Superficial and deep cervical plexus block: Technical considerations
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Regional anesthetic block of the cervical plexus is a safe and useful alternative to general endotracheal anesthesia for surgery of the neck, upper shoulder, and occipital scalp area. The sensory component of the cervical plexus can be blocked separately and easily by a superficial cervical plexus block. Both motor and sensory block can be obtained by deep cervical plexus block. Minor transient side effects are common to deep cervical plexus blocks, but they are rarely of any consequence. Recent years have seen an increase in interest in the use of the cervical plexus block, because its popularity for surgical procedures such as carotid endarterectomies has grown. An understanding of the anatomy and principles of this anesthetic technique will enable the clinician to offer the patient and surgeon an important anesthetic option.

Key words: Anesthetic, carotid endarterectomy, deep cervical plexus block, superficial cervical plexus block.

Introduction and history
Cervical plexus block (CPB) was first performed by Halstead in 1884 at Bellevue; and later, Kappis in Germany described the posterior route. Although Heidenhein introduced the lateral approach, it was Labat who popularized this technique in America. In more recent years Winnie described an alternative single-injection technique in an effort to simplify the procedure and reduce the incidence of potential complications from the block.

Within the past decade, the interest in and popularity of CPB has reemerged. A number of surgical procedures can be performed under CPB anesthesia (Table I). In addition, when conventional medical treatments have failed, the anesthetist can provide a valuable service for the nonsurgical uses of CPB (Table II). Another reason for the rising popularity of this block can be attributed to the results of recent multicenter studies concerning the indications and positive outcomes of patients undergoing carotid endarterectomy (CE), which have led to an increase in the frequency with which this operation is being performed.

| Table I |
| Surgical procedures amenable to cervical plexus block |
| 1. Carotid endarterectomy |
| 2. Plastic repairs |
| 3. Lymph node dissection |
| 4. Thyroidectomy* |
| 5. Tracheostomy* |

*Require bilateral blocks (See text for precautions and protocol.)
Table II
Potential nonsurgical uses for cervical plexus block
1. Neuralgias (differentiation and localization of)
2. Treatment of hiccup
3. Pain relief (secondary to pharyngeal cancer)
4. Relief of occipital headaches

Anesthesia providers who seek the optimal method for monitoring continuous cerebral function during CE have found that an awake patient is possibly the best answer. Therefore, much study has been done not only by anesthesia researchers but also by surgical and neuromedical scientists that confirmed the utility of CPB for this procedure. Unfortunately, many practitioners are unfamiliar with CPB. As with the use of any regional anesthetic, a solid foundation in the anatomy involved and the proper technique of performing the block are the keys to success. It is with this in mind that the most common approaches to CPB are presented in this review.

Anatomic considerations
The cervical plexus (CP) is formed from the first four cervical spinal nerves, C-1, C-2, C-3, and C-4. The first cervical nerve is considered to have no sensory components and only minor motor components in the posterior neck; therefore, our focus will be on C-2, C-3, and C-4. These spinal nerves emerge from the intervertebral foramina and pass behind the vertebral artery and vein in the gutter formed by the anterior and posterior tubercles of the corresponding transverse processes of the cervical vertebrae (Figure 1).

As the nerves approach the lateral edge of the transverse process, all but C-1 divide into an ascending and descending branch. The nerve roots of C-2, C-3, and C-4 then enter a perineural space created by tendons and muscles that are attached to the anterior and posterior tubercles of the corresponding cervical vertebrae and form a fascial compartment. This compartment is lined anteriorly by the scalenus anterior muscle and posteriorly by the scalenus medius muscle. It is this compartmental concept that inspired Winnie to describe the single-injection technique for CPB. However, others feel that this compartment is less developed than the one formed just below it around the brachial plexus.

The ventral primary divisions of C-2, C-3, and C-4 separate into descending and ascending branches that form a pattern of three loops. These loops constitute the plexus formation, and they also communicate with sympathetic fibers derived from the superior, middle, and inferior cervical ganglia. In addition, there is an intricate fiber network that communicates with several cranial nerves. The vagus, hypoglossal, and accessory nerves all communicate with the cervical plexus (Table III). Such communication may partially explain some of the side effects often seen with CPB.

Early in the formation of the CP, motor fibers course deep into the neck and separate from sensory fibers, which spread out superficially over the neck. This rare anatomical characteristic allows selective sensory blockade of the CP. The series of loops of the CP form the development of superficial and deep branches.

The deep branches of the CP provide motor

Table III
Cranial nerve communications with the cervical plexus

<table>
<thead>
<tr>
<th>Cranial nerve</th>
<th>Cranial nerve communications with the cervical plexus</th>
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<tbody>
<tr>
<td>X</td>
<td>Vagus</td>
</tr>
<tr>
<td>XI</td>
<td>Accessory</td>
</tr>
<tr>
<td>XII</td>
<td>Hypoglossal</td>
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innervation to the majority of the muscles of the neck and most importantly to the phrenic nerve, which is predominantly derived from C-4.\textsuperscript{16,18} The anterior branches course behind the anterior scalene muscle, and then separate from the motor branches, continuing laterally to emerge superficially under the posterior border of the sternocleidomastoid muscle (Figure 2). It is this anatomical separation that enables the sensory branches of the CP, via the superficial cervical plexus (SCP) to be blocked selectively without any motor blockade within the neck.

**Superficial cervical plexus block**

The superficial cervical plexus block (SCPB) is simple and easy to perform, but unfortunately it is often overlooked as an option to general anesthesia. It is important to understand that the SCPB provides the same sensory (dermatome) anesthesia as the deep cervical plexus block (DCPB), which simply incorporates the motor component of the CP at the nerve roots before the sensory and motor aspects separate.

Because only the sensory nerves are anesthetized in the SCPB, one may encounter some surgical difficulty with major muscle retraction within the neck, because the muscles will maintain their tone and ability to flex and move intraoperatively.\textsuperscript{19} As a result of potential problems with retraction, use of the SCPB is often reserved for surgical procedures that are more cutaneous in nature, rather than deep within the neck and that require either little or no muscle relaxation. Plastic procedures, some lymph node biopsies, and tracheostomy are among the surgeries that can be performed under SCPB. In the case of tracheostomy, a bilateral SCPB along with supplemental local infiltration from the surgeon is an option to general anesthesia. However, some clinicians routinely utilize SCPB for procedures that are performed at deeper surgical planes, such as CE. In these cases, the surgeon should be made aware that a lack of motor blockade can be expected.

The SCP, by way of the anterior rami of C-2, C-3, and C-4, distributes sensory innervation to the skin, starting at the base of the skull and covering the anterior and lateral neck from the mandible to the clavicle and the superficial aspect of the shoulder.\textsuperscript{19} Cervical plexus block does not provide adequate anesthesia within the shoulder joint itself, and it should not be considered for surgical procedures involving this area. From under the midpoint of the posterior border of the sternocleidomastoid muscle, the four individual sensory nerves emerge to form the SCP. It should be noted that in close proximity and slightly superior, the spinal accessory nerve passes through the bulk of the sternocleidomastoid muscle.\textsuperscript{17,18}

The four sensory nerves of the CP innervate the neck as follows: The lesser occipital nerve, with its origin predominately at C-2, emerges as the first of these sensory nerves.\textsuperscript{17,19} It ascends from the posterior border of the sternocleidomastoid muscle and supplies a bandlike area behind the ear both superiorly and inferiorly. The second branch, the great auricular nerve, derived from C-2 and C-3, provides sensation to the skin over the parotid gland and posteriorly to the surface of the ear, as well as inferiorly to the angle of the mandible. The third cutaneous nerve, which also arises from C-2 and C-3, is the transverse cervical or anterior cutaneous nerve, which passes anteriorly and perforates the platysma of the neck, where it divides into anterior and posterior branches. Sensory innervation from the mandible to the sternum and as far posteriorly as the angle of the mandible is supplied. The fourth and final sensory nerve of the SCP is the supraclavicular nerve, which arises from C-3 and C-4. This nerve sup-
plies the largest surface area, because its branches penetrate the platysma and innervate inferiorly below the clavicle and laterally over the deltoid area. The surface of the trapezius and acromion are also supplied by the branches of the supraclavicular nerve (Figure 3). All of these nerves make up the SCP and are easily blocked by infiltration with a local anesthetic.

The technique for an SCPB is as follows:
1. The patient lies supine with a small towel under the head, which is turned slightly toward the side that is not being blocked.
2. Against gentle resistance from the anesthetist's hand, the patient is instructed to lift his or her head. A simultaneous slight Valsalva's maneuver is encouraged to help outline the sternocleidomastoid muscle and locate the external jugular vein.
3. The midpoint of the posterior border of the sternocleidomastoid muscle is located and marked. This usually corresponds with the external jugular vein as it crosses the border of the muscle.
4. A 22-gauge 4-cm needle is advanced from 1-2 inches superiorly and inferiorly into the subfascia along the border of the muscle, and 5-10 mL of local anesthetic is then infiltrated (Figure 4). Paresthesia is not sought. Ten to 15 minutes should be allowed after injection of the local anesthetic before the adequacy of the block is determined. (Note: Because of the close proximity of the accessory nerve [cranial nerve XI], the ipsilateral trapezius muscle is often paralyzed for the duration of the SCPB.)

Deep cervical plexus block
A DCPB is in essence a paravertebral nerve block of the C-2, C-3, and C-4 spinal nerves as they emerge from the sulcus in the transverse processes of the cervical vertebrae. If the CPB is performed close to the lateral edge of the transverse processes, the nerve roots are anesthetized before the motor and sensory components separate, which is one of the primary differences between a DCPB and an SCPB. Thus the DCPB not only anesthetizes all the sensory components of the CP but also the muscles that arise and insert on the corresponding cervical vertebrae and transverse processes of C-2, C-3, and C-4. This produces a more complete anesthetic block and provides excellent surgical conditions deep within the neck. This more profound block is usually needed for operations such as a carotid endarterectomy. The nerve roots themselves are blocked, providing an anesthetized "capelike" region that can be identified by...
dermatomes (Figure 5), providing the same sensory anesthetic field as with the SCPB.

The technique for a DCPB is as follows:

1. The patient is placed supine with a small towel under the head, which is turned slightly toward the side opposite the one to be blocked. The anesthetist should stand at the head of the table and somewhat to the side being blocked. This allows for good control of the head and helps to maintain a more caudad approach with the needles.

2. The mastoid processes are identified and marked. The transverse processes are palpated, and the most prominent tubercle, that of C-6 (Chassaignac's tubercle) is identified and marked. To conform C-6, another line can be drawn from the cricoid cartilage posteriorly until it intersects the first line (Figure 6).

3. The cervical processes can now be palpated approximately 0.5-1 cm posterior to the line drawn between the mastoid process and C-6. There is no transverse process for the first cervical vertebra, so C-2 should lie 1.5 cm (about one finger's breadth), below the mastoid process and can usually be palpated. An "X" is made to mark C-2.

4. The transverse processes of C-3 and C-4 are palpated approximately 1.5 cm below their respective superior transverse processes, and each is marked with an "X." To confirm C-4, a horizontal line can be drawn from the lower border of the mandible until it meets the vertical line (Figure 6).

5. Skin wheals are raised at all three "X" marks that were placed over the transverse processes of C2-C4.

6. Three separate 5-mL syringes with local anesthetic and 5-cm 22-gauge needles are used, which are introduced through the wheals in succession and advanced medially and caudally (Figure 6). It is important to maintain a caudal direction to avoid unintentional entry into the intervertebral foramen, resulting in an epidural or subarachnoid block. The end point is the transverse process,

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Figure 5
Superficial and deep cervical plexus blocks provide a "capelike" field of anesthesia, which are identified here by appropriate dermatomes.

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Figure 6
Classic 3 injection technique

Left: deep cervical plexus block landmarks are identified by drawing a line from the mastoid process to C-6 (Chassaignac's tubercle.) C-6 is located at the level of the cricoid cartilage.

Right: Three separate injections are made as shown with needles at slight caudad direction.

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which is usually at a depth of 1.5-3.0 cm. The needle is walked laterally until it slips off the most lateral aspect of the bone, and the tip is then reidentified.\textsuperscript{10} It is important to locate the process as far laterally as possible to avoid any contact of the needle with the vertebral artery (Figure 1).

7. Paresthesias are usually not necessary, but they may sometimes be elicited. After careful aspiration for cerebral spinal fluid and blood, 4-5 mL of the local anesthetic is injected. This process is repeated at C-3 and C-4.

8. Many clinicians subsequently perform an SCPB to complement the DCPB.\textsuperscript{11} Should a nerve root be inadvertently "missed" during DCPB, anesthetizing the SCP at least ensures the sensory component of the block and avoids a possible failure of the regional technique.

The cervical plexus can also be blocked by the single-injection technique, as described by Winnie.\textsuperscript{1,4} This procedure is done at C-4, whose location was described earlier. The groove between the anterior and middle scalene muscles is palpated just posterior to the sternocleidomastoid muscle. The needle is then inserted between the two heads of the interscalene groove perpendicular to the skin and slightly caudad.\textsuperscript{4} It is critical to avoid a horizontal pass with the needle so that vertebral vessels, perineural space, or the subarachnoid space are not encountered.

After identifying the transverse process, eliciting paresthesia, and following negative aspiration, 10-15 mL of anesthetic solution is injected. If properly placed, the needle lies in the fascia enclosed space described earlier. Fortunately, the paravertebral space communicates freely in the cervical region, so the local anesthetic solution can spread easily to adjacent levels.\textsuperscript{18} Digital pressure just below the injection site obstructs the caudad spread of the local anesthetic and concentrates the drug on the cervical nerve roots in an effort to prevent brachial plexus involvement.\textsuperscript{4}

**Local anesthetics and the duration of CPB**

Mepivacaine or lidocaine can be used at 1% concentration with or without the addition of epinephrine. This should provide onset in 5-15 minutes, with a duration of up to 2 hours in the case of mepivacaine if no epinephrine is used. Some clinicians advocate lower concentrations of local anesthetic (0.25-0.5% lidocaine or bupivacaine with 1:200,000 epinephrine) and larger volumes.\textsuperscript{5,14}

Because of the high vascularity of the cervical area and more rapid absorption of the drug, shorter durations of local anesthetic effects are expected. The authors prefer to use higher concentrations with a lower volume technique (usually less than a total of 25 mL) and no epinephrine. The addition of epinephrine prolongs the block and allows lower concentrations of local anesthetic to be used. However, since this block is most often used for carotid endarterectomy in a high-risk group of patients, low epinephrine concentrations may produce undesirable cardiovascular effects.\textsuperscript{20,21}

**Side effects and complications**

Cervical plexus block is a relatively low-risk procedure, if the local anesthetic solution is placed at the tips of the transverse processes of either the anterior or posterior tubercle. Clinicians who are learning to perform a DCPB sometimes make the error of selecting incorrect landmarks that guide them too posteriorly or insert the needle too far anteriorly to the vertebral column.\textsuperscript{14,18} Injection of even minute volumes of local anesthetic in the neck can lead to a number of possible side effects and complications. Fortunately, the more serious complications occur very rarely, and the side effects that do occur more frequently are almost always of little significance. Some of the potential complications are listed below.

- **Toxic reactions** result from either intravascular injections or high blood levels due to overly large volumes of local anesthetic with a resultant overdose. Continuous aspiration during injection is mandatory. Accidental injection of volumes as small as 0.5 mL into the vertebral or carotid artery can produce immediate transient loss of consciousness, convulsions, or both.\textsuperscript{18,22} Total reversible blindness has also been described after similar inadvertent injections of small amounts (1 mL) of local anesthetic into a vertebral artery.\textsuperscript{18,23}

- **Subarachnoid and epidural injections at the cervical level can occur if the needle is not kept in a slightly caudad direction during injection. Not only does the possibility of intraspinal puncture and subsequent injury to the spinal cord exist, but it is also possible for the local anesthetic to spread into the neuraxis by means of direct penetration of the intervertebral foramen of the cervical spine, producing total brainstem anesthesia.\textsuperscript{24} Careful aspiration is required for any evidence of cerebrospinal fluid. Epidural injection, unlike subarachnoid injection, cannot spread into the cranium. An epidural block at the cervical level results in anesthesia of the upper limbs and thorax and can cause bilateral phrenic nerve block with subsequent bilateral diaphragmatic paralysis.

- **Phrenic nerve block** is a frequent occurrence with DCPB. However, it is not associated with SCPB. Castresana and colleagues recently showed that the incidence of hemidiaphragmatic paresis in patients undergoing carotid endarterectomy...
under DCPB was more than 60%. These results agree with earlier research by Takasaki on phrenic nerve block after a cervical epidural.

If the ipsilateral diaphragm is paralyzed, only patients with chronic obstructive pulmonary disease seem to be at any risk for significant changes in carbon dioxide concentration. In our experience, which includes more than 60 patients with fluoroscopic confirmation of hemidiaphragmatic paresis, patients without lung disease had no significant changes in arterial blood gases.

Most patients with hemidiaphragmatic paresis experienced only a "heavy chest" sensation. If hemidiaphragmatic paresis occurs, providing reassurance and administering supplemental oxygen with the patient's head slightly elevated is the only treatment that is generally required.

Additionally, it is reassuring to note that all the patients who developed hemidiaphragmatic paresis recovered normal diaphragmatic motion, which was confirmed by fluoroscopy approximately 2 hours after administration of the block. Our group has further shown that the diagnosis of hemidiaphragmatic paresis can be made in a reliable manner by performing preblock and postblock handheld peak expiratory flow measurements. This simple measurement correlates well with conventional fluoroscopic diagnosis and is also much easier and less costly.

Bilateral nerve blocks at the level of C-4 have also been used for permanent relief of hiccoughs. It has been suggested that the intercostal muscles compensate adequately for the decrease in diaphragmatic activity. However, a bilateral phrenic nerve block can pose a serious ventilatory hazard. Until controlled studies are carried out, bilateral DCPB is not recommended unless strict protocol is followed.

As in the case of a thyroidectomy, which requires a bilateral CP block, there are several options to consider. First, a bilateral SCPB can be performed with little risk of phrenic nerve block. If a bilateral DCPB is desired, prior to initiating the block and administering any sedation, baseline handheld peak expiratory flow measurements should be performed. Unilateral DCPB can then be carried out, and after a 20-minute period, the patient should be retested for any reduction in ventilatory capacity. If there are no changes in the peak expiratory flow studies postblock, DCPB can then be performed on the remaining unanesthetized side. (Note: Should the phrenic nerve be blocked, one can expect a decrease in peak expiratory flow rates ranging from 25-40% below preblock values.) If postblock peak expiratory flow studies indicate a reduction in vital capacity, use of SCPB on the remaining side should be considered or general anesthesia should be used.

- Carotid sheath compression by injecting the local anesthetic anterior to the transverse processes has been demonstrated by Labat to possibly impair blood flow to the brain. This could be an especially significant complication in patients who have preexisting carotid artery stenosis.
- Hematoma formation can not only compress the major vessels in the neck but in some cases the pharynx and larynx as well. In rare instances the airway can be compromised. Furthermore, the surgeon may encounter difficult operating conditions caused by the hematoma within the neck.
- Hoarseness secondary to vagal nerve block or recurrent laryngeal nerve involvement probably occurs more often than previously thought. Moore originally reported an incidence of 2-3%. The occurrence of hoarseness in association with SCPB has not been reported. However, in DCPB, Castresana and colleagues have shown the incidence to be as high as 55%. It has been speculated that the anterior spread of the local anesthetic to the vertebral fascia may be responsible, as the recurrent laryngeal nerve enters the larynx at the level of the sixth cervical vertebra. Hoarseness, when combined with an increase in heart rate, probably indicates a block of the vagus nerve itself. The occurrence of hoarseness, while sometimes annoying to the patient, is transient and rarely causes any problems. However, it should not be ignored, and the surgeon should be made aware of any hoarseness prior to the incision. Hoarseness during surgical manipulation in the awake patient has been used by the surgeon as a guide in locating and avoiding the recurrent laryngeal nerve. As with most side effect of DCPB, hoarseness clears as the block dissipates.
- Dysphagia is another usually inconsequential but frequent side effect seen after CPB. It has been shown to occur approximately 50% of the time. Dysphagia following CPB is believed to be secondary to involvement of the ninth and tenth cranial nerves or a combination of both through the pharyngeal plexus. The patient usually describes a sensation of "fullness" in the back of his or her throat. These symptoms also resolve in the postanesthesia care unit as the anesthetic wears off.
- Horner's syndrome is characterized by ptosis of the eyelid, constricted pupil, and lack of sweating on the affected side of the face. It most often occurs when local anesthetic is injected anterior to the transverse process, and the middle cervical sympathetic ganglion is blocked. In the authors' experience, this syndrome most often presents as injected conjunctiva, constricted pupil, and stuffi-

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ness of the nose in the CPB patient. The incidence appears to be in the range of 20% (Castresana, Masters, personal observations on interim results of ongoing studies). The presence of Horner’s syndrome should be noted prior to surgical incision, because of the potential for interference with neurological examination intraoperatively and postoperatively.

- **Headache**, usually occipital, has been reported after thyroid surgery under CPB. However, headaches are also reported after general anesthesia for the same procedure and are probably due to prolonged hypertension of neck muscles rather than the block itself. Cervical plexus block has, in fact, been used to treat occipital headaches by blocking the lesser occipital nerve. Headaches can also occur after carotid endarterectomy secondary to reperfusion of the cerebral circulation.

The potentially serious complications associated with CPB, specifically DCPB, are extremely rare. In our experience, which has involved more than 250 SCPB and DCPBs, there has been one incidence of transient ischemic attack that was thought to be the result of either inadvertent intravascular injection or reduction of blood flow to the brain from having turned the head too far during the block. In this case the symptoms resolved within minutes, and the procedure was performed 2 days later without sequela. Less serious complications occur more frequently, but they have been shown to be of little or no significance.

It is interesting to note that while phrenic nerve block is seen in more than 60% of DCPB patients, it has been associated with 100% of brachial plexus blocks performed by interscalene approach. As with any major regional anesthetic block, full resuscitation and airway management equipment should be immediately available.

In most cases, it is helpful to inform the patient prior to the block as to the possibility of hoarseness, difficulty swallowing, and perhaps a “heavy chest” sensation, which might develop as a result of the anesthetic. When this occurs, reassuring the patient that all is well and that these symptoms will resolve in an hour or so is almost always sufficient.

**Summary**

Cervical plexus block anesthesia is a safe and useful anesthetic technique for surgery of the neck. Interest in performing a carotid endarterectomy in the awake patient has increased the popularity of CPB. A thorough knowledge of the pertinent anatomy and the proper technique for the block is essential in order to achieve good clinical results. A number of potential side effects and complications are inherent to CPB, but they usually are of minimal significance if they are properly managed.

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