Regional anesthesia and invasive techniques to manage head and neck pain

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Head and neck regional anesthesia provides the practitioner the option of managing acute and chronic pain situations. The dermatomes are well defined with good options for approaching and blocking the majority of peripheral nerves in this region of the body (Figs. 1 and 2).

Local anesthesia considerations

Carefully administered in select patients, nerve blocks can be effective in the management of acute or procedural pain as well as chronic head and neck pain. For surgery in shorter cases, 1% to 2% lidocaine or 2% to 3% mepivacaine are effective in producing rapid onset of regional anesthesia with short duration. With the addition of epinephrine 1:100,000 or 1:200,000, a degree of hemostasis can be obtained and anesthesia prolonged. Because of bupivacaine’s longer onset time, this agent is often injected after the initial block has been assured to provide a sustained block. Reinforcement of the block using 0.5% bupivacaine can provide anesthesia for longer procedures and be used as an integral part of postoperative pain control strategies.

Sympathetic blockade can be achieved by using concentrations of local anesthetic below that required for sensory and motor loss. Thus, the practitioner can produce a select block involving unmyelinated C fibers and A delta fibers without significant impairment of motor function. Typically, 0.25% bupivacaine is used for diagnostic and therapeutic blocks for pain that is sympathetically mediated. Sympathetic blockade significantly outlasts the pharmacologic action of the local anesthetic. Neurolytic blocks can be

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doi:10.1016/S0030-6665(03)00134-8
produced by the use of alcohol, phenol, cryotherapy (−70°C centigrade), or thermocoagulation (70°C centigrade).

The practitioner must use caution with patients on anticoagulant therapy and infection at the site of the block. Local anesthesia toxicity is a concern where large volumes of concentrated local anesthetic are used. Clinicians must use care to avoid injecting more milligrams per kilogram than is recommended to avoid a toxic response, which could potentially lead to CNS, respiratory, and cardiac depression. When there is a need for a large volume of local anesthetic to be administered, the incidence of toxicity can be avoided by using the lowest concentration of local anesthetic that will produce the required block and calculating the maximum volume of this solution that each patient may receive in advance of starting the injection. This is especially true in the pediatric patient where drug toxicity can become a life-threatening complication if maximum doses are not strictly controlled. Additionally, neurolytic agents may produce significant complications related to development of neuritis and vascular compromise.
**Cervical plexus**

The cervical plexus is formed by the first four cranial nerves. The dorsal and ventral roots join to form a spinal nerve as they exit through the intervertebral foramen. The cervical spinal nerves then divide into dorsal and ventral divisions. These dorsal branches innervate the muscles and skin of the back of the neck and head. The ventral branches of C1-4 form the cervical plexus. These nerves emerge from the intervertebral foramina and then lie on the transverse processes and scalenous medius muscle covered by the prevertebral fascia. Lateral to the transverse process, these cervical nerves are in a fascial space derived from the fascia of the muscles attached to the tubercles of the transverse processes. This space is continuous with the interscalene fascial plane and inferior to it, allowing for a single injection to anesthetize the plexus.

The anterior primary rami of C2-4 form three loops, which are referred to as the cervical plexus. This plexus lies behind the sternomastoid muscle, giving off superficial and deep branches [1]. The superficial branches innervate skin and superficial tissues in the head, neck, and shoulder. The four branches of the superficial cervical plexus are the lesser occipital, the great auricular, the transverse cervical, and the supraclavicular nerves (Fig. 3) [2]. Cervical plexus block is useful for many surgical procedures of the anterior neck, lateral neck, and supraclavicular fossa (Box 1).

Anatomical landmarks for accessing the cervical plexus include the tip of the mastoid process of the temporal bone and the anterior tubercle of C6 transverse process at the level of the cricoid arch. To achieve superficial cervical plexus block, the midpoint of the sternomastoid muscle at the posterior border is identified. The needle is inserted subcutaneously behind and deep to the sternomastoid muscle with 5 mL of local anesthetic injected.
Also, 5 mL of local anesthetic is injected from this point going superiorly, and 5 mL of local is directed inferiorly [3].

Deep cervical plexus block is most commonly accomplished by way of a lateral approach rather than a posterior one. Traditionally, three needles are inserted at the C2-4 levels [4]. However, a single injection technique has become more popular for producing blockade of the deep cervical plexus. A single needle is placed at the C4 level behind the sternomastoid muscle and directed slightly cephalad toward the C4 process. In the adult patient, the C4 transverse process is located approximately 3 cm below C2, which is 1 to 2 cm below the mastoid process. The volume of local anesthetic required to block C2-4 using this approach is 10 to 15 mL [5]. Cervical plexus block combined with laryngeal nerve block and subfascial infiltration produces good regional anesthesia for neck surgery (Fig. 4).

The practitioner must use care to avoid local anesthetic injection into the subarachnoid space, epidural space, the vertebral artery, and the pleura of the lung. Aspiration before injection is always advocated. The development
of brachial plexus anesthesia on the side opposite the block may indicate developing epidural or spinal anesthesia.

**Occipital nerve block**

The sensory innervation of the posterior head and neck comes from the second and third cervical nerves. The lateral section of the posterior scalp is supplied by the lesser occipital and great auricular nerves (Fig. 5). Once the mastoid process, the greater occipital protuberance, and the superior nuchal line have been identified, the practitioner can palpate the occipital arterial pulse which is located one third of the distance from the greater occipital protuberance toward the mastoid [6]. The needle is then placed medial to the artery along this plane and 3 to 5 mL of local anesthetic is injected to achieve the block.

**Trigeminal blocks**

The trigeminal nerve is the largest of the cranial nerves (Fig. 6), containing sensory and motor fibers. General somatic afferent nerve fibers carry sensory impulses from the face (Fig. 7). Somatic impulses, including thermal, touch, and pain, are transmitted from the skin of the face and forehead, mucous membranes of the nasal surfaces and oral cavity, the teeth, the anterior two-thirds of the tongue, and anterior portions of the cranial dura. Proprioceptive impulses are carried from the teeth, periodontium, hard palate, and temporomandibular joint. The trigeminal nerve is involved in carrying afferent impulses from stretch receptors in the muscles of mastication. Additionally, visceral efferent fibers innervate the muscles of mastication, the tensor tympani and tensor veli palatine muscles, muscles of the eye, and facial muscles.
First division trigeminal/orbital blocks

Block of the supratrochlear and supraorbital nerves is useful for forehead surgical procedures. Additionally, these blocks may provide relief of neuralgias and headaches in the distribution of the ophthalmic nerve. The supraorbital nerve traverses through the supraorbital foramen, which lies approximately 2 to 3 cm lateral to the midline of the face at the inferior edge of the supraorbital ridge. The supratrochlear nerve exits the orbit between the trochlea and the supraorbital foramen to innervate the lower part of the forehead. To block the supraorbital nerve, a short, small-gauge needle is advanced perpendicular to the skin toward the supraorbital notch with injection of 1 to 2 mL of local anesthetic once paresthesia is obtained or the foramina encountered. Caution should be used not to auger the needle into the foramina to avoid potential nerve damage. To block the supratrochlear nerve, a short, small-gauge needle is advanced medial to the supraorbital notch. Again, the block is obtained with 1 to 2 mL of local anesthetic.

Orbicularis oculi muscle block results in eyelid paresis. This block is common with intraocular surgery to prevent blepharospasm. Local anesthetic is infiltrated at the lower lateral angle of the inferior orbital
margin along the lateral margin of the orbit and along the inferior orbital margin.

Retrobulbar block is performed by needle entry through the lower eyelid at the lower lateral angle of the orbit. The needle is advanced to enter at the lower lateral angle of the orbit and directed toward the apex of the orbit. As the ciliary ganglion is located deep in the orbit lateral to the optic nerve and lateral to the rectus muscle, the adult needle depth in the adult patient from the skin should not exceed 3.5 cm to avoid puncturing the blood vessels in the apex of the orbit [7]. A local anesthetic volume of 2 to 4 mL provides satisfactory regional anesthesia.

Second and third division trigeminal blocks

Extraoral maxillary and mandibular blockade

Intraoral injections to achieve nerve blockade of the maxillary and mandibular branches are the trigeminal nerves are commonly performed by the dental profession. However, obtaining definitive regional anesthesia of these branches of the trigeminal nerve can be more easily obtained by using the lateral extraoral approach. The needle enters the skin at the point of intersection of the lower border of the zygoma and the anterior border of the mandibular ramus through the coronoid notch. For blockade of the maxillary nerve, the needle is directed slightly upward, forward, and
medially until it meets the greater wing of the sphenoid. For blockade of the mandibular nerve, the needle starts at the same place on the skin as the maxillary extraoral block. After the needle contacts the lateral pterygoid plate, it is withdrawn and reinserted upward and slightly posterior until a paresthesia is noted or the needle has reached a depth of 5 cm. Though the anterolateral approach is a consideration for maxillary nerve blockade, the lateral approach appears to offer more consistent nerve blockade (Fig. 8).

The maxillary, second division of the trigeminal nerve is a sensory nerve. It exits the skull through the foramen rotundum, enters the pterygopalatine fossa extending into the inferior orbital fissure and then to the oral cavity. It exits in the front of the maxilla by the infraorbital foramen. The posterior
superior alveolar and zygomatic nerves originate in the pterygopalatine fossa. The maxillary nerve branches into the infraorbital nerve at the infraorbital fissure.

*Infraorbital block*

The infraorbital foramen is approximately 2 to 3 cm lateral to the midline of the face. It emerges from the infraorbital foramen and dives into four branches: the inferior palpebral, the external nasal, the internal nasal, and the superior labial. These branches innervate the lower eyelid, lateral inferior portion of the nose and vestibule, and the upper lid and mucosa. The anterior superior alveolar nerve branches from the infraorbital nerve in the anterior part of the infraorbital canal and innervates the maxillary incisor and cuspid teeth.

The extraoral approach to this nerve is the preferred access for nerve blockade. The infraorbital ridge of the maxillary bone is located and the infraorbital foramen palpated approximately 2 cm from the lateral surface of the nose. The anterior portion of the canal in the orbit is typically covered.
with a thin plate of bone, so the needle should start 0.5 cm below and slightly medial to the foramen to allow for the backward and upward slant of the infraorbital canal. The needle must be advanced past the opening of the infraorbital canal so that the anterior superior alveolar nerve is not blocked. However, the needle should not be advanced more than 0.5 cm past the entry into the infraorbital foramen. A volume of 1 to 3 mL of local anesthetic is sufficient for nerve blockade.

**Nasopalatine block**

This injection provides soft tissue palatal anesthesia or to supplement anesthesia of the nasal passages (Fig. 9). The needle is advanced 0.5 cm intraorally into the incisor canal behind the maxillary incisors. As the palatal tissues are not highly elastic, the practitioner should slowly inject 0.25 to 0.5 mL of local anesthetic for the blockade.

**Sphenopalatine block**

The sphenopalatine ganglion (pterygopalatine, nasal, or Meckel’s ganglion) is one of four autonomic ganglia in the head. The ganglion is a 5 mm triangular structure comprising the largest group of neurons in the head, except for the brain. Major branches of the trigeminal nerve, facial nerve, carotid plexus, and superior cervical ganglion arise from the sphenopalatine ganglion. Nerve blockade is obtained by application of topical anesthetic to the upper posterior wall of the nasal pharynx and the upper border of the middle turbinate at the sphenoid. Transnasal injection of 5 to 10 mL of local anesthetic to this region may also be performed for the blockade (Fig. 10).
Anterior approach to trigeminal ganglion by way of the foramen ovale

A more complex block to anesthetize any of the three trigeminal nerve divisions involves placing the needle through the foramen ovale into the gasserian ganglion (Fig. 11). The subzygomatic approach to the trigeminal nerve ganglion is optimized by use of fluoroscopy to guide the needle into the foramen ovale. A nerve stimulator is often used to differential the exact portion of the nerve the practitioner desires to block. This approach is often used for treatment of chronic trigeminal neuralgia and intractable cancer pain in patients that are refractory to aggressive pharmacological pain management. Longer nerve block duration may be obtained with use of radiofrequency or neurolytic gasserian ganglionotomy. The first division of the trigeminal nerve is most medial and deepest within the foramen. The second division is centrally located and intermediate in depth. The third division is most lateral and superficial.

Trigeminal neuralgia therapy with gamma knife radiosurgery

Because of the unique therapy offered by gamma knife surgery (GKS) and the contemporary nature of the device, the background and current considerations for the management of trigeminal neuralgia by GKS should be discussed. The revolution of sophisticated software and computer technology combined with advanced radiation physics has produced a new
tool for the successful treatment of many neurologic conditions, including trigeminal neuralgia. The gamma knife is not a knife but a complex machine that uses cobalt-60 to provide the energy for cutting. It is able to focus a precise intersection of 201 beams of gamma rays to perform radiosurgery. The evolution of high-resolution CT and MRI scans coupled with computer technology permits targets to be clearly defined. Currently, there are 120 gamma knife surgery (GKS) centers around the world and 45 in North America. Arteriovenous malformations, brain metastases, acoustic nerve tumors, meningiomas, and other benign brain tumors can be managed with the gamma knife. Certain functional disorders, such as intractable pain, seizures, the tremors and rigidity of Parkinson’s disease, and certain psychoneuroses, have responded to gamma knife radiosurgery. Of special interest to health professions treating patients with head and neck pain is the use of the gamma knife in the treatment of trigeminal neuralgia.

Several options exist for the treatment of trigeminal neuralgia. Medical therapy with carbamazepine, phenytoin, and gabapentin has provided good first-line treatment [8–11]. Microvascular decompression, glycerol rhizotomy, radiofrequency rhizotomy, and nerve section have proven effective surgical options [12,13]. Currently, GKS has become a good option for patients unresponsive to medical therapy. Recent advances in imaging and increased experience with this procedure support the value of GKS as a treatment for trigeminal neuralgia.
In 1951, Lars Leksell, the inventor of the gamma knife, was the first to use radiosurgery for the treatment of functional disorders such as trigeminal neuralgia. Using a conventional stereotactic frame, he aimed the radiation beam produced by an orthovoltage x-ray tube at the trigeminal ganglion [14]. Over the next 40 years, poor imaging, poor target fixation, and the choice of the gasserian ganglion as the target brought less than satisfactory results [15,16]. In 1996 a multicenter study coordinated by the University of Pittsburgh rekindled interest in the radiosurgical treatment of trigeminal neuralgia [17]. In this study, the proximal trigeminal nerve near the pons, rather than the ganglion in Meckel’s cavity, was chosen as the target. This permitted direct visualization of the nerve proper to be treated. High-resolution MRI permitted accurate targeting. With this modification, 94% of the patients in the study showed resolution or significant decrease of their pain. Many authors have since reported similar results [18–21]. Success rates are similar to other interventional procedures. Complications are primarily limited to facial numbness, which occurs at a frequency of less than 10%.
GKS is now being used as a safe alternative to traditional surgery and as first-line therapy for trigeminal neuralgia.

Procedure planning is performed by a multidisciplinary group. The expertise of a neuroradiologist, radiation oncologist, medical physicist, and neurosurgeon are combined to provide optimal treatment. GKS is a four-step procedure. The patients are first fitted with the Leksell stereotactic headframe. Because neurophysiologic feedback is not a component of the targeting procedure, high-quality and accurate imaging is necessary. High-resolution images of the target and the surrounding structures must be obtained. MRI is the neurodiagnostic modality of choice. Gadolinium enhanced T1-weighted MRI with magnetization-prepared rapid gradient echo, T2-weighted fast spin-echo sequences and other MRI algorithms are used. Long-Tr MR sequences can be used in adjunct to contrast the nerve against the high-signal CSF background. The trigeminal nerve is identified in coronal, axial, and sagittal planes on its course from the brainstem to Meckel’s cavity. For patients with pacemakers, metallic foreign bodies, or other contraindications to MRI, high-resolution computerized topography with contrast cisternography can be used [22]. The ElectaLeksell gamma knife unit with cobalt-60 sources is used to irradiate the target. The trigeminal nerve is targeted at the location of an imaged vascular compression or at the site of the trigeminal nerve exit from the pons if no compressing vessel is identified. The effectiveness of treatment at this exit zone is thought to be due to the proximal nerve being covered by oligodendrocyte myelin, which is more radiosensitive than the distal swan-cell myelin, or because of concomitant irradiation to the dorsal root entry zone at the brainstem. Care is taken to protect the brainstem from radiation exposure, which presents minimal difficulty because of the precision of the gamma knife system. Target doses range from 65 to 100 Gy, with a mode of 70 to 90 Gy. Old age and multiple sclerosis are criteria for the lower doses. Higher doses are used for patients with a history of previous trigeminal surgeries. A dose of 80 Gy is effective in 90% of patients, with the risk of partial facial numbness at less than 10%, and a risk of anesthesia dolorosa under 1% [23]. The entire procedure is performed under local anesthesia with sedation.

The exact mechanism of GKS pain relief is not known. The majority of patients report an immediate decrease in the intensity of the pain even if the attacks still occur. This is postulated to be the result of an immediate interruption of ephaptic transmission. Several weeks later there is classically complete cessation of the attacks. This is probably secondary to delayed demyelination injury to the nerve. Regis et al [24] have speculated that gamma knife irradiation has a differential effect on myelinated and unmyelinated fibers, allowing for control of pain without dysesthesia. This is not supported by the recent finding of Kodziolk at al [25]. They performed histologic analysis of two baboons treated with gamma knife. They targeted the trigeminal nerve just anterior to the pons and used doses in the 80 to 100 Gy range. All irradiated nerves exhibited axonal
degeneration with remnants of some myelinated axons. Myelinated and unmyelinated fibers were affected. Nerve necrosis was identified with the 100 Gy treatment. The pathohistologic changes of lower doses are not known, and further studies are needed. Young et al reported a 74.5% rate of complete relief, and a 95.5% response rate [26,27]. In their multicenter study published in 1996, 60% of the patients became pain-free and required no further medical therapy, 17% had a 50% to 90% reduction in pain, and 9% had slight pain improvement [19,21,28]. Of those that attained complete relief, only 10% developed a relapse of their pain. Similar high response rates and long-term pain relief have been found by several other authors.

The effectiveness of the treatment is confounded by the type of neuralgia. Additional studies found that the highest response rate was for essential neuralgia (77%) followed by neuralgia with multiple sclerosis (43%), postherpetic neuralgia (38–44%), and atypical neuralgia (33%) [29,30]. Patients with atypical symptomatology or those with prior surgical procedures, have lower initial and long term response rates [27]. In a study of 172 patients, Brisman found that those treated with gamma knife as primary management had better outcomes than those treated as secondary treatment. Thus, GKS may be considered for first-line treatment in some patients. The overall response rate with gamma knife compares favorably with that of other surgical modalities. This gains support when the practitioner considers that most patients undergoing GKS present with having failed medical and surgical treatment and present a challenge.

Side effects of GKS are limited primarily to facial paresthesias or sensory loss. In most reports the rate of such complications is less than 10%. In the 1996 Young et al multicenter trial, 6% of patients developed increased paresthesia after the procedure [26,27]. Nicol et al found that higher doses (90 Gy) might be associated with increased rates of paresthesia (16.7%) and dysgeusia (9.5%) [31]. The overall rate of facial paresthesia is slightly higher than MVD but substantially lower than the 60% to 80% quoted for percutaneous procedures [32,33]. Unlike traditional surgery, though, GKS does not carry the increased risk of infection, anesthesia complications, hematoma formation, CSF leak, facial weakness, hearing loss, and brainstem injury. Serious side effects are rare, no hospital stay is usually required, treatment is accomplished in one session, and patients may return in a short time to normal activities.

**Glossopharyngeal block**

The glossopharyngeal nerve is the ninth cranial nerve. It exits through the intermediate compartment of the jugular foramen. It then runs between the internal carotid artery and internal jugular vein and travels around the stylopharyngeus muscle deep to the styloid process and goes toward the pharynx and the tongue. The nerve supplies motor fibers to the pharyngeal muscles and sensory fibers to the middle ear, posterior third of the tongue, and
the pharynx. It innervates the carotid sinus and carotid body. It is important to remember the close proximity of the glossopharyngeal nerve to the vagus nerve, accessory nerve, and the sympathetic trunk. In the adult patient, a 3-inch needle is required to perform this block. The practitioner must gently contact the styloid process with the needle entering the skin at a point midway between the angle of the mandible and the mastoid process. Once the styloid process has been identified, the needle is withdrawn and redirected anterior to the styloid process at a depth 0.5 cm further than when the styloid was identified. Then, 2 to 3 mL of local anesthetic is deposited for the blockade.

**Stellate ganglion/cervicothoracic ganglion sympathetic block**

The stellate ganglion is located between the anterolateral surface at the seventh cervical vertebral body and the neck of the first rib. The
The cervicothoracic ganglion is a continuation of this autonomic chain and located at the sixth cervical vertebral body. The cervicothoracic ganglion is formed by the joining of the most inferior cervical and the first thoracic sympathetic ganglia (Fig. 12). This block has several indications for the diagnosis and management of chronic pain conditions (Box 2).

Typically, this block is performed at the C6 level, which reduces needle entry to the vertebral artery and the lung. The cervicothoracic ganglion is located at the sixth cervical vertebral body and is formed by the joining of the most inferior cervical and the first thoracic sympathetic ganglia.

**Box 2. Stellate/cervicothoracic ganglion block indications**

- Complex regional pain syndrome (CRPS) Type 1 (reflex sympathetic dystrophy)
- Complex regional pain syndrome (CRPS) Type 2 (causalgia)
- Neuropathic pain states (postherpetic neuralgia)
- Raynaud’s disease
- Vascular occlusion or impaired circulation
- Scleroderma and arteriopathies
- Occlusive vascular disease

![Fig. 13. Cervicothoracic ganglion paratracheal approach block. Transverse section at the C6 level showing the needle medial to the finger, which is retracting the carotid artery laterally.](image-url)
formed by the joining of the most inferior cervical and the first thoracic sympathetic ganglia. This block has several indications for the diagnosis and management of chronic pain conditions (see Box 2).

The anterior paratracheal technique is commonly used. Local anesthetic concentration can be reduced, as autonomic nerves (C-fibers) are small with no myelin. Lidocaine 0.5% or bupivacaine 0.25% is effective. Needle placement for the cervicothoracic ganglion block requires the patient to be supine with the needle inserted vertically at 90 degrees between the cricoid cartilage and the carotid artery to touch the anterior tubercle on the transverse process of C6 (Fig. 13). A 10-mL dose of local anesthetic is required for sympathetic blockade. Careful aspiration before injection is mandatory because injection of only a small volume of local anesthetic into the vertebral artery can lead to immediate convulsion, blindness, and loss of consciousness [34]. This block will interrupt sympathetic outflow to the face, head, neck, and upper extremity.

Summary

Regional anesthesia of the head and neck is an effective method of obtaining surgical anesthesia for various procedures. Diagnostic and therapeutic head and neck blocks can also assist with the diagnosis and management of many chronic pain conditions, including headache, postherpetic neuralgia, and cancer pain in this region. Gamma knife surgery offers a unique approach to the management of refractory trigeminal neuralgia. Because of the proximity of so many critical structures adjacent to these nerves, a solid understanding of the anatomical basis of these nerve blocks is necessary. Appropriate patient selection, monitoring, proper injection technique, knowledge of the pharmacokinetics and pharmacodynamics of local anesthetics and vasoconstrictors, possible drug interactions, and recommended doses will ensure safe and successful application of head and neck nerve blockade.

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