the different sonoanatomic landmarks that would be visualized while scanning in a caudad to cephalad direction. superior articular process of C7 (SAP) with cephalad edge of C7 transverse process visible (TP), brachial plexus is visible anteriorly (BP).

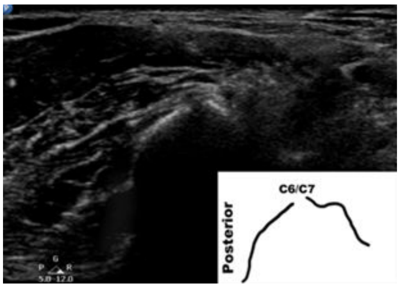


**Figure 6D:** Transverse scan of the lower cervical spine demonstrating the different sonoanatomic landmarks that would be visualized while scanning in a caudad to cephalad direction. C6/C7 joint.

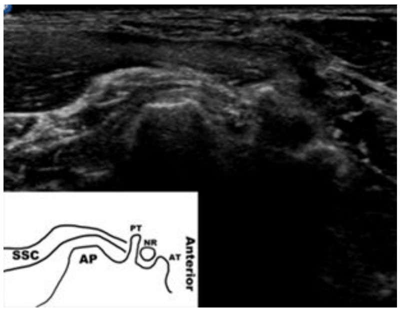


**Figure 6E:** Transverse scan of the lower cervical spine demonstrating the different sonoanatomic landmarks that would be visualized while scanning in a caudad to cephalad direction. Injection target on the articular pillar (AP) of C6 covered by the tendinous insertion of the semispinalis capitis muscle (SSC), the posterior tubercle (PT), nerve root of C6 (NR) and anterior tubercle (AT) of C6 are seen anteriorly.

## Block Technique

Patients are placed in the lateral decubitus position with their head supported in a neutral position (Figures 7A and 7B). An L14-5 MHz linear array probe and a 2.5 inch, 22- or 25-gauge block needle are commonly employed. Steroids provide limited benefits for CMBB [6]. Nonetheless should one be used, a non-particulate formulation (such a dexamethasone) would reduce the risk of neurological complications in the event of periforaminal arterial breach [14]. Local anesthetic volumes used in validation studies vary between 0.3 mL (MB C3-C6), 0.6 mL (MB C7) and 0.9 mL (TON)[10-13].

**Figure 7A:** Patient positioned for a cervical medial branch block. Probe position for a transverse scan.

**Figure 7B:** Patient positioned for a cervical medial branch block. Probe position for a coronal scan.

## TON, C3, C4 Medial Branch

The neck is initially scanned in the coronal plane along the posterior edge of the AP in order to identify the drop-off at the C2-C3 level. Further confirmation is sought by imaging the vertebral artery (cephalad and anterior) (Figure 3). The probe is then rotated to a transverse plane, and the C2-C3 zygapophyseal joint identified for TON block (Figure 5). From this point, the probe is moved caudally to target the C3 and C4 APs.

## C5, C6, C7 Medial Branch

The base of the neck is scanned in the transverse plane and the T1 TP identified. As the probe is moved cephalad, the TP of C7 is localized, followed by targets on the APs of C6 and C5. The SAP of C7 can be occasionally imaged cephalad to the C7 TP: if prominent, it could be mistaken for the C6 AP (Figures 6A, 6B, 6C, 6D, 6E).

## Needle Placement after Target Level has been identified

Once the target has been identified in the transverse plane, manual pressure on the probe is decreased and the color doppler mode engaged to detect potential blood vessels in the needle path (Figures 8, 2I). A posterolateral in-plane approach is used. The needle is advanced until contact with the periosteum. The probe is then rotated to obtain a coronal scan, and the needle tip confirmed to be in the middle of the targeted AP (Figure 9, 2B). Returning to a transverse view, LA is then injected under real time visualization; if necessary, the position of the needle tip is adjusted to obtain a sub-SSC LA spread that covers the anteroposterior diameter of the AP or joint (TON) (Figure 1). The extent of cephalocaudal spread can be documented in the coronal plane. For TON block, needle placement can be further refined by placing the tip next to the nerve, which can often be insonated near the C2-C3 joint in the coronal plane. The C7 MB, because of its variable anatomy, requires 2 injections, with half the volume deposited on the SAP and half 3 mm lateral to the latter.

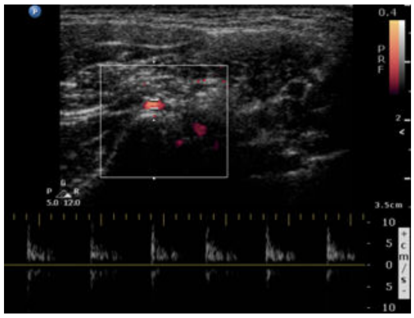

**Figure 8:** Pulsed wave Doppler tracing of an artery seen during a transverse scan of a C6 articular pillar.

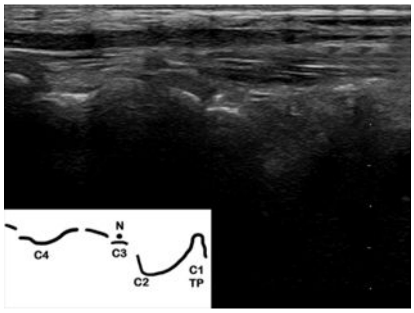


**Figure 9:** Coronal scan of the upper cervical spine confirming appropriate needle (N) positioning for a C3 medial branch block in a 73 years old patient with degenerative changes altering the bony contours of the articular pillars. The articular pillars of (C3) and (C4) can be seen, however the contours of the zygapophyseal joints have been distorted by osteophytes. Inferior articular process of C2 (C2); C1 transverse process (C1 TP).

## Conclusions

An emerging body of literature supports the use of ultrasound imaging for CMMBs. In addition to its lower cost, greater accessibility and lack of ionizing radiation, USG decreases performance time as well as the incidence of vascular breach when compared to traditional fluoroscopy. Further clinical trials are required to determine if this will lead to a lower incidence of procedure related complications.

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