Cervical Medial Branch Blocks and Radiofrequency Ablation

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Abbreviations

AP	Articular pillars
CMBBs	Cervical medial branch blocks
LA	Local anesthetic
SSC	semispinalis capitis muscle
TON	Third occipital nerve
TP	transverse process
US	ultrasound
USG	ultrasound-guided

Considerations

Cervical medial branch blocks and radiofrequency ablations are commonly employed for the diagnosis and management of facet-related pain. The latter constitutes the most important cause of axial neck pain and has been implicated in 40% of all cases. In addition, the upper cervical joints can also cause cervicogenic headaches, an often-debilitating condition representing up to 20% of chronic headaches. Well-defined pain referral patterns for each joint can help operators select the appropriate injection level. 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. Nonetheless, several anatomic features unique to the neck offer an ideal canvas for ultrasound guidance (USG). For instance, cervical targets are relatively shallow (usually ≤3 cm under the skin surface): 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. Unlike fluoroscopy, USG allows the operator to visualize and avoid these structures during needle insertion, which may reduce complication rates related to vascular breach. This chapter will review techniques based on both the imaging modalities, which can often be combined for optimal effect.

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Patient Selection

Eligible patients will typically have had neck pain for at least 3 months and not responded to conservative therapies. Levels to be treated are determined by known pain referral patterns (Fig. 15.1), and specific joints are blocked by targeting the medial branch above and below (i.e., the C5 and C6 nerves for the C5/C6 joint), while the TON is anesthetized for the C2/C3 joint. Although clinical trials examining the effect of cervical medial branch radiofrequency ablation have selected only patients with complete (100%) relief of the affected segment following controlled diagnostic blocks, such stringent criteria are often not followed in clinical practice. As this may result in more modest post-procedural pain relief, the clinical significance of any pain reduction following a diagnostic block should be carefully considered before proceeding with an ablation.

Functional Anatomy

Each zygapophyseal joint is innervated by the medial branch above and below it, except for the C2/C3 level, which is solely innervated by the third occipital nerve. The later originates from C3 spinal nerve in the C2/C3 foramen and curves posteriorly through the intertransverse space where it divides into several smaller branches, in addition to a larger superficial branch (the third occipital nerve), which crosses the C3 articular pillar at or below the C2/C3 facet joint. Whereas from C4 to C7, the posterior ramus divides into a lateral and medial branch as it crosses the transverse process. The medial branch then courses posteriorly, following the contour of the articular pillar (typically 1–2 mm lateral to the periosteal surface), and sends articular branches to the adjacent joints from the posterior aspect of the articular pillar (Fig. 15.2). In contrast to other segments where medial

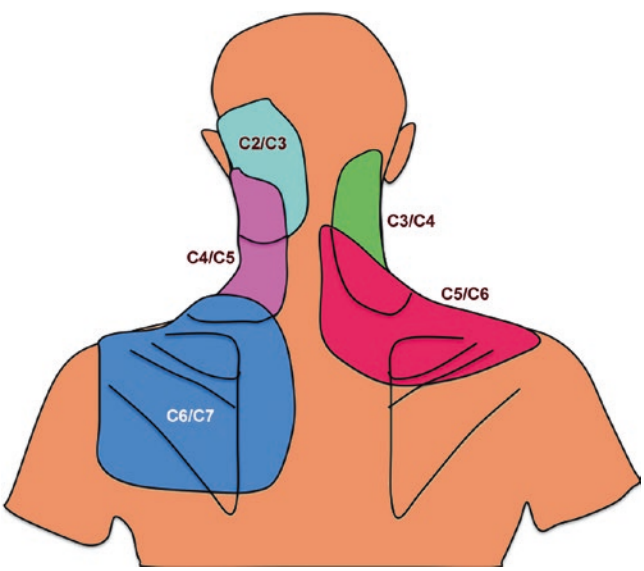

Fig. 15.1 Segmental pain referral patterns for cervical zygapophyseal joints. (Adapted from Dwyer A, Aprill C, Bogduk N. Cervical zygapophyseal joint pain patterns: a study in normal volunteers. *Spine* 1990;15:453–457. Reproduced with permission from Philip Peng Educational Series)

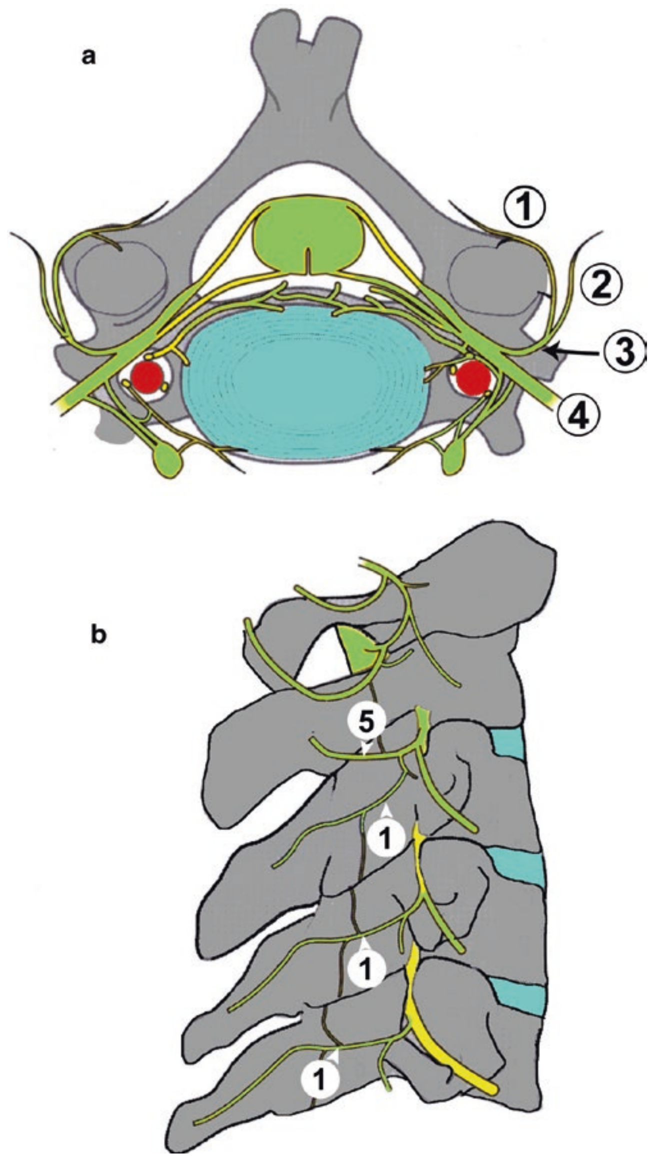

Fig. 15.2 (**a**) Transverse view of a C5 vertebra demonstrating the spinal nerve anatomy. Medial branch of posterior ramus (1); lateral branch of posterior ramus (2); posterior primary ramus (3); anterior ramus (4). (**b**) Lateral view of a cervical spine model demonstrating the course of the cervical medial branches. A cervical medial branch traverses the articular pillar, supplying the zygapophyseal joint above and below (1); The C2/C3 joint is unique as it is innervated solely by the third occipital nerve (5), which emerges from the posterior ramus along with the medial branch of C3. The latter innervates the C3/C4 joint with the C4 medial branch. (Reproduced with permission from Philip Peng Educational Series)

branches course near the centroid of the articular pillar, at C7 the nerve crosses the superior articular process, or less commonly, the root of the transverse process. Whereas all medial branches innervate segments of the posterior neck muscles (multifidus and interspinalis), the third occipital nerve is unique in providing cutaneous sensory innervation to a suboccipital patch of skin.

Although fluoroscopy and ultrasound provide different imaging perspectives, an understanding of bony anatomy is critical for the performance of techniques using either modality.

Fluoroscopic Anatomy

Lateral and anteroposterior views and their bony correlates are illustrated in Fig. 15.3. Additional views used during radiofrequency ablation procedures, including oblique and pillar view, are also presented (Fig. 15.4).

Sonoanatomy

Coronal (long axis) scan: This view is used for level confirmation in both the upper and the lower cervical spines. In the long axis, the AP appears as a series of peaks (zygapophyseal joints lines) and valleys (convex shapes of the APs) (Fig. 15.5). Above the C2-C3 joint, the slope of the inferior articular process of C2 creates a characteristic drop-off with the vertebral artery visible immediately cephalad to it (Fig. 15.6). In the lower cervical spine, the TP of C7, which can be found anterior to the AP, provides a reference for needle positioning (Fig. 15.7).

Transverse (short axis) scan: This view is used for needle placement. The targets are the C2–C3 zygapophyseal joint (TON) and the centroid aspect of the AP (C3–C6 medial branches, MB). The latter appears as a distinctive flat hyperechoic line that can be appreciated when moving the probe in a cephalo-caudal direction (Fig. 15.8). It can be differentiated from the joint line, which is rounded and less echogenic (Fig. 15.9). The tendinous insertions of the SSC (semispinalis capitis) can be identified just above the AP; their importance lies in the fact that they confine the injectate to the periosteal plane, thus ensuring a successful block with small volumes of local anesthetic. A useful landmark in the lower cervical spine is the narrow TP of C7, which has no anterior tubercle: this permits its differentiation from the TPs of other cervical levels and the wider square shape of the more posterior T1 TP (Fig. 15.10).

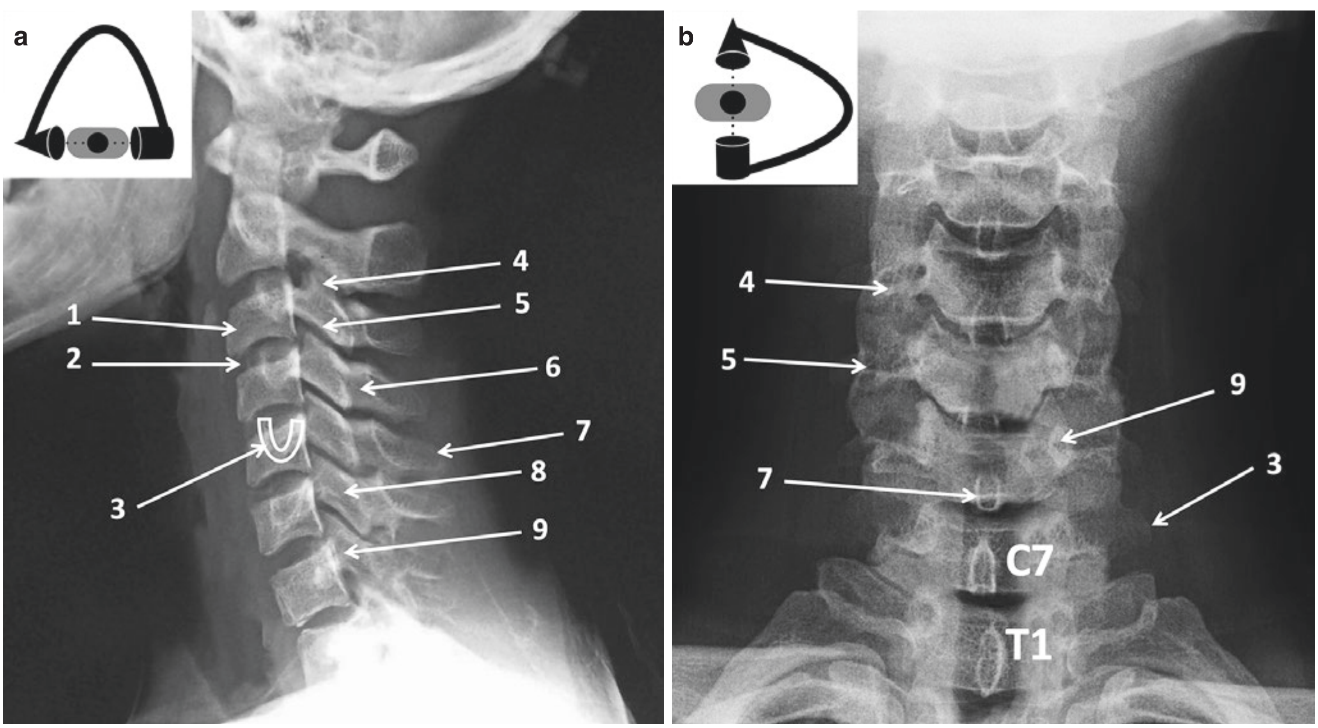

Fig. 15.3 Vertebral body (1); disc space (2); outline of transverse process (3); superior articular process (4); inferior articular process (5); lamina/vertebral canal (6); spinous process (7); articular pillar (8); pedicle (9). (**a**) True lateral x-ray view of the cervical spine as confirmed by the following: the transverse processes occupy the posterior superior quadrant of their vertebral body; the disc spaces are clear; half the vertebral canal can be seen between the articular pillar and bases of the spinous processes; the articular pillars of both sides are superimposed. (**b**) Anteroposterior view of the cervical spine. (Reproduced with permission from Philip Peng Educational Series)

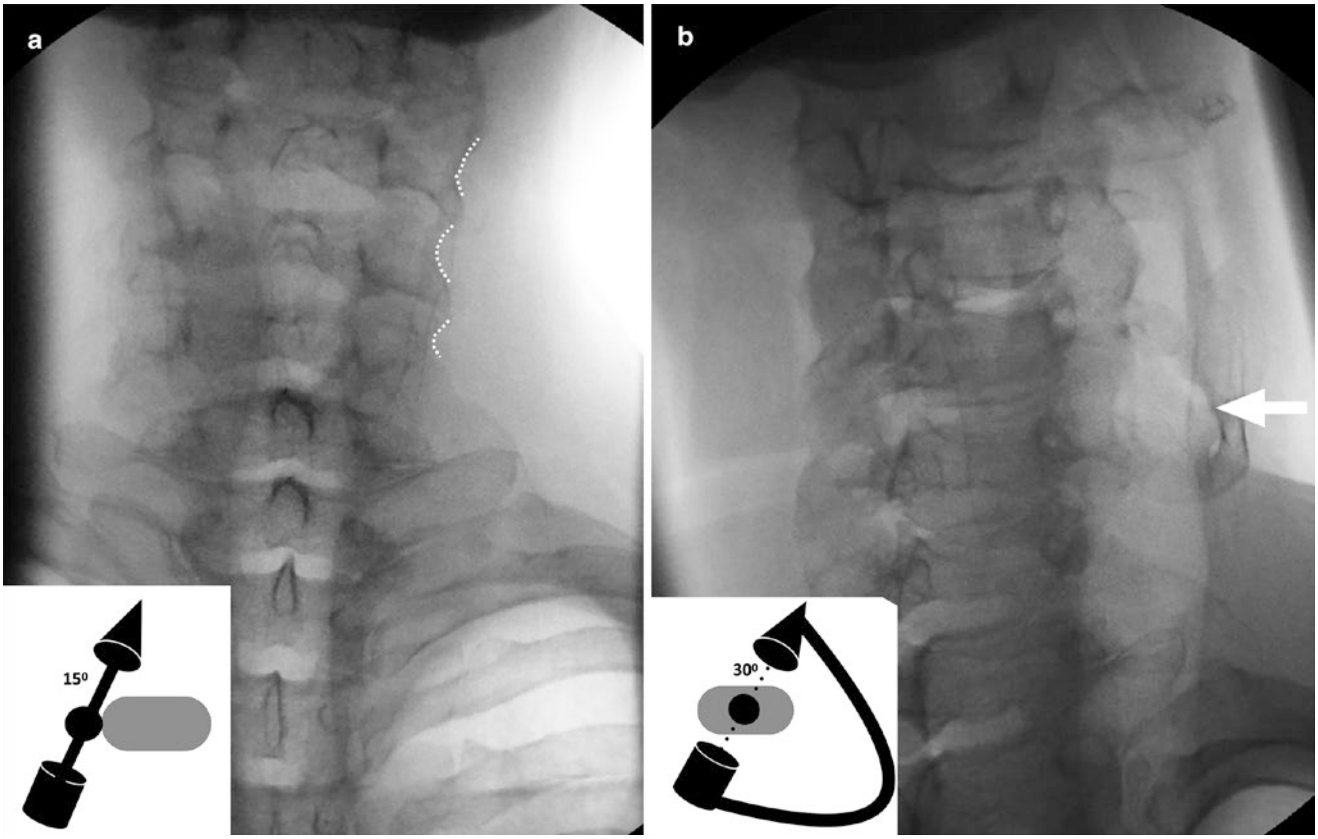

Fig. 15.4 (**a**) Pillar or declined anteroposterior view of the cervical spine in which the c-arm head has been inclined 15° caudally (left lower inset), allowing the articular pillar contours to be visualized (white dashed lines). This view is used for parasagittal cannula placements. (**b**) 30° ipsilateral oblique view, the targeted side is indicated by the white arrow. This view is used for oblique cannula placements. Because the contours of the articular pillars are not readily visualized in this view, the use of a finder needle is generally required for accurate placement. (Reproduced with permission from Philip Peng Educational Series)

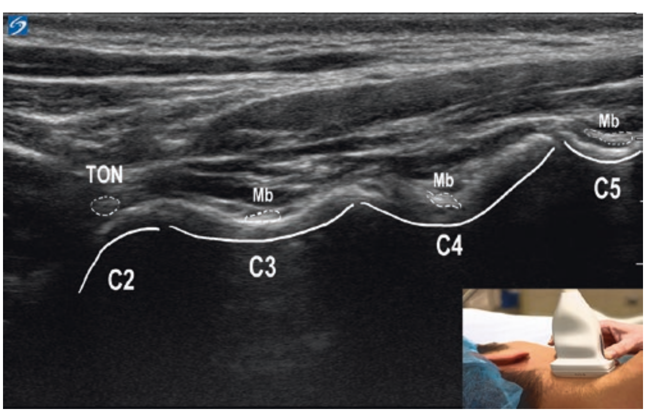

Fig. 15.5 Coronal scan of the cervical spine demonstrating the articular pillars of C4, C5, and C6, as well as the inferior articular process of C2. This view is used for level and needle position confirmation. The medial branches (mb) of C3, C4, and C5 can be seen, as well as the third occipital nerve (TON). (Reproduced with permission from Philip Peng Educational Series)

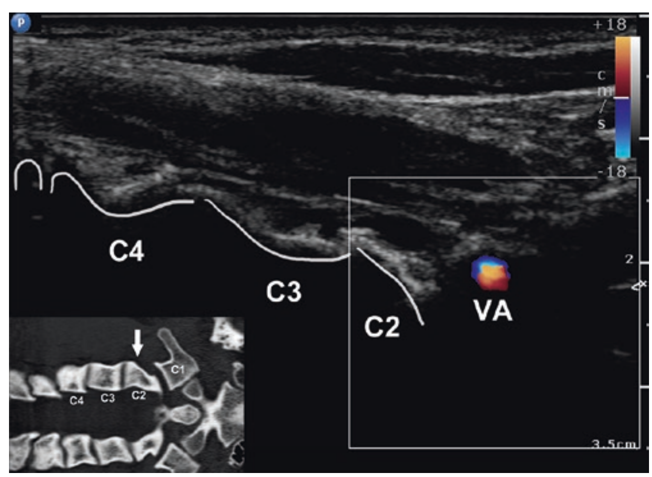

Fig. 15.6 Coronal scan of the upper cervical spine demonstrating the drop-off formed by the inferior articular process of C2; the vertebral artery (VA) can be imaged with duplex Doppler immediately cephalad. This view facilitates identification of the C2/C3 joint which is used as a landmark during third occipital nerve blocks. The left lower inset is a coronal CT scan of the cervical spine demonstrating the drop-off formed by the inferior articular process of C2 (white arrow). (Reproduced with permission from Philip Peng Educational Series)

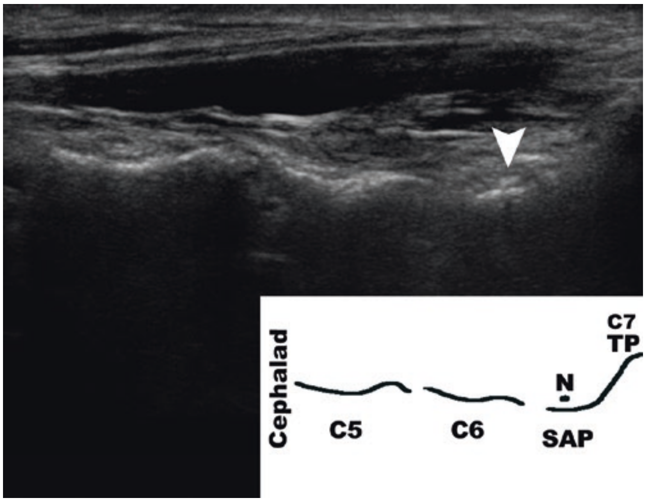

Fig. 15.7 Coronal scan of the lower cervical spine demonstrating the transverse process of C7 (C7 TP); superior articular process of C7 (SAP); articular pillar of (C5) and (C6). This view is used to confirm needle (N) positioning for blocks of the lower cervical medial branches. (Reproduced with permission from Philip Peng Educational Series)

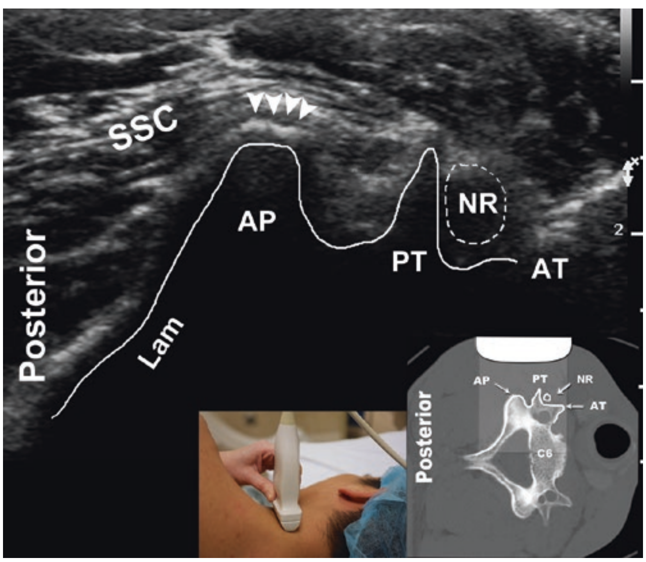

Fig. 15.8 Transverse scan of the cervical spine at the level of C6. The centroid of the articular pillar (AP) forms a distinct flat hyperechoic line and constitutes the target for cervical medial branch blocks (arrows). The (SSC) inserts on the posterior tubercle of the transverse process (PT) and courses over the AP. Further anterior, the nerve root (NR) and anterior tubercle (AT) can be seen. A CT overlay of the same bony landmarks is depicted in the right lower inset. When performing a cervical medial branch block, the injectate should be deposited along the periosteum of the AP, beneath the SSC. (Reproduced with permission from Philip Peng Educational Series)

Technique: Medial Branch Block

Common supplies include a 2.5-in., 22- or 25-gauge block needle and a local anesthetic (lidocaine or bupivacaine). In addition, a radiocontrast agent is required if fluoroscopic

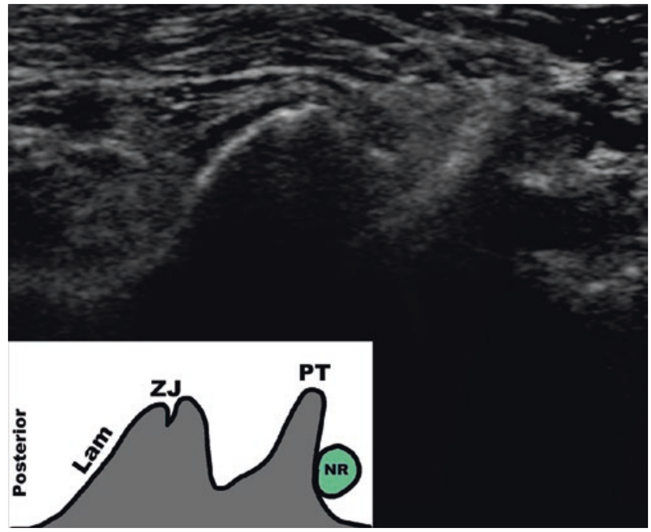

Fig. 15.9 Transverse scan at the level of the C5/C6 zygapophyseal joint (ZJ). When moving the probe in a cephalo-caudal direction, the joints, which are rounded and hypoechoic, can be differentiated from the flatter and hyperechoic articular pillars. *Lam* lamina, *PT* posterior tubercle, *NR* nerve root. (Reproduced with permission from Philip Peng Educational Series)

imaging is used. Volumes used for diagnostic blocks are 0.3 mL (MB C3-C6), 0.6 mL (MB C7), and 0.9 mL (TON). Steroids appear to have limited value when added to local anesthetics for cervical medial branch blocks (CMBB), and the use of particulate steroids should be avoided in the cervical spine.

Fluoroscopy

While a posterior parasagittal approach has been described, this section will review the more commonly used lateral approach, which is performed with the patient in a supine or lateral decubitus position. The acquisition and maintenance of a true lateral view are critical for the safe conduct of this procedure, and frequent adjustments of the c-arm may be required to compensate for patient movement or rotation of the cervical spine (Fig. 15.3a). In addition, needles should be inserted parallel to the x-ray beam in the lateral view and advanced cautiously in small increments, with frequent reevaluation of their position using a biplanar imaging technique (lateral and anteroposterior views) to avoid misdirection. As an additional precaution, 0.3 mL of contrast agent is usually injected before the LA to excluded intravascular or aberrant spread. In contrast to other levels, where a single point is targeted at the centroid of the AP, the C7 and TON (C2/C3) levels require multiple injections (Fig. 15.11). Indeed, for the TON, three injections of 0.3 mL are performed around the C2/C3 joint to ensure coverage of the nerve and the resulting caudal spread over the C3 AP

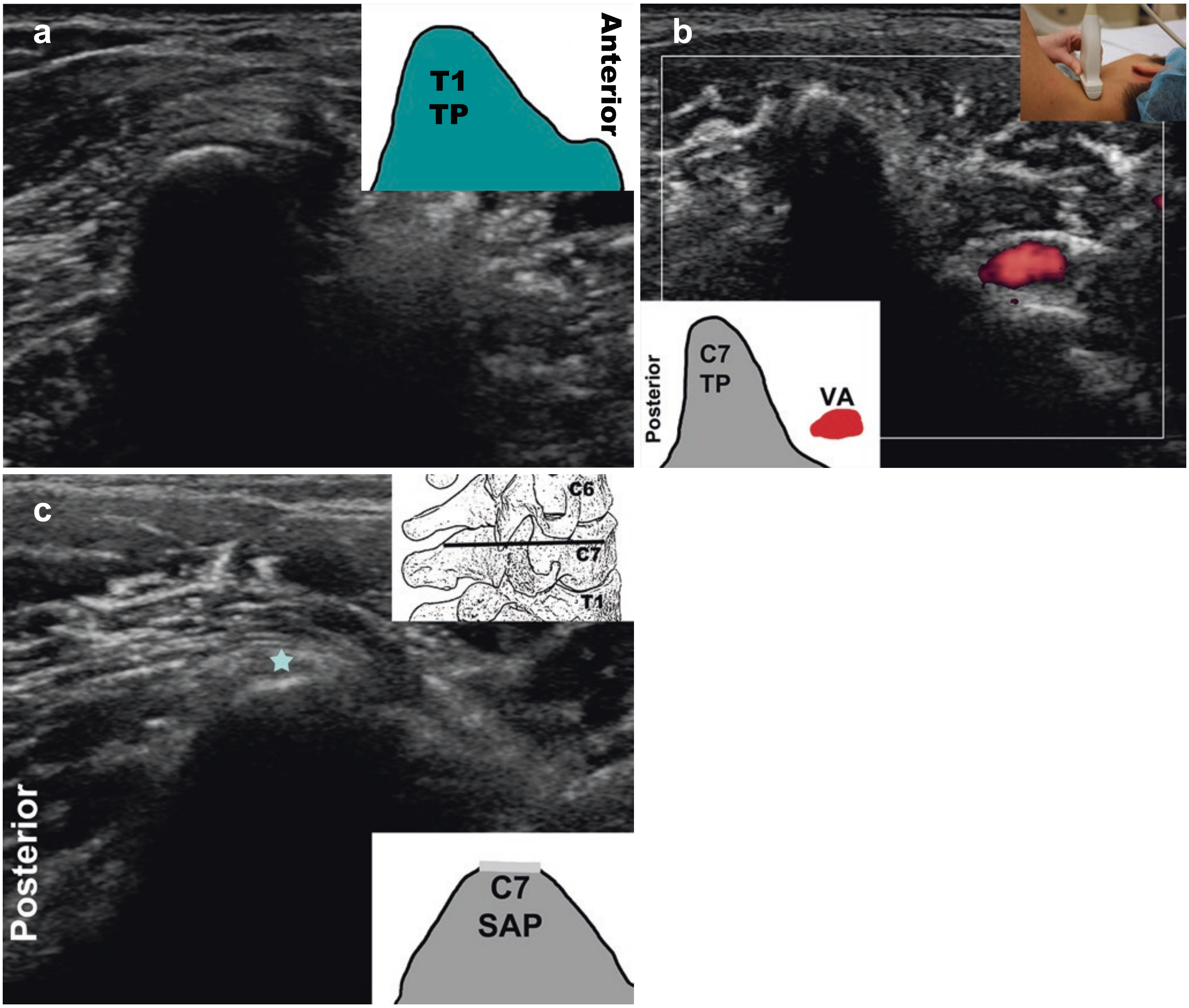

Fig. 15.10 Transverse scan of the lower neck. (**a**) The T1 transverse process (T1 TP) can be recognized because of its typical wide and square contour. Further confirmation can be obtained by tilting the probe caudally and imaging the pleura. (**b**) When scanning cephalad in a transverse plane from T1, the C7 transverse process (C7 TP) can be found anterior to that of T1. Visualizing this posterior to anterior translation is a reliable way to identify the C7 TP, which can be differentiated from that of C6 (depicted in Fig. 15.8) because it lacks an anterior tubercle. The vertebral artery (VA) can be imaged anterior to the C7 TP. (**c**) The C7 superior articular process (C7 SAP) is targeted when performing C7 medial branch blocks (white star). It can be found immediately cephalad to the C7 transverse process and appears as a small hyperechoic line. The right upper inset shows the scan line on a model spine. (Reproduced with permission from Philip Peng Educational Series)

obviates the need to separately target the C3 MB. While only one point on the superior articular process is targeted for the C7 level, two injections of 0.3 mL are performed (on the periosteum and 3 mm lateral) to ensure spread over the proximal transverse process (Fig. 15.12).

Ultrasound

1. *TON, C3, C4 medial branches*: The neck is first scanned in the coronal plane along the posterior edge of the AP in order to identify the drop-off at the C2-C3 level (Figs. 15.5 and 15.6). The probe is then rotated to a transverse plane, and the C2-C3 zygapophyseal joint identified for the TON block (Fig. 15.13). From this point, the probe is moved caudally to the target points on the C3 and C4 APs.
2. *C5, C6 medial branches*: The base of the neck is scanned in the transverse plane and the TP of T1 identified. As the probe is moved cephalad from this point, the more anterior TP of C7 is localized (Fig. 15.10b), followed by the targets on the AP of C6 and C5 (Fig. 15.8).

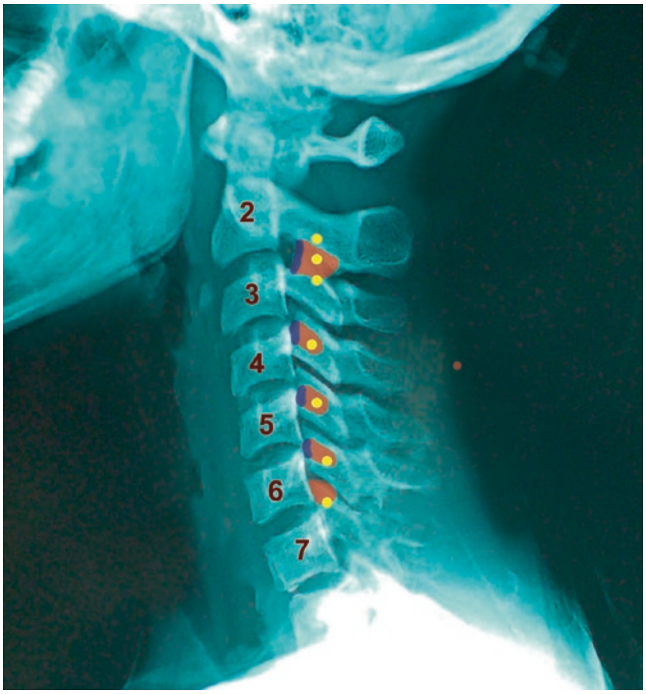

Fig. 15.11 Lateral x-ray view of the cervical spine demonstration of the targets for third occipital and cervical medial branch block (yellow dots). In addition, the target zone for radiofrequency ablation is represented for the parasagittal (red) and oblique (blue) cannula placements. Vertebral bodies are numbered to reflect their respective levels. (Reproduced with permission from Philip Peng Educational Series)

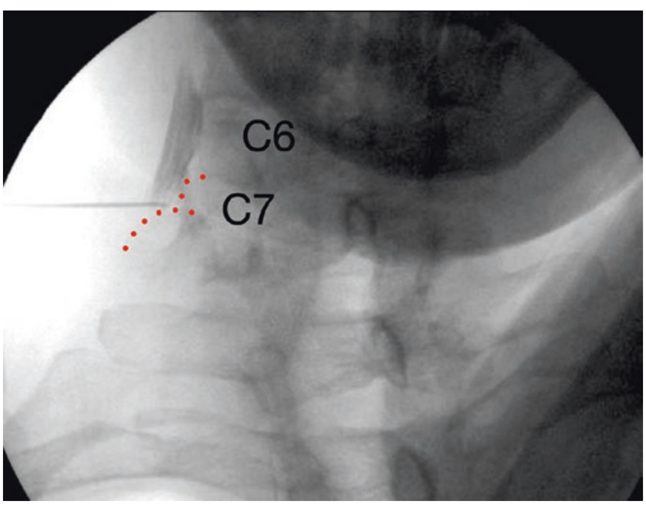

Fig. 15.12 Anteroposterior fluoroscopic view taken during a C7 medial branch block demonstrating contrast spread over the proximal C7 transverse process and superior articular process, as well as the articular pillar of C6. A needle can be seen adjacent to the superior articular process and cephalad to the transverse process (both outlined by red dots). (Reproduced with permission from Philip Peng Educational Series)

3. *C7 medial branch*: The base of the neck is scanned in the transverse plane and the TP of T1 identified. As the probe is moved cephalad from this point, the more anterior TP of C7 is localized (Fig. 15.10). The superior articular process of C7 can be imaged cephalad to the TP of C7 (Fig. 15.10c).

Needle placement after target level has been identified: Once the target has been identified in the transverse plane, pressure on the probe is reduced and the color Doppler mode engaged to detect potential blood vessels in the needle path. A posterolateral in-plane approach is used and the needle advanced until contact with the periosteum (Fig. 15.13). The probe is then rotated to obtain a coronal scan and the needle confirmed to be in the middle of the targeted AP (Fig. 15.7). Returning to a transverse view, local anesthetic (LA) is then injected under real-time visualization; if necessary, the position of the needle tip is adjusted to obtain an LA spread under the semispinalis capitis muscle that covers the anteroposterior diameter of the AP or joint (TON) (Fig. 15.14). Local anesthetic spread can also be visualized in the coronal plane, and this view can be useful when confirming coverage of the different cervical levels (Fig. 15.15). When performing a TONB, needle placement can be further refined by placing the tip next to the nerve as it can often be imaged near the C2–C3 joint in the coronal plane (Fig. 15.5). The C7 MB, because of its variable anatomy, requires two injections, with half the volume deposited on the superior articular process of C7 and the remainder 3 mm lateral to it.

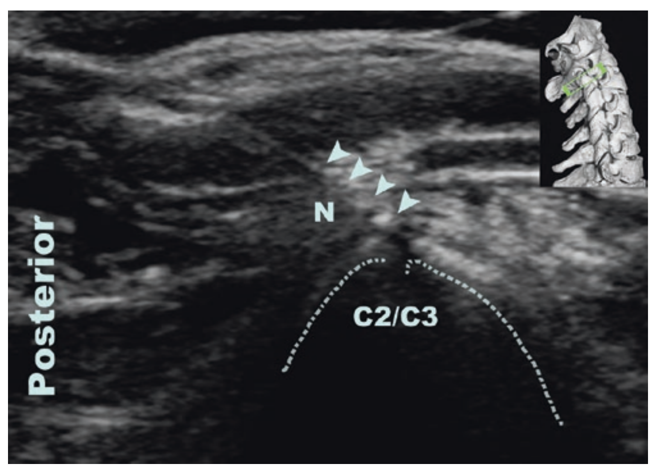

Fig. 15.13 Transverse scan of the upper neck demonstrating a needle (N) outlined by arrows, which has been placed on the (C2/C3) zygapophyseal joint using an in-plane technique and a posterolateral approach during the performance of a third occipital nerve block. The right upper inset shows the scan line on a model spine. (Reproduced with permission from Philip Peng Educational Series)

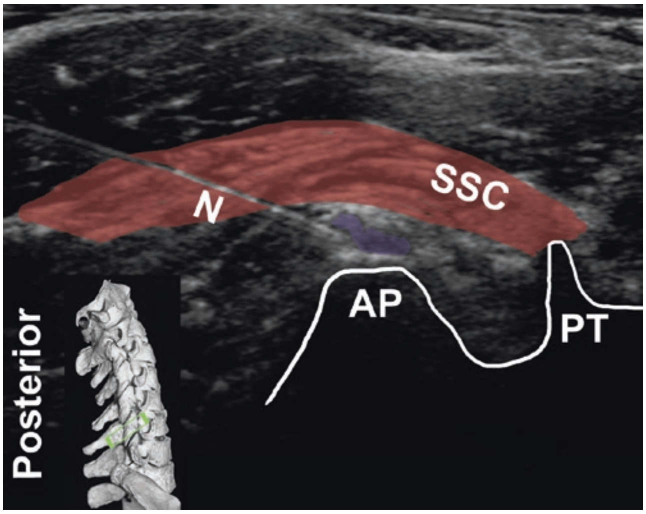

Fig. 15.14 Transverse scan of the lower neck demonstrating a needle (N) that has been placed on the C6 articular pillar (AP) using an in-plane technique and a posterolateral approach during the performance of a C6 medial branch block. The injectate (blue outline) can be seen spreading under the semispinalis capitis muscle (SSC, red highlight). Posterior tubercle (PT); left lower inset illustrates the scan line on a model spine. (Reproduced with permission from Philip Peng Educational Series)

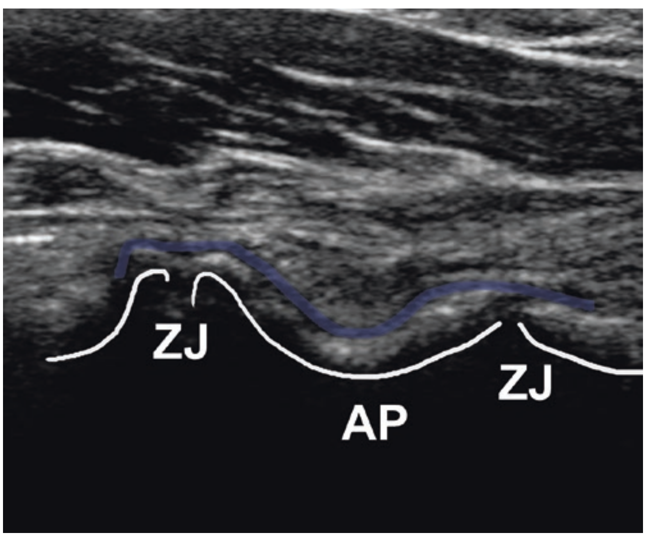

Fig. 15.15 Coronal scan of a C4 articular pillar (AP) illustrating the cephalocaudal spread of local anesthetic (blue highlight) along the periosteum and under the semispinalis capitis muscle following an ultrasound-guided medial branch block; zygapophyseal joint (ZJ). (Reproduced with permission from Philip Peng Educational Series)

Technique: Cervical Medial Branch Radiofrequency Ablation

Common supplies include a temperature-controlled radiofrequency lesion generator and a compatible probe/cannula set. Whereas cannula length (50 or 100 mm) is determined by patient body habitus, an active tip of 5 mm generally provides an adequate lesion for most individuals while minimizing unnecessary damage to posterior soft tissue structures. In addition, lesioning times of 90–120 s at 80–90 °C are commonly used.

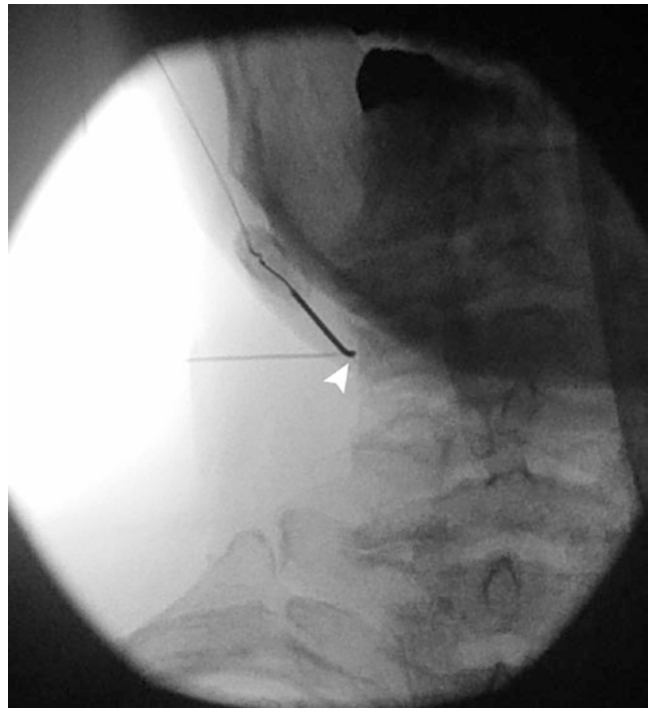

Fig. 15.16 Anteroposterior fluoroscopic view of the cervical spine demonstrating a finder needle that was previously inserted using a lateral view to facilitate the placement of a radiofrequency cannula on the C5 articular pillar (arrow). (Reproduced with permission from Philip Peng Educational Series)

A pre-procedural medial branch block should be performed to provide anesthesia at the targeted levels using 1 mL of local anesthetic and 2 mg of dexamethasone per segment. When inserted using a lateral approach, block needles can be left in situ and serve as finder needles to facilitate level recognition in anteroposterior fluoroscopic views (Fig. 15.16).

Fluoroscopy

Effective radiofrequency ablation requires targeting a sufficiently long portion of the targeted nerve to produce long-lasting pain relief. To this aim, a two-step lesioning process involving oblique and parasagittal cannula positioning has traditionally been advocated, as it follows the curve of the medial branch around the AP (Fig. 15.17a). In order to maximize the contact with the medial branches, parasagittal passes are performed in a pillar or declined view, a modification of the standard anteroposterior approach which aligns the cannula with the natural cephalocaudal inclination of the

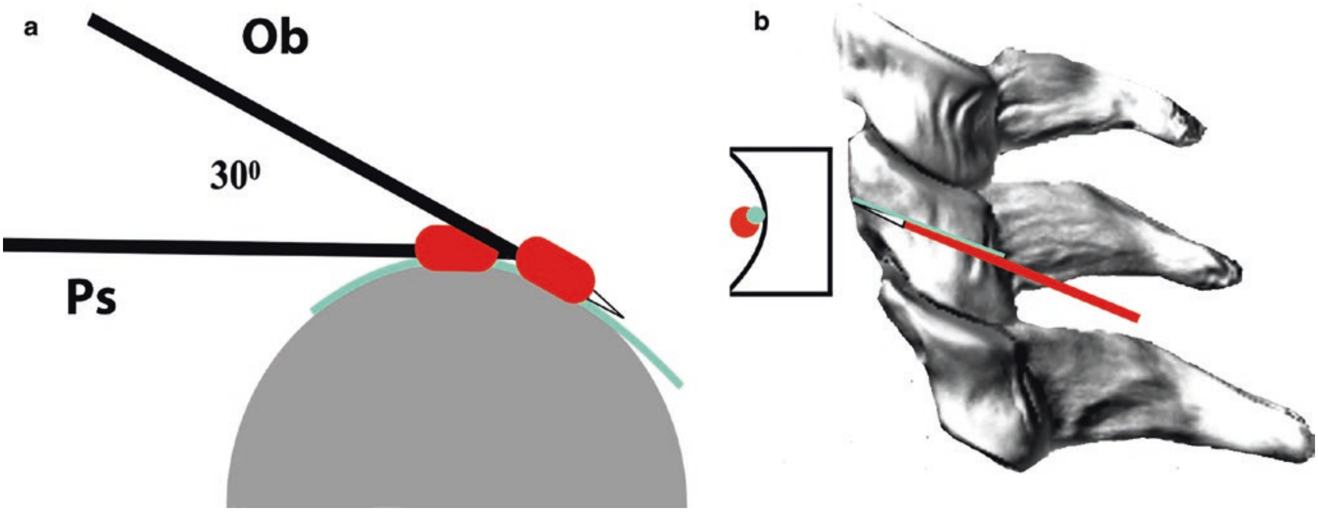

Fig. 15.17 Cervical medial branch radiofrequency ablation techniques are influenced by the bony contours of the articular pillars and zygapophyseal joints. (**a**) Both parasagittal (Ps) and 30° oblique (Ob) cannula placements are performed to maximize the length of the medial branch lesioned. (**b**) Parasagittal cannula placements are performed using a pillar view (Fig. 15.4), which aligns the insertion angle to match that of the zygapophyseal joints. In contrast, cannula placed in the 30° oblique view does not require a similar cephalocaudal angulation, as it targets the anterior aspect of the articular pillar and thus less likely to be deflected by the raised surface of the joint. (Reproduced with permission from Philip Peng Educational Series)

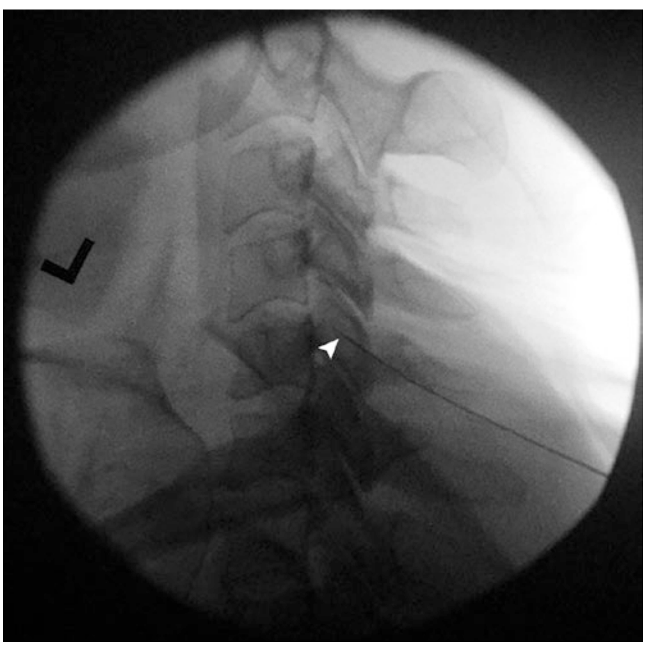

Fig. 15.18 Lateral fluoroscopic view illustrating a parasagittal radiofrequency cannula placement on the articular pillar of C5 (arrow). (Reproduced with permission from Philip Peng Educational Series)

facet joints (Figs. 15.17b and 15.18). In contrast, oblique placements target the anterior portion of the AP and are therefore less likely to be deflected laterally by the raised joint contours. As such, they can be performed in a standard oblique view. Radiofrequency ablation targets are represented in Fig. 15.11, and the number of lesions required per level depends on cannula width, as well as patient-related factors such AP length. In addition, there are level-specific considerations, such as the TON, which generally requires six lesions (three each in oblique and parasagittal) to cover the length of superior articular process of C3 (Fig. 15.19), and C4 and C5 where at least two lesions should be considered because of the 20% incidence of double medial branches at those levels.

Ultrasound

Ultrasound imaging can be used as adjunct to fluoroscopy or as a standalone modality for cervical medial branch radiofrequency ablation procedures. When used in an assistive role, US can help refine cannula positioning by providing a two-dimensional view of bony surface anatomy, which can be useful in patients with altered anatomy caused by degenerative changes. In addition, when significant vascular structures are visualized in proximity to a targeted site, potentially affecting the safety and efficacy of a planned lesion, an operator may decide to modify or abandon the intervention for that level. When using US as a primary imaging modality, two different strategies have been described. The first relies on identifying target nerves in a coronal scan and then positioning a cannula next to it using a transverse view. Unfortunately, because medial branches cannot always be identified, particularly in the lower

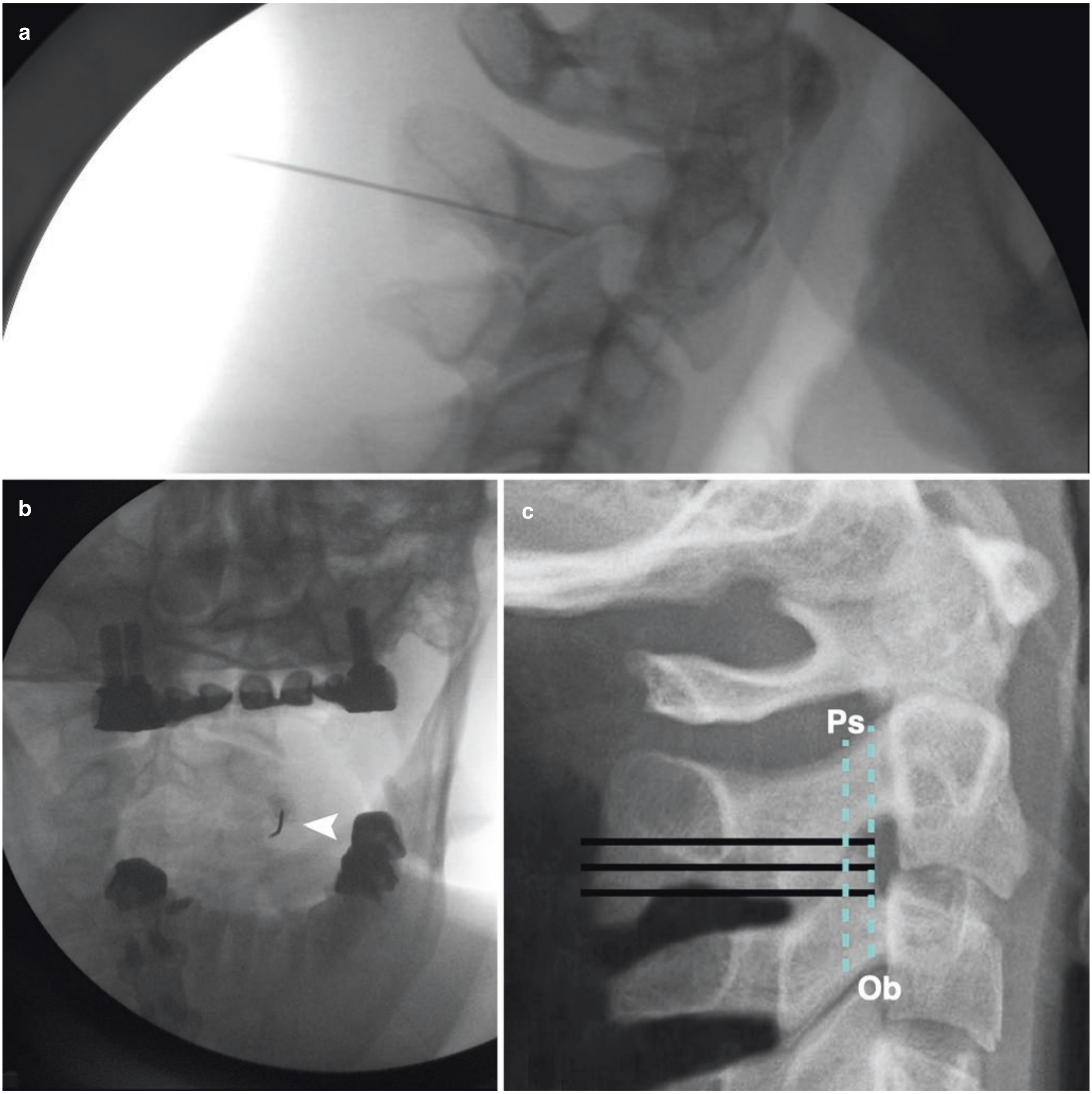

Fig. 15.19 Radiofrequency ablation of the third occipital nerve. (**a**) Lateral fluoroscopic view of the upper cervical spine demonstrating a parasagittal radiofrequency cannula placement at the upper target point for third occipital nerve ablation. (**b**) Anteroposterior open-mouth view of the cannula placement illustrated in (**a**). (**c**) The three transverse cannula placements (black lines) targeting the superior articular process of C3 for radiofrequency ablation of the third occipital nerve are shown. Final cannula tip positions for the parasagittal (Ps) and oblique (Ob) passes are also illustrated (broken white lines). (Reproduced with permission from Philip Peng Educational Series)

cervical spine and in the presence of degenerative changes, this strategy may not be reliable. The second strategy uses bony landmarks and a bi-planar USG technique to produce a lesion pattern similar to that of the fluoroscopic technique (Fig. 15.20). Indeed, by visualizing the contours of the articular pillars, operators can adjust insertion angles to optimize periosteal contact. While nerve roots are readily imaged, smaller structures such as lateral branches can be more difficult to identify. However, unintended damage to the latter can be avoided by ensuring that cannula tips remains 3 mm behind the posterior tubercle of the transverse process.

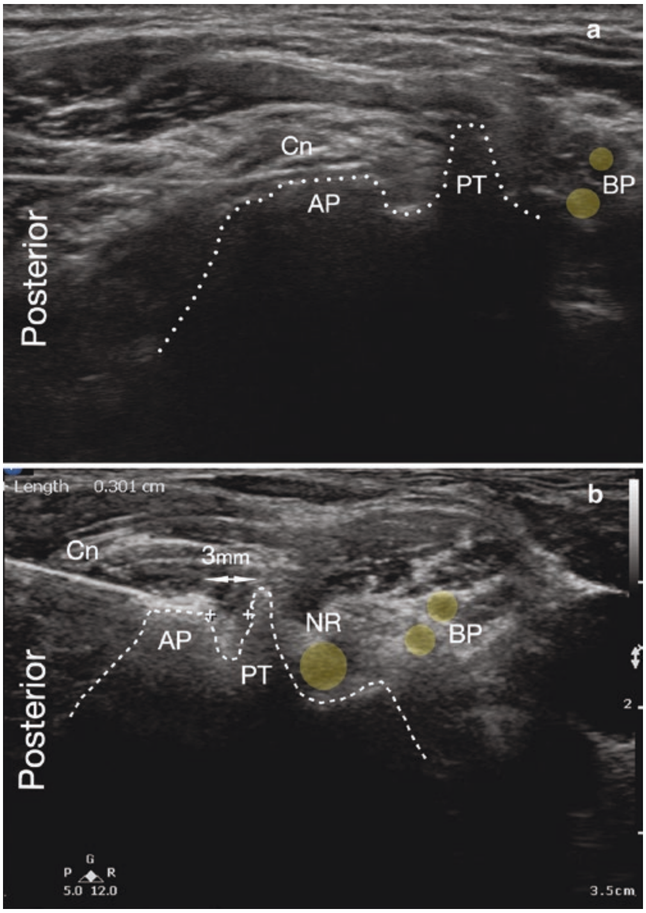

Fig. 15.20 (**a**) A conventional radiofrequency cannula (Cn) has been placed on a C5 articular pillar (AP) using an in-plane ultrasound-guided technique. The posterior tubercle (PT) and brachial plexus (BP) can be visualized anteriorly. (**b**) A deployment multi-tined radiofrequency cannula (Cn) has been placed on a C6 articular pillar (AP) using a posterolateral approach and in-plane technique. The distal tine has been placed 3 mm behind the posterior tubercle (PT) to minimize the possibility of unintentional lesioning of the lateral branch. The nerve root of C6 (NR) and brachial plexus (BP) can be seen anteriorly. (Reproduced with permission from Philip Peng Educational Series)

Ultrasound image quality is significantly affected by the presence of air, which can be introduced to the target area by needle or cannula insertions, as well as tissue degassing caused by the lesioning process. Therefore, technologies that minimize the number of lesions required can be particularly useful in the context of ultrasound guidance. One such recent innovation is the multi-tined deployment cannula, which creates a large lesion adjacent to the periosteum that is less affected by approach angles and bony contours than conventional cannula. These valuable characteristics could thus form the basis of a simplified ultrasound technique involving an approach similar to that used for medial branch blocks (Fig. 15.20b).

Complications and Safety Considerations

- Rare reports in the scientific and medicolegal literature indicate that cervical medial branch procedures can be associated with serious neurological complications when improper technique is used. In contrast, transient minor side effects (segmental skin numbness and dysesthesia) are common, affecting 20–30% of patients undergoing C4–C7 lesions and 55–95% of those undergoing TON procedures, which carry the additional risk of transient ataxia.
- Injections of local anesthetic around the cervical spine carry the risk of accidental intravascular or intrathecal spread, which can sometimes result in life-threatening complications. Fortunately, most patients will make a full recovery with timely treatment and therefore resuscitation capability should be available when performing these procedures. Furthermore, injections of particulate steroids carry the additional risk of causing vascular events affecting the anterior spinal cord (radicular artery) or posterior circulation (vertebral artery) and should therefore be eschewed in favor of dexamethasone.
- Vertebral arteries can frequently be found in proximity to the cannula path when targeting the TON at C2/C3, particularly in older age groups where patients are more likely to present arterial loops that course caudally toward the joint. A pre-procedural ultrasound scan can help identify this potentially dangerous situation.
- The use of precautionary motor stimulation prior to lesioning is controversial and its value in preventing unintended lesioning of the lateral branches or nerve roots is uncertain. Therefore, lesions should not be performed if imaging cannot confirm a safe cannula position.

Literature Review

The use of radiofrequency ablation to treat cervical pain is supported by two randomized controlled trials and several cohort studies. These suggest that approximately 63% of patients selected with dual comparative blocks (100% relief required for inclusion) will present complete pain relief at 6 months. While cervical medial branch blocks are used primarily as a diagnostic tool, they can also have a therapeutic effect. Indeed, one randomized controlled trial found that patients selected with dual comparative blocks achieved 50% relief for an average of 14 weeks following CMBB with bupivacaine. In addition, the authors found no advantage to the addition of steroids.

An emerging body of literature supports the use of ultrasound imaging for CMMBs. Compared to fluoroscopy, the latter provides similar accuracy but reduces performance time and the number of required needle passes. In addition, USG CMBBs are associated with the same short- and long-term clinical effects (pain reduction, improved functional status) as their fluoroscopy-guided counterparts. Although several trials have reported a lower incidence of vascular breach in patients assigned to ultrasound guidance, further prospective studies involving larger numbers of patients are required to determine whether US can reduce procedural complications. While there are several proof of concept studies examining the use of USG for radiofrequency ablation, no randomized controlled trials have been published.

Suggested Reading

Elgueta MF, Jimenez JO, Wang NN, Lara AP, Chankowsky J, Charghi R, Tran DQ, Finlayson RJ. Anatomical variations of the vertebral artery in the upper cervical spine: clinical relevance for procedures targeting the C1/C2 and C2/C3 joints. Reg Anesth Pain Med. 2018;43:367–71.

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