

Below we examine the strengths and weaknesses of the various imaging modalities used for diagnosis in the head and neck.

**CT** (American College of Radiology) is sensitive for benign and malignant paranasal sinus pathology. It is also excellent for lymphadenopathy and evaluating bone invasion from malignancy. It has proven to be superior for the work-up of distant metastasis. CTA should be used for carotid and vertebral dissection, while PET/CT is the most sensitive in the work-up for cancer.

**MRI** (American College of Radiology) demonstrates superior soft tissue contrast in the head and neck while capable of distinguishing between neoplastic, inflammatory, and obstructive processes in nasal cavity tumors. It is sensitive for trigeminal neuralgia (neurovascular compression for cranial nerve V root entry zone). The migraine phenomenon may be demonstrated in the brain. It is more sensitive for infection than CT, including herpes zoster ophthalmicus. Moreover, it is superior to CT in evaluating the tongue/oral cavity, palate and intracranial extension from the skull base, as well as for detecting malignant perineural and intracranial invasion. MRA can demonstrate carotid and vertebral artery dissection (mimics cluster headache).

**Angiography** is useful in the evaluation of carotid and vertebral dissection if CTA or MRA is inconclusive. Pseudoaneurysm can be detected as a complication.

**PET** (American head and Neck Society; Coleman): PET/CT is used for the work-up of suspected malignancy with negative CT or MRI. FDG identifies a primary cancer in 20–40% of patients who present with metastatic disease in the neck with an unknown primary tumor. PET and CT have similar accuracy in the initial staging of nodal disease. PET is more accurate

than CT or MRI in detecting recurrent tumor (study of choice for follow-up). It is sensitive for staging neck cancer, unknown primary, distant metastasis, and response to therapy. However, it is limited by tumor size to less than 3–4 mm. Moreover, it may provide false positive results in inflammation, muscular activity, and healing bone. A thorough understanding of artifacts is required.

**Ultrasound** is useful in characterizing palpable masses (thyroglossal duct cysts, branchial cysts, cystic hygromas, salivary gland tumors, abscesses, carotid body tumors, vascular tumors, and thyroid masses). It is also capable of characterizing vascularity in real-time and in duplex mode.

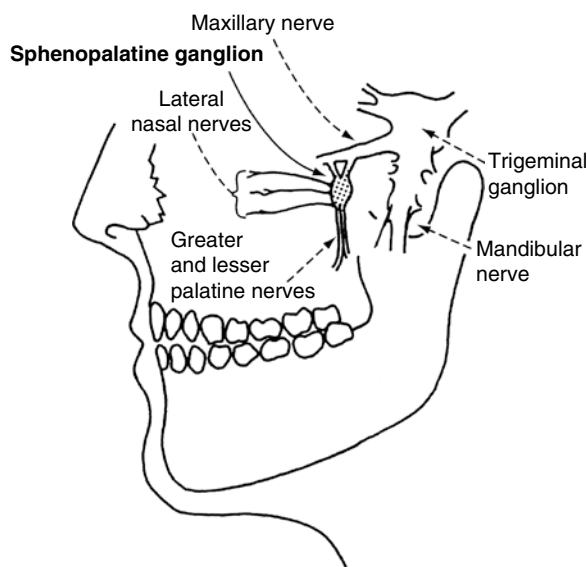
## 2.1 Sphenopalatine Nerve Block

### 2.1.1 Anatomy

The sphenopalatine ganglion is the largest collection of neurons exterior to the cranium in the head. The ganglion is positioned within the pterygopalatine fossa. It has a complex of nerves attaching to it (Fig. 2.1).

The ganglion hangs from V2 via the pterygopalatine nerves. The vidian nerves (composed of greater and lesser petrosal nerves) project posteriorly, which travel through the pterygoid canal. The vidian nerve contains sympathetic fibers from the superior cervical ganglion, which pass through the sphenopalatine ganglion into the lacrimal gland and nasal/palatine mucosa.

The greater and lesser palatine nerves extend inferiorly from the ganglion. The superior posterior lateral nasal and pharyngeal nerves also emanate from the ganglion.



**Fig. 2.1** Anatomy of the sphenopalatine ganglion and its immediate connections (Raj et al.)

The parasympathetic innervation arises in the superior salivatory nucleus. It then courses through the facial nerve to constitute the greater petrosal nerve. The greater petrosal nerve combines with the deep petrosal nerve to become the vidian nerve. The vidian nerve terminates in the sphenopalatine ganglion and then post ganglionic fibers supply nasal mucosa and V2 on route to the lacrimal gland.

The pterygopalatine fossa is a small cavity through which many important structures are associated. V2 travels through the foramen rotundum which is located at the upper, medial, and posterior portion of the fossa. The vidian nerve courses through the pterygoid canal at the lower lateral and posterior portion of the fossa. The maxillary artery is contained within the fossa.

The ganglion is separated from the nasal cavity by a thin layer of lateral nasal mucosa at the posterior aspect of the middle turbinate (sphenopalatine foramen). The ganglion communicates to the oral cavity via the greater palatine canal, which contains the greater and lesser palatine nerves. The ganglion communicates to the cranial cavity through the pterygoid canal, foramen rotundum, and foramen lacerum.

The roof of the pterygopalatine fossa is the sphenoid sinus, the outer border is the infratemporal fossa,

the inner border is the palatine bone, and the anterior border is the maxillary sinus.

### 2.1.1.1 Function

It is a parasympathetic terminal ganglion. Preganglionic parasympathetic fibers from the greater petrosal nerve (of the facial nerve CNVII) via the vidian nerve synapse at the ganglion. Postganglionic sympathetic axons arrive via the vidian nerve from the deep petrosal nerve and pass through the ganglion without synapsing.

The postganglionic parasympathetic axons exit via the greater and lesser palatine nerves, nasopalatine nerve, sphenopalatine nerves, and zygomatic nerves.

It provides secretomotor innervation to the mucous glands of the palate, nasal cavity, lacrimal gland, and the mucosa of the nasopharynx posterior to the auditory tube.

### 2.1.1.2 Injection Site

There are various approaches that are used including: a lateral approach (discussed below only) including suprazygomatic and infrazygomatic arch approach, intranasal topical application to the back of the nasal pharynx along the middle turbinate, and the greater palatine foramen approach.

## 2.1.2 Cross-Sectional Anatomy: Lateral Approach

### 2.1.2.1 What Does the Needle Traverse?

The needle traverses the structures within the infratemporal fossa (infrazygomatic masticator space) prior to entering the pterygopalatine fossa as its final destination (applies to the infrazygomatic approach). The path is just superior to the coronoid process of the mandible. Alternatively, a transnasal or transoral approach (using the pterygopalatine canal to enter the sphenopalatine foramen) can be used. The structures

traversed within the infratemporal fossa (within the infrazygomatic masticator space) include (Figs. 2.5–2.6):

- Superficial layer of the deep cervical fascia
- Masseter muscle
- Temporalis muscle/tendon
- Lateral pterygoid muscle
- Pterygoid venous plexus (Harnsberger et al. 2006a)
  - Located both medial and lateral to the lateral pterygoid [<http://www.emory.edu/ANATOMY/AnatomyManual/fossae.html>]
- Retromaxillary fat pad (Buccal space)
- Internal maxillary artery (Harnsberger et al. 2006b)
  - Travels anteromedially within the masticator space lateral to the pterygoid muscle to end up within the pterygopalatine fossa
- Pterygopalatine fossa (Harnsberger et al. 2006c)
  - Communicates with the masticator space via the pterygomaxillary fissure between the maxilla and lateral pterygoid plate

### 2.1.2.2 Which Structures the Needle Should Avoid

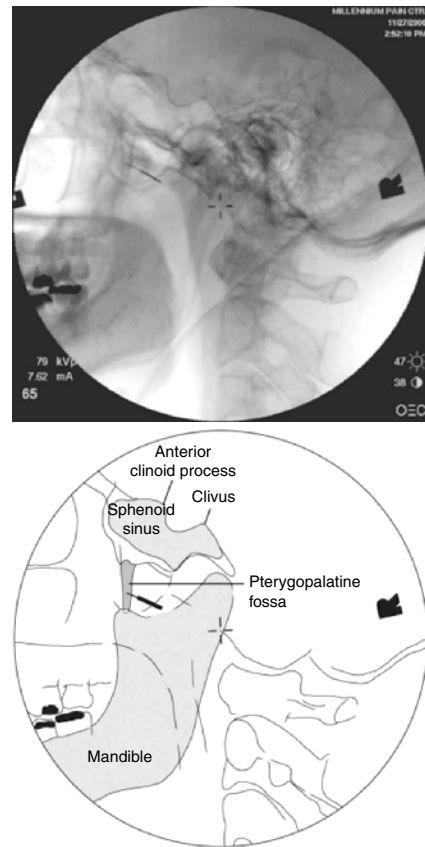
*Pterygoid venous plexus:* This is a prominent venous plexus medial and lateral to the surface of the lateral pterygoid muscle. It may be difficult to avoid; however, it is a venous structure and therefore under low pressure for potential hematoma formation.

*Maxillary artery:* The artery travels from its origin within the parotid gland through the masticator space anteromedially on the lateral aspect of the lateral pterygoid (usually) to terminate in the pterygomaxillary fissure as the sphenopalatine artery. It may be difficult to purposefully avoid puncture unless a blunt-tipped needle is used in the infrazygomatic approach.

*Inferior orbital fissure:* If the needle is advanced too far the orbital structures including the globe can be punctured.

### 2.1.2.3 Imaging/Radiology

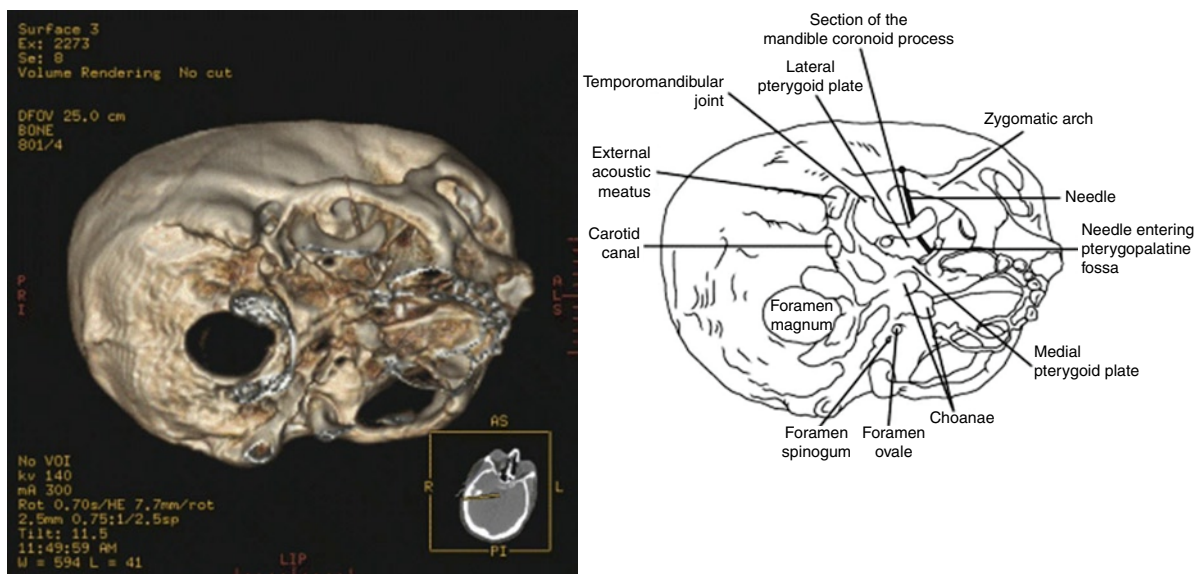
CT and fluoroscopic approaches can be combined (Vallejo et al. 2007) (Figs. 2.2–2.6).



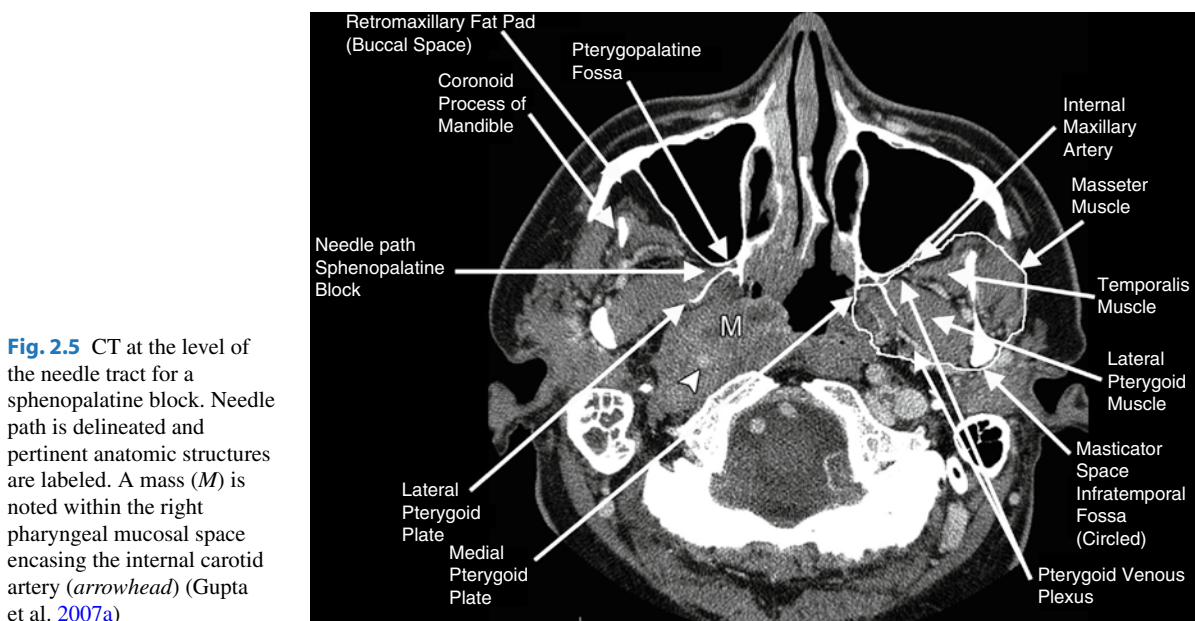
**Fig. 2.2** Lateral fluoroscopic view, with the mandibles aligned, the pterygopalatine fossa is seen as an “inverted vase,” with the needle inside



**Fig. 2.3** AP fluoroscopic view with the tip of the needle at the lateral wall of the nose



**Fig. 2.4** Reconstructed CT image showing the needle inside the pterygopalatine fossa (Vallejo et al. 2007)



**Fig. 2.5** CT at the level of the needle tract for a sphenopalatine block. Needle path is delineated and pertinent anatomic structures are labeled. A mass (*M*) is noted within the right pharyngeal mucosal space encasing the internal carotid artery (arrowhead) (Gupta et al. 2007a)

### 2.1.3 Indications

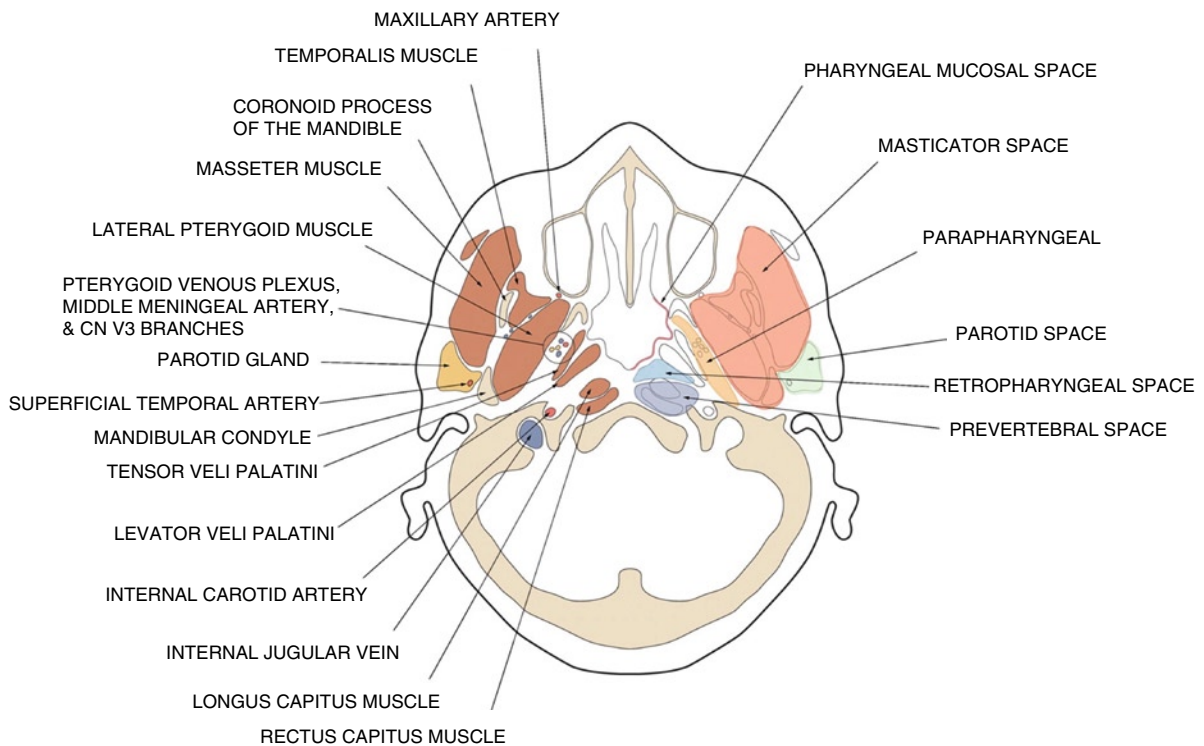
The following are common indications for intervention in the head and neck:

- Sphenopalatine neuralgia – Sluder's (sphenopalatine) neuralgia is pain of the eyes and nose, with radiation to the ear. The greater superficial petrosal nerve (GSPN) is most likely the pathway along

which this pain radiates to the ear. It is crucial to exclude benign and malignant sinus disease before making the diagnosis of (idiopathic) sphenopalatine neuralgia (Weissman 1997).

- Paranasal sinus infection\*\* – Causing irritation of the sphenopalatine ganglia (SPG) – disputed.
- Intranasal deformities\*\* – deviated septum, septal spurs and prominent turbinates.
- Vasomotor syndrome.



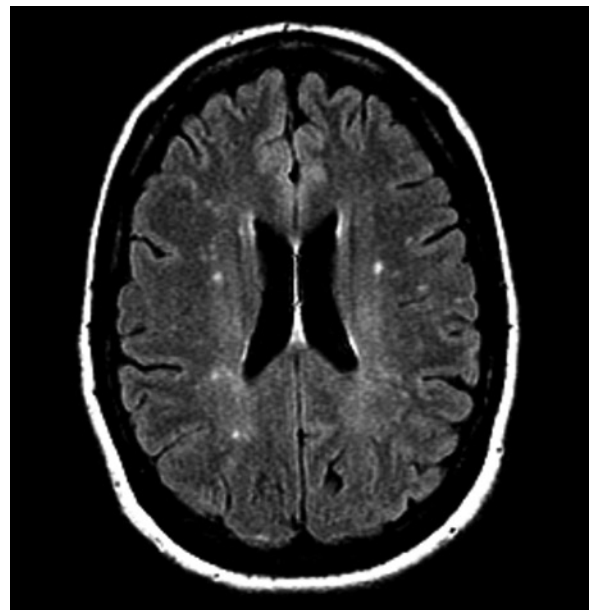


**Fig. 2.6** Axial cross-sectional anatomy at the level of the upper maxillary antrum. Anatomic structures are shown on the *left side* of the diagram; spaces are shown on the *right side*. CN cranial nerve (Gupta et al. 2007a)

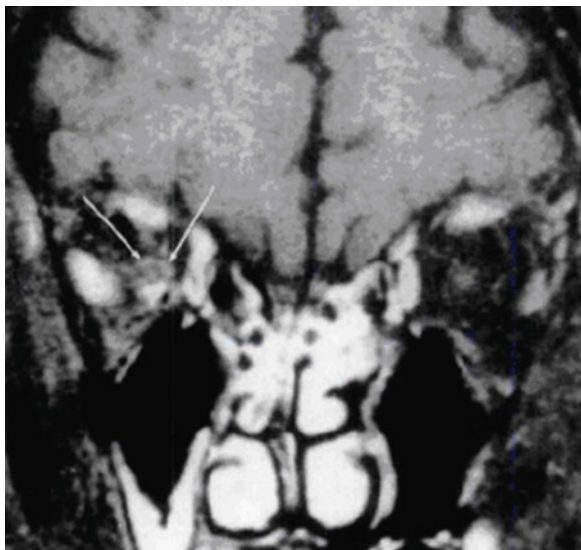
- Trigeminal neuralgia.\*\*
- Head and neck cancer\*\* – cancer of the tongue and floor of the mouth (intranasal approach) (Varghese et al. 2002).
- Lethal midline granuloma\*\* (intranasal approach) (Saade and Paige 1996).
- Migraine\*\* (Fig. 2.7) and cluster headaches – imaging is useful in excluding structural lesions that can mimic cluster headache (i.e., herpes zoster, sinusitis, subarachnoid hemorrhage, trigeminal neuralgia, meningiomas of the cavernous sinus, arteriovenous malformations, pituitary adenomas, nasopharyngeal carcinoma, etc) (Sargeant 2007; Mendizabal 2005).
- Atypical facial pain
- Herpes zoster ophthalmicus\*\* (Fig. 2.8)

#### 2.1.4 Contraindications

Contraindications may include invasion of the pterygopalatine space\*\* (contraindication for percutaneous approach, but not for intranasal approach) (Fig. 2.9) (Varghese and Koshy 2001).



**Fig. 2.7** WM increased T2 signal in migraine headache (Fazekas et al. 1992)



**Fig. 2.8** Herpes zoster ophthalmicus in a 68-year-old patient with shingles surrounding the right orbit. Coronal T1-weighted (600/20, two excitations) MR image with gadopentetate dimeglumine and fat suppression shows shaggy, perineural enhancement surrounding right optic nerve (*arrows*). (Reprinted with permission from Tien et al. 1993)

### 2.1.5 Complications

The six main complications include: (1) Infection\*\*;

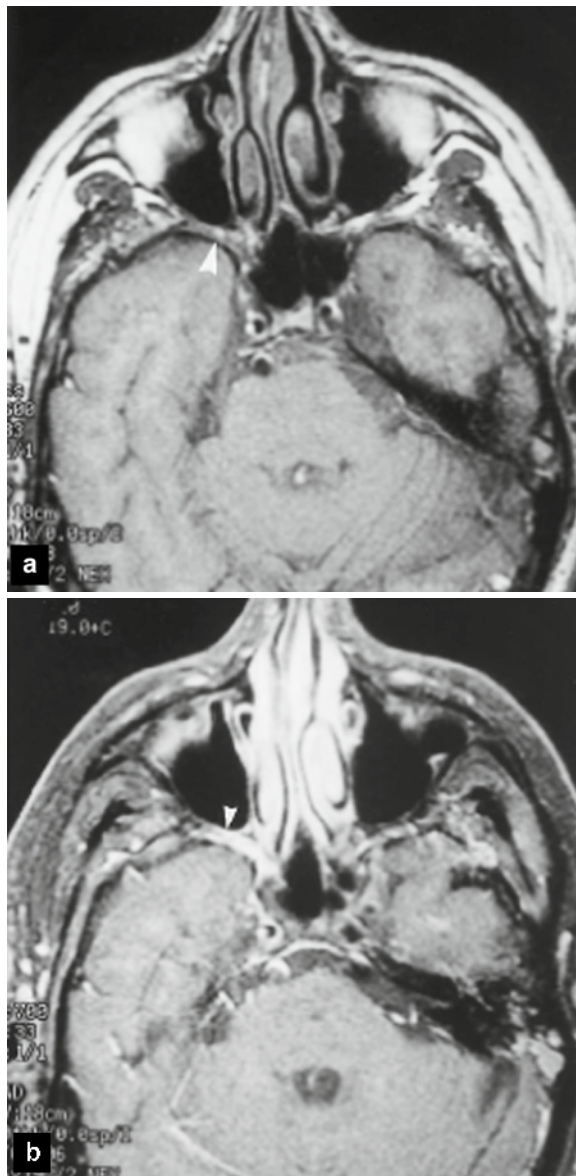
(2) epistaxis\*\* (this can be imaged angiographically if there is an associated pseudoaneurysm); (3) hematoma – large venous plexus overlying the pterygopalatine fossa or the maxillary artery is punctured\*\* (Figs. 2.10–2.11); (4) hypesthesia, dysesthesia or numbness of the palate, maxilla, or the posterior pharynx; (5) blindness due to needle advancement into the inferior orbital fissure; (6) Parotid gland injury.

## 2.2 Maxillary and Mandibular Nerve Block

### 2.2.1 Maxillary Nerve Block (Fig. 2.12)

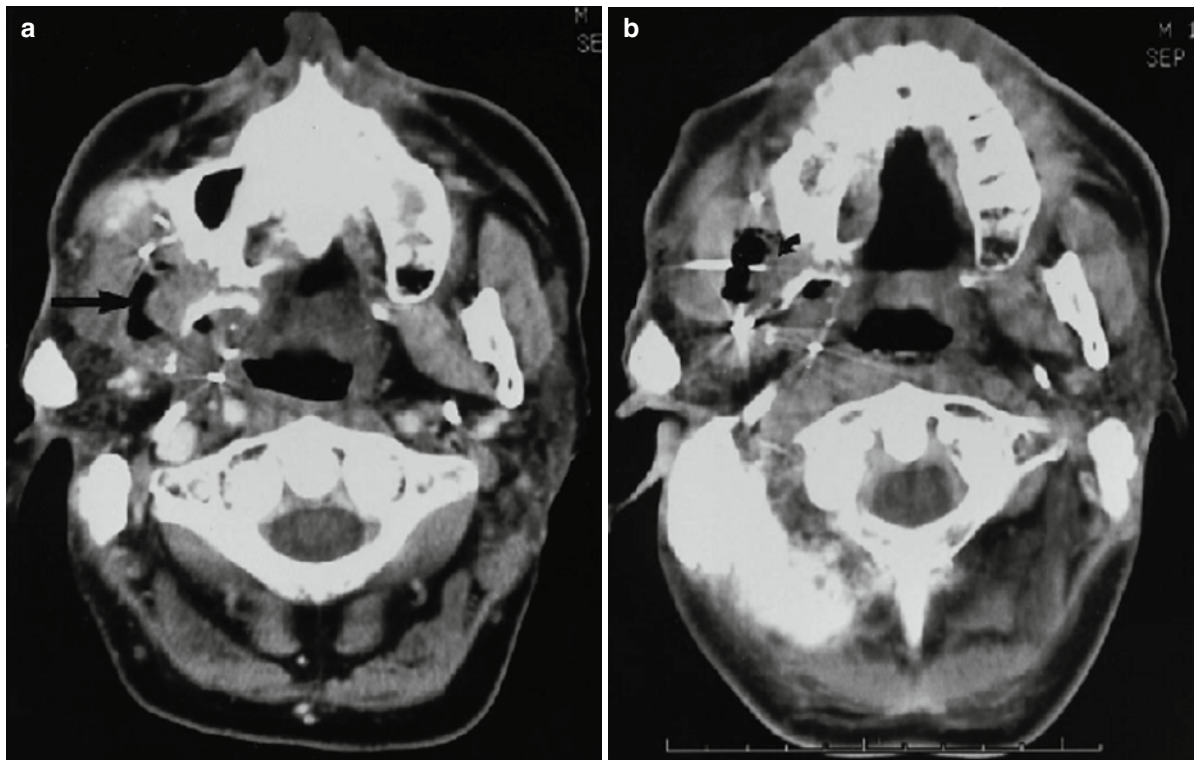
#### 2.2.1.1 Anatomy

The maxillary nerve (V2) originates from the trigeminal ganglion, crosses the cavernous sinus, and exits



**Fig. 2.9** (a) Axial T1-weighted (600/33/2) MR image shows subtle but definite loss of the normal fat signal hyperintensity in the right pterygopalatine fossa (*arrowhead*), representing tumor. (b) Axial postcontrast, fat-suppressed, T1-weighted (700/33/2) MR image shows excessive, abnormal enhancement in the right pterygopalatine fossa (*arrowhead*), representing tumor (Ginsberg and DeMonte 1998)

the foramen rotundum to leave the cranium. It traverses the pterygopalatine fossa and approaches the orbit through the inferior orbital fissure. It then traverses the infraorbital groove and canal at the floor of the orbit. Finally, it enters the face through the infraorbital foramen where it is known as the infraorbital nerve.

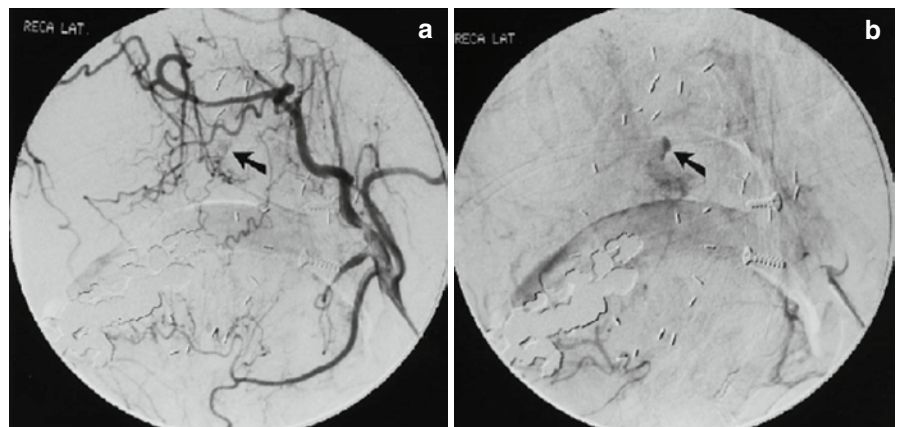


**Fig. 2.10** (a, b) CT-directed fine-needle biopsy. (a) Contrast-enhanced axial CT image shows a focal soft-tissue mass within the masticator space (*arrow*). Gas surrounding the lesion is related to a postsurgical defect that communicates with the oral

cavity. (b) Axial nonenhanced CT image shows the tip of a 22-gauge Chiba needle within the anterior aspect of the soft-tissue abnormality (*curved arrow*). The region was sampled twice

**Fig. 2.11** Histologic analysis showed only inflammatory changes. (a, b)

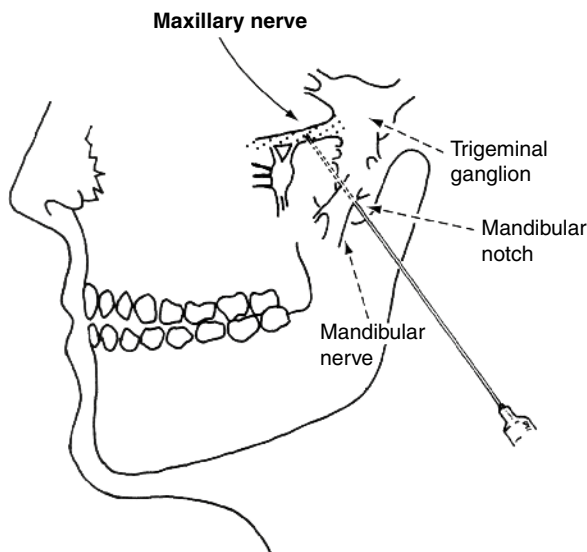
Pseudoaneurysm of the buccal branch of the distal internal maxillary artery. (a) Selective right external carotid arteriogram, lateral projection, shows mild irregularity of the distal internal maxillary artery and focal dilatation of the distal buccal branch (*arrow*). (b) Delayed image from same injection shows filling of a 5-mm pseudoaneurysm (*arrow*) (Walker et al. 1996)



### 2.2.1.2 Function

The maxillary nerve is purely sensory. It supplies sensation to the skin and mucosa between the

palpebral fissure and the mouth, including the upper lip, nose, nasal cavity, sinuses, dura mater, temporal and lateral zygomatic region, and maxillary teeth.



**Fig. 2.12** A patient with the needle on the maxillary nerve entering through the mandibular notch (Waldman 2001a)

### 2.2.1.3 Injection Site

The classic approach for the maxillary block is a lateral approach anterior to the coronoid process of the mandible through the mandibular notch. This block is usually performed using external anatomical landmarks and by eliciting paresthesia (Fig. 2.12).

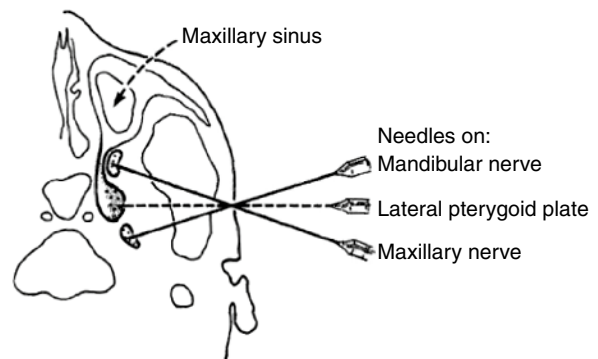
### 2.2.1.4 Cross-Sectional Anatomy

#### What Does the Needle Traverse? Maxillary Nerve

The needle traverses the structures within the infratemporal fossa (infrazygomatic masticator space) prior to entering the pterygopalatine fossa as its final destination (applies to the infrazygomatic approach). The path is just superior to the coronoid process of the mandible (Figs. 2.13–2.14).

A suprazygomatic approach has also been described with the pterygopalatine fossa as the final destination (Fig. 2.15).

Alternatively, a transnasal or transoral approach is used; however, this is predominately performed by oral surgeons (using either the pterygopalatine canal to enter the sphenopalatine foramen or around the maxillary tuberosity).



**Fig. 2.13** Transverse section of the head and face at the level of the mandibular notch showing needle placement on the mandibular nerve, on the lateral pterygoid plate, and on the maxillary nerve. After the pterygoid plate is touched, the needle is slightly withdrawn and pushed posterior until it slips off the pterygoid plate (Raj et al.)



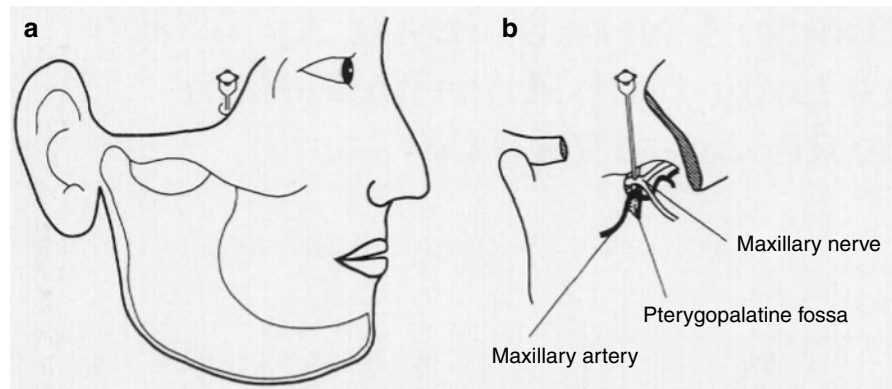
**Fig. 2.14** Axial CT of head. An arrow indicates the needle tip located at the entrance of the pterygopalatine fossa (Okuda et al. 2000)

The structures traversed within the infratemporal fossa (within the infrazygomatic masticator space) include:

- Superficial layer of the deep cervical fascia
- Masseter muscle



**Fig. 2.15** (a) Maxillary nerve block by the suprazygomatic route. A skin wheal is raised just above the superior edge of the zygomatic arch. (b) The needle is in the pterygopalatine fossa (Okuda et al. 2000)



- Temporalis muscle/tendon
- Lateral pterygoid muscle
- Pterygoid venous plexus (Harnsberger et al. 2006a)
  - Located both medial and lateral to the lateral pterygoid [<http://www.emory.edu/ANATOMY/AnatomyManual/fossae.html>]
- Retromaxillary fat pad (Buccal space)
- Internal maxillary artery (Harnsberger et al. 2006b)
  - Travels anteromedially within the masticator space lateral to the pterygoid muscle to end up within the pterygopalatine fossa.
- Pterygopalatine fossa (Harnsberger et al. 2006c)
  - Communicates with the masticator space via the pterygomaxillary fissure between the maxilla and lateral pterygoid plate

pterygopalatine fossa compared to the maxillary nerve. Also, with this approach, there is minimal distance between the point of entry of the needle and the pterygopalatine fossa (see Fig. 2.15).

*Emissary veins from the orbit.*

*CSF space:* The needle should not be advanced farther than 1.5 cm medially past the lateral pterygoid plate.

*Posterior aspect of the orbit/optic nerve:* Avoid by not advancing too cephalad or deeply in the pterygomaxillary fissure to allow entry of injectate into the infraorbital fissure.

*Pharynx:* if the needle is placed too posterior and air is aspirated (Raj et al.).

#### Strengths and Weaknesses of Each Image Guidance Modality

- Fluoroscopy
  - Fast
  - Easy
  - Allows complex angulation
  - May be slightly less accurate and reliable than CT

A reliable block can be difficult because fluoroscopy does not always show the relationship of the pterygopalatine fossa and foramen rotundum (Okuda et al. 2000).

- CT with contrast
  - Accurate
  - Safe
  - Vascular structures can be identified initially under contrast administration
  - Cancer may be avoided reliably compared to fluoroscopic guidance with lateral approach

#### Which Structures the Needle Should Avoid

*Pterygoid venous plexus:* This is a prominent venous plexus medial and lateral to the surface of the lateral pterygoid muscle. It may be difficult to avoid; however, it is a venous structure and therefore under low pressure for potential hematoma formation.

*Maxillary artery:* The artery travels from its origin within the parotid gland through the masticator space anteromedially on the lateral aspect of the lateral pterygoid (usually) to terminate in the pterygomaxillary fissure as the sphenopalatine artery. It may be difficult to purposefully avoid puncture unless a blunt tipped needle or meticulous aspiration is used in the infrazygomatic approach.

A suprazygomatic approach may avoid the maxillary artery more successfully. This is because the maxillary artery is more ventrally positioned in the

- Reliable/more efficacious
- Anatomic variations better visualized
- Complex angulation more difficult
- Slower than fluoroscopy
- Approaches of CT and fluoroscopy can be combined (Vallejo et al. 2007)

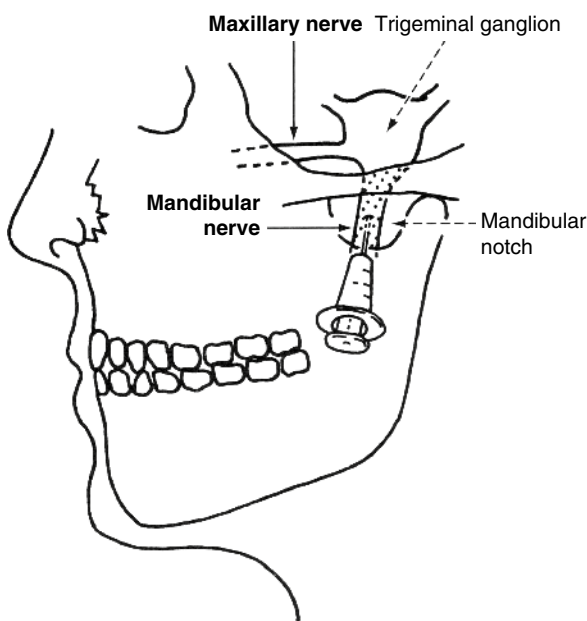
### Strengths and Weaknesses of Each Imaging Modality for Diagnosis (Indications/Contraindications and Complications)

(Please see beginning of Head and Neck section, Chapter 2, page 5 for listing of strengths and weakness of various imaging modalities)

## 2.2.2 Mandibular Nerve Block

### 2.2.2.1 Anatomy

The mandibular nerve ( $V_3$ ) (see Fig. 2.16) is composed of sensory and motor roots. It originates from the



**Fig. 2.16** Point of needle entry in the mandibular notch for extraoral mandibular nerve block (Waldman 2001a)

trigeminal ganglion and exits through the foramen ovale.

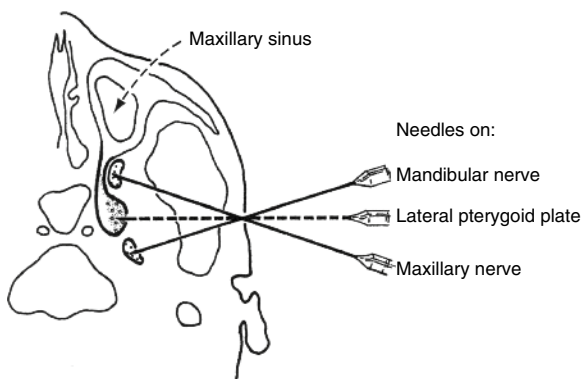
### 2.2.2.2 Function

The mandibular nerve is a combined motor and sensory nerve that innervates:

- Mylohyoid muscle and digastric muscle
- Mucous membrane of the anterior two-thirds of the tongue
- The inside of the cheek (the buccal mucosa)
- Teeth and gums of the mandible
- Skin of the temporal region
- Auricula
- Lower lip and chin
- Muscles of mastication
- The muscles tensor tympani and tensor veli palatini

### 2.2.2.3 Injection Site

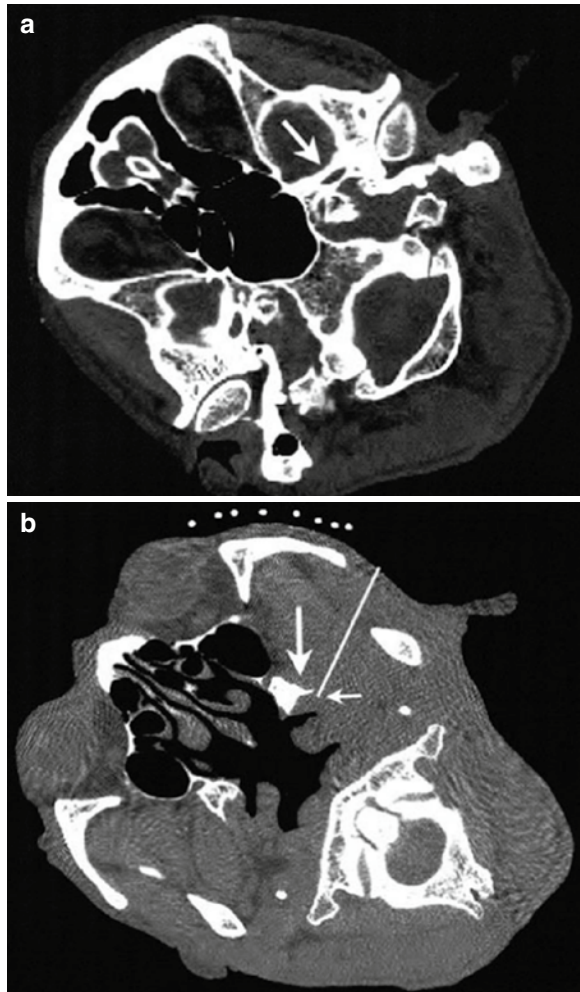
The classic technique involves external landmarks with or without fluoroscopy. The needle is placed through the mandibular notch and is directed posteriorly to the posterior margin of the lateral pterygoid plate (see Figs. 2.16 and 2.17).



**Fig. 2.17** Transverse section of the head and face at the level of the mandibular notch showing needle placement on the mandibular nerve, on the lateral pterygoid plate, and on the maxillary nerve. After the pterygoid plate is touched, the needle is slightly withdrawn and pushed posterior until it slips off the pterygoid plate (Raj et al.)

#### 2.2.2.4 What Does the Needle Traverse? Mandibular Nerve

The needle traverses the same pathway as in the maxillary nerve block until reaching the lateral pterygoid plate. The needle is then directed posteriorly (see Fig. 2.18).



**Fig. 2.18** Axial CT sections of the head. (a) Arrow indicates foramen ovale, which is a landmark to identify the location of nerve exit from the cranium on CT images in this patient. (b) The safest and shortest route (white line) to the target site (small arrow) is determined on the CT image (b, caudal section to a). The mandibular nerve immediately caudal to the foramen ovale in the posterior margin of lateral pterygoid plate (large arrow) is considered to be the target site (Koizuka et al. 2006)

#### 2.2.2.5 Which Structures to Avoid

The same structures should be avoided as in maxillary nerve block, except that there is much less risk of entering the CSF and orbit.

#### 2.2.2.6 Strengths and Weaknesses of Each Image Guidance Modality

Again, the same strengths and weaknesses are seen in image guidance as with the maxillary nerve.

### 2.2.3 Imaging/Radiology for Both Maxillary and Mandibular Nerve Blocks

*Fluoroscopy.* The foramen rotundum may be visualized for the maxillary nerve. The foramen ovale may be visualized for the mandibular nerve.

*CT.* The structure that exits through the foramen rotundum is the maxillary nerve. The structure that exits inferior through the foramen ovale is the mandibular nerve.

*MRI.* This is the procedure of choice for directly imaging the nerve (see Figs. 2.19–2.20) (Barakos et al. 1991).

#### 2.2.3.1 Indications (Waldman 2001a)

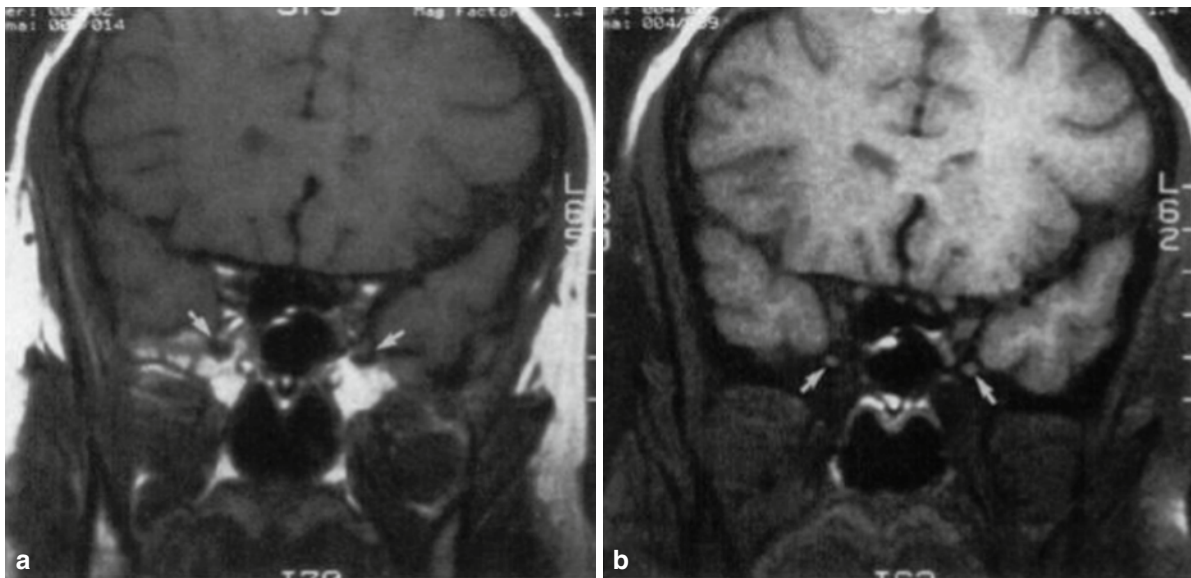
The main indications for imaging/radiology for maxillary and mandibular nerve blocks include: Acute pain emergencies; acute herpes zoster refractory to stellate block\*\* (Fig. 2.22); cancer\*\* (Fig. 2.21); trigeminal neuralgia\*\*; cluster headaches refractory to sphenopalatine (SPG) block; trismus.

#### 2.2.3.2 Contraindications (Waldman 2001a)

A relative contraindication for maxillary or mandibular nerve blocks is altered anatomy due to surgery.

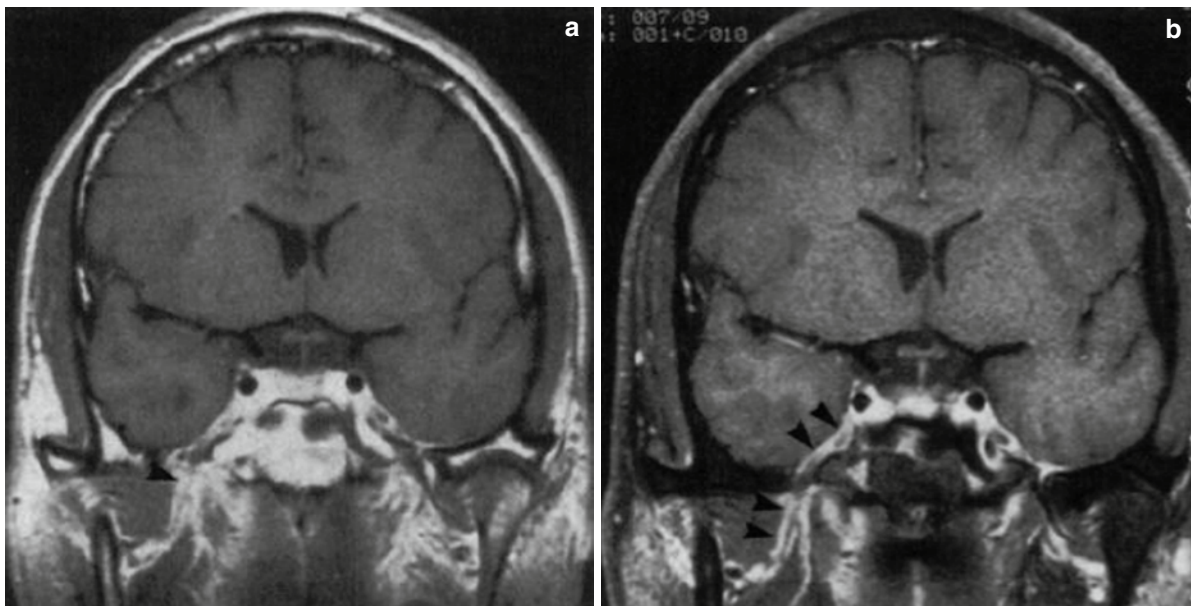
#### 2.2.3.3 Complications

Complications of maxillary and mandibular nerve blocks are the following: Activation of herpes/labialis and herpes zoster\*\*; postprocedure dysesthesias,



**Fig. 2.19** (a) Coronal T1-weighted (600/20) image. Chemical shift artifact results in partial obscuration of the maxillary division of the mandibular nerve as it courses through the foramen rotundum (*arrows*). (b) After fat suppression, the chemical

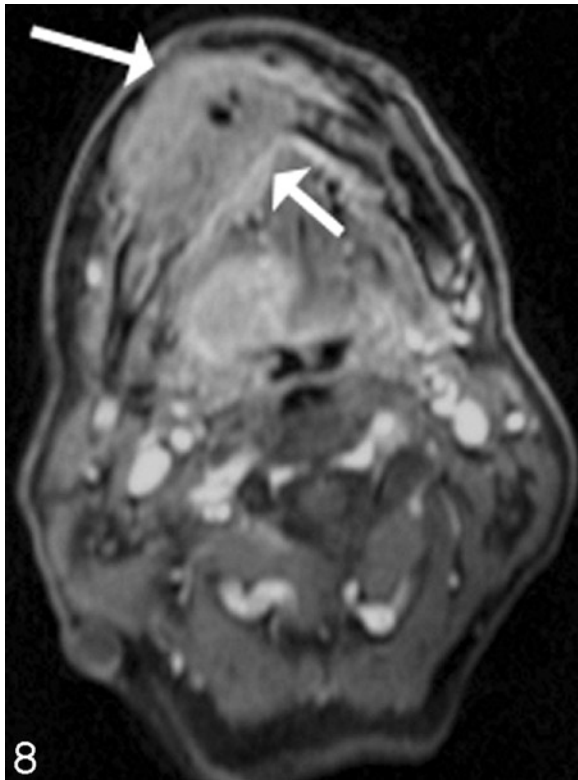
shift artifact is eliminated, allowing better visualization of the second division of the trigeminal nerve (*arrows*) (Barakos et al. 1991)



**Fig. 2.20** (a) Coronal T1-weighted (600/20) image obtained after contrast material administration. The enhancing perineurium of the mandibular division of the trigeminal nerve is difficult to distinguish from surrounding fat (*arrowhead*). (b) Coronal fat-suppressed T1-weighted image. Note the uniform suppres-

sion of the subcutaneous and diploic space fat. After fat suppression, the perineurium that envelops the trigeminal nerve (*arrowheads*) is easily defined. Note the enhancement of the perineurium but not the normal nerve itself (Barakos et al. 1991)





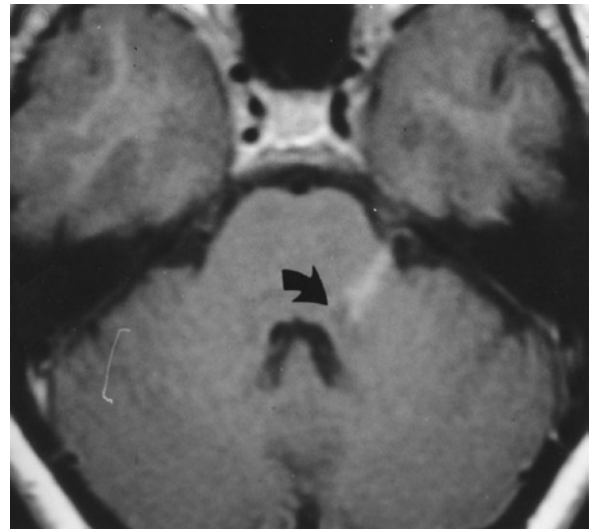
**Fig. 2.21** Postgadolinium-enhanced scan through the floor of the mouth demonstrates a contrast-enhancing mass (arrows) infiltrating the right side of the mandible and extending into the subcutaneous tissue. There is an associated mass at the right lateral base of the tongue. Note infiltration of the mandible extends across the midline (Yousem et al. 2006). This cancerous mass would result in pain that could be treated with a mandibular block

including anesthesia dolorosa; facial asymmetry; Horner's syndrome; facial ecchymosis and hematoma\*; ocular subscleral hematoma\*; middle meningeal artery injection (mandibular block).

## 2.3 Trigeminal Ganglion Block: Trigeminal (Gasserian) Ganglion Block for Trigeminal Neuralgia (Tic Douloureux)

### 2.3.1 Anatomy

The trigeminal nerve is the largest of the cranial nerves. The preganglionic trigeminal nerve arises (at the root



**Fig. 2.22** A 33-year-old woman with herpes zoster. Axial contrast-enhanced T1-weighted spin-echo MR image shows enhancement along pontine course of trigeminal nerve and low signal intensity at the site of the main trigeminal sensory nucleus (arrow) (Kamel and Toland 2001)

entry zone) from the lateral pons at its superior to mid portion as a large sensory and small motor root. The preganglionic nerve travels forward in the posterior cranial fossa above the superior aspect of the petrous temporal bone. It then merges with trigeminal ganglion at the apex of the petrous temporal bone (Meckel's cave) in the middle cranial fossa. The ganglion is bordered by the cavernous sinus, trochlear nerve, and optic nerve medially, the inferior surface of the temporal lobe superiorly, and the brain stem posteriorly. There are three postganglionic nerve divisions: V1, which exits via the superior ophthalmic fissure into the orbit; V2, which exits via the foramen rotundum and crosses the pterygopalatine fissure and inferior orbital fissure into the orbit; V3, which exits the foramen ovale towards the mandible.

### 2.3.2 Function

The trigeminal nerve provides sensation for the face and mouth. It supplies the muscles of mastication as well as the tensor tympani, tensor veli palatini, the mylohyoid, and anterior belly of the digastric muscle.

### 2.3.3 Clinical Presentation

Trigeminal neuralgia presents as episodic excruciating pain of the unilateral face, forehead, jaw, or any isolated facial structure (eye, lip, nose, etc).

### 2.3.4 Etiology

Etiologies include vascular compression (superior cerebellar artery, aneurysm),\*\* trauma\*\* (root canal), tumor,\*\* arachnoid cyst\*\* in the cerebello-pontine angle, multiple sclerosis,\*\* and postherpetic neuralgia.\*\*

### 2.3.5 Differential Diagnosis

Differential diagnoses include cluster headache, sinusitis,\*\* temporomandibular joint syndrome,\*\* atypical facial pain syndrome, odontogenic pain,\*\* acute glaucoma, and intracranial aneurysm.\*\*

### 2.3.6 Injection Site

The needle is inserted at the lateral margin of the lips (Fig. 2.23). It is then advanced along the inner aspect of the mandible between the mandible and the oral mucosa. The index finger is positioned inside the mouth to stabilize the needle and prevent it from puncturing the oral mucosa on its way to the foramen ovale. The needle is pushed past the posterior margin of the mandible to the skull base under fluoroscopic guidance. The needle tip is then advanced just inside the foramen ovale. In the lateral view the needle tip should not be advanced past a line between the tips of the anterior and posterior clinoid processes (Figs. 2.24–2.26).

### 2.3.7 Cross-Sectional Anatomy

#### 2.3.7.1 What Does the Needle Traverse?

- Taking an anterior approach, the needle first penetrates the skin and passes through the fascia. It then

enters the buccal space through the inferior portion of the retromaxillary fat pad between the buccinator muscle and the masseter. It may traverse the medial margin of the temporalis muscle. The lateral pterygoid muscle is then traversed to reach the foramen ovale adjacent to the lateral surface of the lateral pterygoid.

A lateral approach to the foramen ovale can also be used similar to the mandibular nerve block (Krol and Arbit 1988).

#### 2.3.7.2 Which Structures the Needle Should Avoid (Kaplan et al. 2007)

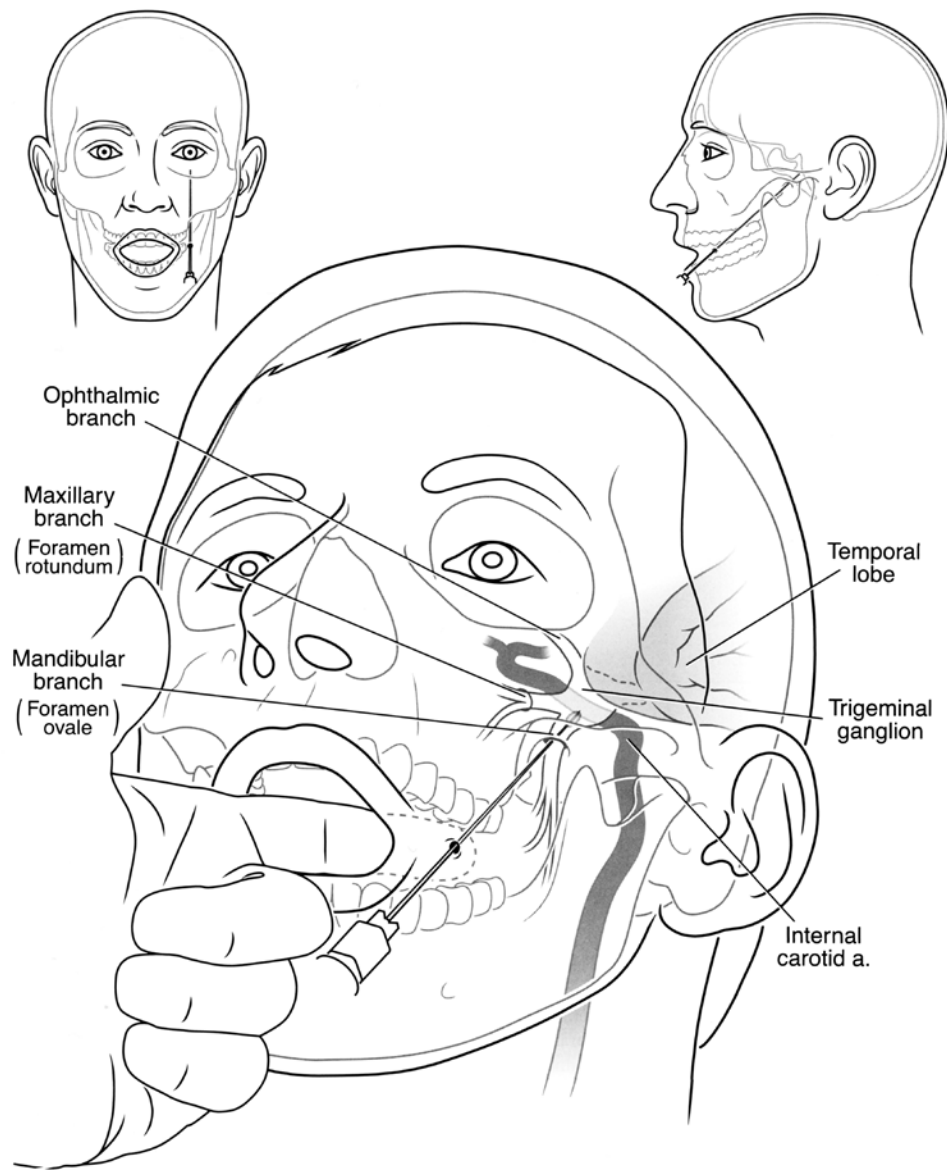
It is advisable that the needle avoid the following structures:

- Optic nerve
- Inferior orbital fissure (needle injury to CN III and/or IV)
- Nasociliary nerve or injury to its feeding artery
- Recurrent meningeal artery (feeding vessel for the trochlear nerve)
- Motor branch innervation to masseter muscle
- Abducens nerve (CN VI)
- Greater superficial petrosal nerve
- Genuiculate ganglion (if the needle advanced too far within the middle cranial fossa into the petrous bone)
- Carotid artery and cavernous sinus
- Anastomotic veins between cavernous sinus and pterygoid plexus
- Middle meningeal artery

#### 2.3.7.3 Imaging/Radiology

*Fluoroscopy:* The target is superior and posterior to the foramen ovale. Precise location of the foramen ovale may be difficult in some patients due to osteoporosis or variant anatomy. Moreover, there is a 15% failure rate using this modality.

*CT:* The trigeminal ganglion is a structure within Meckel's cave, but may not be directly visualized. The foramen ovale can be seen reliably. This method can be combined with CT/fluoroscopy for real-time needle manipulation. 3D volume rendering CT can also be helpful to localize the foramen ovale (Horiguchi et al. 2005).



**Fig. 2.23** Gasserian ganglion block for trigeminal neuralgia (tic douloureux) (Neal, 2007)



**Fig. 2.24** The patient's neck is extended and the angle of the computed tomography (CT) gantry is set vertically to the cranial base on the scout view. The arrow points to the white bar that indicates the inclination of the CT gantry (Sekimoto et al. 2005)



**Fig. 2.26** The needle was advanced following the predesigned route under CT fluoroscopy (Sekimoto et al. 2005)



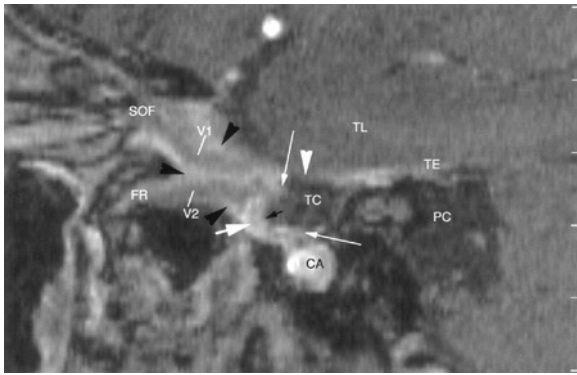
**Fig. 2.25** The safest and shortest route to the foramen was designed on the CT image. The arrows show the marking devices (Sekimoto et al. 2005)

**MRI:** This is the procedure of choice for diagnosis of the various indications including trigeminal neuralgia due to arterial compression or AVMs, migraine phenomenon, and cranial nerve invasion. It is the best modality for excluding other diagnosis in cluster headaches. It is also the best modality for the visualization of complications (hematoma) in the middle cranial fossa and masticator space (Figs. 2.27–2.29).

### 2.3.8 Indications

The following are common indications for trigeminal ganglion block (double asterisks indicate that the pathology can be imaged): Trigeminal neuralgia\*\*; multiple sclerosis \*\*; cancer resulting in direct nerve involvement \*\*; cancer pain in invasive tumors\*\*; cluster headaches; atypical facial pain; and failed sphenopalatine block.



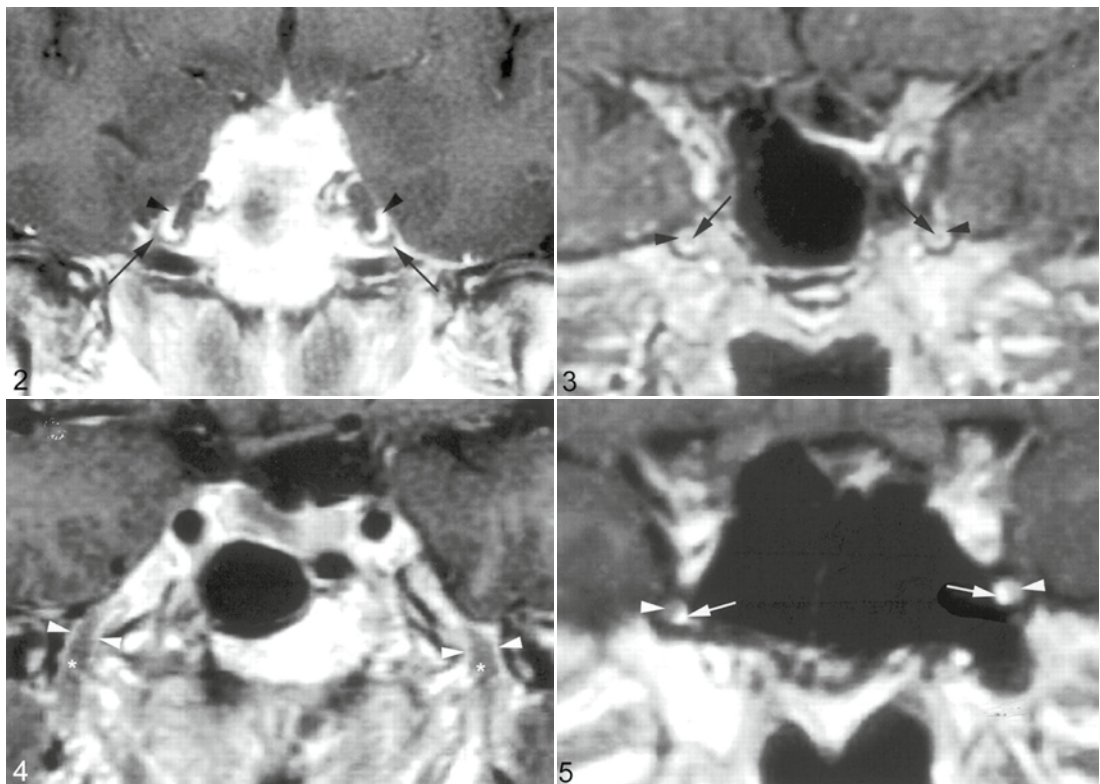


**Fig. 2.27** Sagittal enhanced 3D time-of-flight image through the right side of Meckel's cave in a 53-year-old-man. The enhancing ganglion (*thick white arrow*) is shown at the anteroinferior margin of the cave, in continuity with the dural wall (*white arrowhead*). Superior and inferior lips of the ganglion (*thin white arrows*) are well depicted. No sensory rootlets are seen in the trigeminal cistern (TC). The ophthalmic nerve (V1) and maxillary nerve (V2) are hypointense, linear structures surrounded by strongly enhancing venous channels (*black arrowheads*) in the lateral wall and along the inferior border, respectively, of the cavernous sinus. V2 enters the foramen rotundum (FR), while V1 passes to the superior orbital fissure (SOF). CA carotid artery; PC preoptine cistern; TE cerebellar tentorium; TL temporal lobe (Yousry et al. 2005)

### 2.3.9 Complications

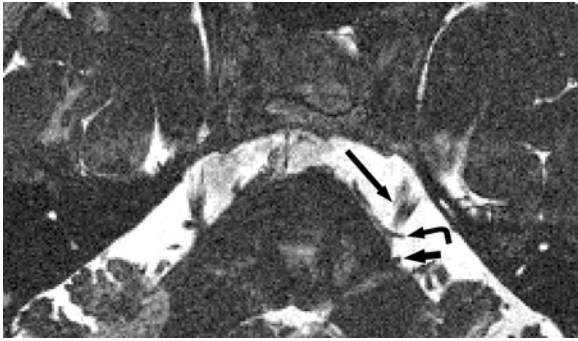
The following are complications of trigeminal ganglion block (double asterisks indicate that the pathology can be imaged) (Kaplan et al. 2007):

- Numbness, hypoesthesia or dysesthesia (trigeminal trophic syndrome) in the entire trigeminal nerve distribution – 29–63% incidence.
- Corneal abnormalities in 3–15% of patients due to nasociliary nerve injury.
- Masticatory weakness (masseter motor innervation injury).
- Reactivation of dormant HSV in 27–94% patients.\*\*
- Hematoma: the pterygopalatine space is highly vascular and significant hematoma of the eye can occur.\*\* Retrobulbar hematoma\*\* can also occur.
- Hemorrhage into temporal fossa (veins into the subtemporal region can be punctured).\*\*
- CSF leak or fistula.\*\*
- Blindness due to optic nerve injury.
- Oculomotor paresis.



**Fig. 2.28** Coronal gadolinium-enhanced T1-weighted image (TR/TE/NEX, 400/15/2) depicts the nonenhancing crescent-shaped trigeminal ganglion (*arrows*) and the prominent perineu-

ral venous plexus (*arrowheads*) superior to it. The venous plexus as well as the ganglion are symmetric in appearance (Williams et al. 2003)



**Fig. 2.29** Image obtained in a 55-year-old woman with trigeminal neuralgia, with neurovascular compression caused by both the vein and anterior inferior cerebellar artery. Transverse 3D CISS MR image (12.25/5.9, 70° flip angle) shows that both the vein (*curved arrow*) and the anterior inferior cerebellar artery (*short straight arrow*) have compressed the left trigeminal nerve (*long straight arrow*) at the root entry zone. This finding was confirmed at surgery (Yoshino et al. 2003)

- Extremely rare injuries to CN 7, 8, and 12.\*\*
- Caroticocavernous fistula.\*\*
- External carotid artery fistula.\*\*
- Meningitis\*\* (Ward et al. 2007; James et al. 1995).

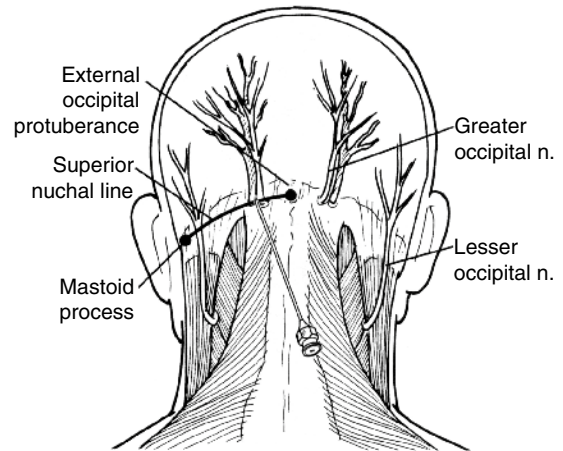
## 2.4 Occipital Nerve Block: For Occipital Neuralgia

### 2.4.1 Anatomy

The greater occipital nerve arises from the C2 nerve root and the lesser occipital nerve receives supply from the C2 and C3 nerve roots. The third occipital nerve originates from the medial sensory branch of the posterior division of C3 nerve root. It courses through the splenius and trapezius medial to the greater occipital nerve. Sites of compression of the greater occipital nerve include the atlantoaxial joint, the posterior arches of C1 and C2, and the site of nerve penetration at the trapezius tendon (Figs. 2.30 and 2.31).

### 2.4.2 Function

The lesser and greater occipital nerves provide sensory supply to the upper neck and occipital scalp.



Occipital nerve block.

**Fig. 2.30** Occipital nerve block for occipital neuralgia (Weiss 2007)



**Fig. 2.31** The occipital region and upper cervical vertebrae viewed from behind showing the course of the greater occipital nerve (G) with possible sites of compression: F due to atlantoaxial joint disease; M as it penetrates the tendinous portion of the trapezius muscles (Z); T as the occipital nerve pierces the posterior atlantoaxial membrane (depicted in light semitransparent blue); and between posterior arches of C1 and C2 vertebrae. Note connections between greater occipital nerve (G) and C1 (i) and C3 (ii) nerves. O occipital bone (Kapoor et al. 2003)

### 2.4.3 Clinical Presentation

Occipital neuralgia presents as chronic headache pain, which may be aching, burning, and throbbing

with intermittent shooting episodes. The headache pain may involve the eyebrows and/or behind the eye. It is usually unilateral. There may be photosensitivity associated with the headaches. There is often associated scalp tenderness. The presentation may be similar to a migraine or a cluster headache.

### 2.4.4 Etiology

Etiologies include trauma such as whiplash injury\*\* or concussion injury with involvement of the lesser and/or greater occipital nerves. Tumor\*\* of the C2 and/or C3 nerve roots, repetitive use injury, rheumatoid arthritis\*\* or osteoarthritis\*\* of the upper cervical spine, cervical spondylosis,\*\* herniated nucleus pulposus,\*\* C1–C2 facet arthritis,\*\* and ligamentum flavum thickening.\*\* Compression of the greater or lesser occipital nerve or the C2 and C3 nerve roots associated with cervical spine degeneration.\*\* Vascular compression by an anomalous, ectatic vertebral artery\*\* or posterior inferior cerebellar artery.\*\* Arnold–Chiari type I syndrome\*\* (foramen magnum syndrome), gout,\*\* diabetes, arteritis,\*\* or infection.\*\*

### 2.4.5 Differential Diagnoses

Differential diagnoses include tension headaches, cluster headaches, migraine headaches, and fibromyalgia.

### 2.4.6 Injection Site

At a theoretical line (level of the superior nuchal margin) between the external occipital protuberance and the mastoid process, the greater occipital nerve is positioned at the inner third. The lesser occipital nerve is positioned between the central and lateral third interface. The subcutaneous tissues at these sites are injected (Figs. 2.30 and 2.32).

### 2.4.7 Cross-Sectional Anatomy

#### 2.4.7.1 What Does the Needle Traverse?

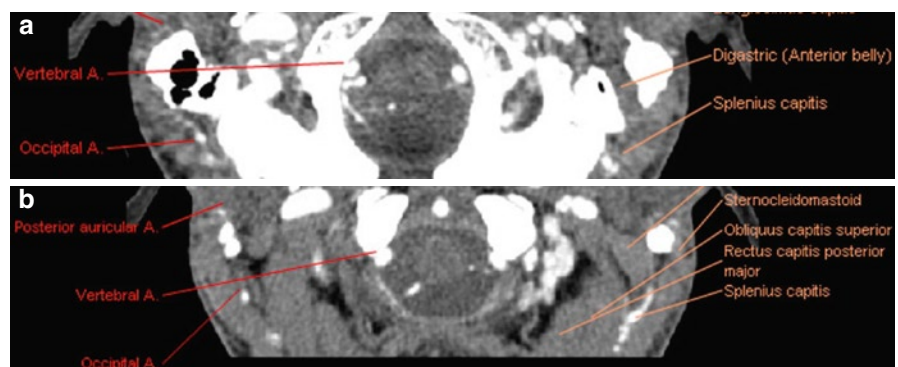
The needle enters the skin and traverses the trapezius muscle. The superficial layer of the deep cervical fascia that surrounds the trapezius is then traversed. The deep layer of the deep cervical fascia is next penetrated by the needle. The needle then crosses the semispinalis/splenius capitis muscle followed by the rectus capitis muscle. The base of the occipital bone is then reached (Fig. 2.32).

#### 2.4.7.2 Which Structures the Needle Should Avoid

The needle should avoid the following structures:

- Suboccipital venous plexus (complex meshwork of superficial veins between layers of muscle in the suboccipital region)
- Condylar emissary vein (connects the suboccipital venous plexus to the sigmoid sinus via the condylar canal at the occipital condyle)
- Occipital artery (nerve lies just medial to the artery)
- Vertebral artery

**Fig. 2.32** (a) Depiction of the occipital artery and posterior scalp musculature at the level of the inferior occipital bone. (b) Depiction of the occipital artery and posterior scalp musculature at the level of the occipital condyle [<http://www.e-anatomy.org/anatomy/human-body/head-neck-face/skull-face.html>] (courtesy of e-Anatomy - Micheau A, Hoa D, [www.imaios.com](http://www.imaios.com))





### 2.4.7.3 Imaging/Radiology

**Plain film radiographs:** Plain films are less sensitive than CT or MRI and are usually not helpful for evaluation of indications for occipital nerve block.

**Fluoroscopy** is the best technique for guidance. It may not be necessary however, since anatomic landmarks are usually palpable.

**Ultrasound:** Cadaver study shows that the nerve can be directly visualized and targeted under ultrasound in its proximal portion before its division at the caudal end of the obliquus capitis inferior muscle (Curatolo and Eichenberger 2007). Ultrasound may be of use to localize the occipital artery.

**CT:** CT is useful for the evaluation of upper cervical spine pathology. It is also useful for guidance of C2–C3 nerve blocks when lesser and greater occipital nerve blocks have failed in the scalp.

**MRI:** This is the modality of choice for the exclusion of intracranial pathology and to evaluate the cervical spine. It is superior to CT except in subarachnoid hemorrhage and cortical bone invasion/pathology.

### 2.4.8 Indications

The following are relatively common indications (double asterisks indicate that the pathology can be imaged): Headache (tension, vascular, cervicogenic), occipital neuralgia, cervical arthritis\*\* (Fig. 2.33) and myofascial pain.

Relatively rare indications include: Arnold–Chiari malformation,\*\* (Fig. 2.34) tumor (primary and secondary),\*\* and infection (mastoid and intraspinal)\*\*.



**Fig. 2.33** Sagittal fast spin-echo MR images of rheumatoid arthritis with superficial and deep enhancement in a 69-year-old woman (rheumatoid arthritis for 31 years). T1-weighted (500/7) (a) and T2-weighted (3,398/150) (c) images show stenoses (waisted) at level C1–C2 and levels C3–C4 through C6–C7, presumably caused by pannus and subluxation on level C1–C2 and by discopathy and ligamentum flavum hypertrophy on subaxial levels. (b) Gadolinium-enhanced T1-weighted SPIR fat-suppressed image (500/7) shows

superficial enhancement lining the cerebrospinal fluid (arrow 1) and enhancement involving deeper structures. Deep-enhancing tissue is recognized as bone and presumably pannus on C1–C2 (arrow 2), as disk on subaxial anterior levels (arrow 3), and as bone on level C3–C4 (arrow 4). Ligamentum flavum and interspinous ligaments enhanced posterior (arrow 5). Deep enhancement coincides mostly with narrowing of the spinal canal on these levels. Note enhancement of the ligamentum nuchae (arrow 6) (Kroft et al. 2004)





**Fig. 2.34** Sagittal T2-weighted MR image in patient with asymptomatic Chiari I malformation. *Arrow* points to herniated cerebellar tonsil extending below the inferior margin of the occipital lobe (Hofkes et al. 2007)

### 2.4.9 Contraindications

The main specific contraindication is suboccipital craniectomy.\*\* (Figs. 2.35–2.36).

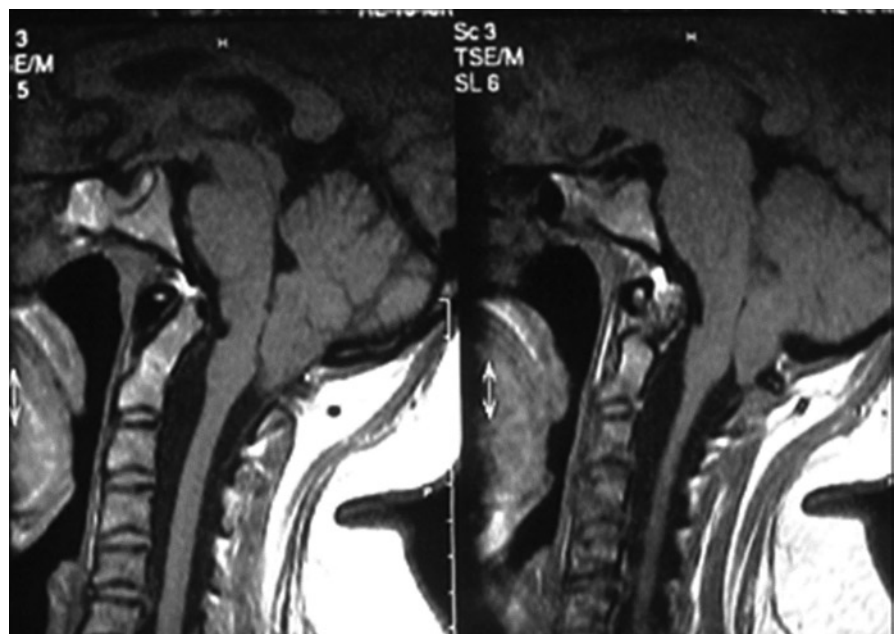
### 2.4.10 Complications

Uncommon complications include: (1) Intravascular injection of occipital artery; total spinal anesthesia in the sub cranial injection of patients who have had posterior suboccipital cranial surgery.

## 2.5 Cervical Plexus Blockade

### 2.5.1 Anatomy

The cervical plexus is formed by the ventral rami of the superior fourth cervical nerves. It lies deep to the sternocleidomastoid. It is lateral to the levator scapulae



**Fig. 2.35** Herniated cerebellar tonsils up to C1



**Fig. 2.36** An example of suboccipital craniectomy. Postoperative MRI showing the recently created cisterna magna. Note that the inferior aspect of the occipital bone is now at the level of the mid cerebellum. *White arrow* points to cisterna magna. *Black arrow* points to inferior margin of the occipital bone (Silva et al. 2005)

muscles and middle scalene. This is surrounded by the prevertebral fascia. The plexus has links to cranial nerves 11, 12, and the sympathetic trunk. The cervical plexus becomes superficial at the posterior margin of the sternocleidomastoid along the posterior triangle. There are four cutaneous and one muscular branch. A deep and superficial component to the cervical plexus is present (Fig. 2.37).

## 2.5.2 Function

The cutaneous branches of the cervical plexus include the lesser occipital nerve, which provides sensory supply to the lateral portion of the occipital scalp; the greater auricular nerve, which provides sensory supply to the auricular region of the ear

(behind the ear); the transverse cervical nerve, which provides sensory supply to the ventral neck; the supraclavicular nerve, which provides sensory supply to the shoulder, upper thorax, and suprascapular region (Fig. 2.37).

The ansa cervicalis provides motor supply to the geniohyoid, thyrohyoid, sternothyroid, sternohyoid, and omohyoid muscles. The phrenic nerve provides motor supply to the diaphragm.

There is a contribution to cranial nerve 11 for the sternocleidomastoid and trapezius muscles.

## 2.5.3 Injection Site

For the superficial plexus, the site is chosen at the mid-point of the posterior margin of the sternocleidomastoid, one-half the depth of the muscle superiorly and inferiorly along the posterior border (Fig. 2.37).

For the deep cervical plexus, an anterior approach is utilized such that the needle is adjacent to the transverse processes of C2 through C4. The point of injection is chosen along a line between the mastoid process and the C6 transverse process (Chassaignac's tubercle) (Figs. 2.38–2.41).

## 2.5.4 Cross-Sectional Anatomy: Superficial Cervical Plexus Block

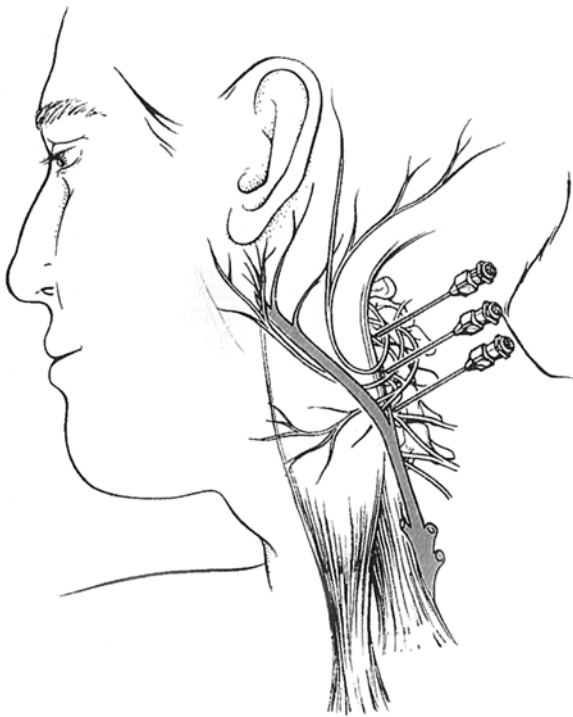
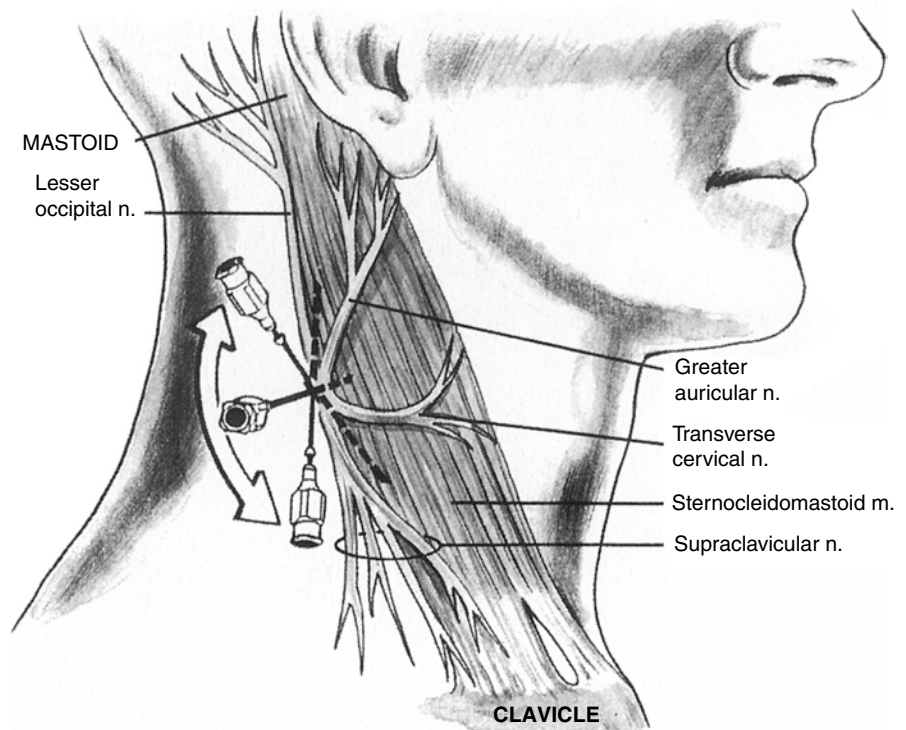
### 2.5.4.1 What Does the Needle Traverse?

The needle enters the skin and traverses the posterior margin of the platysma. The needle next traverses the superficial layer of the deep cervical fascia at the posterior margin of the sternocleidomastoid to enter the posterior cervical space. The needle is then superficial to the deep layer of the deep cervical fascia surrounding the levator scapulae muscle (Figs. 2.41a and 2.41b).

### 2.5.4.2 Which Structures the Needle Should Avoid

Care must be taken to avoid cranial nerve 11 (spinal accessory nerve), which runs in the floor of the posterior cervical space. This supplies innervation to the trapezius. The nerve is located within the occipital

**Fig. 2.37** Superficial cervical plexus block – anatomy and technique (Brown 1992)



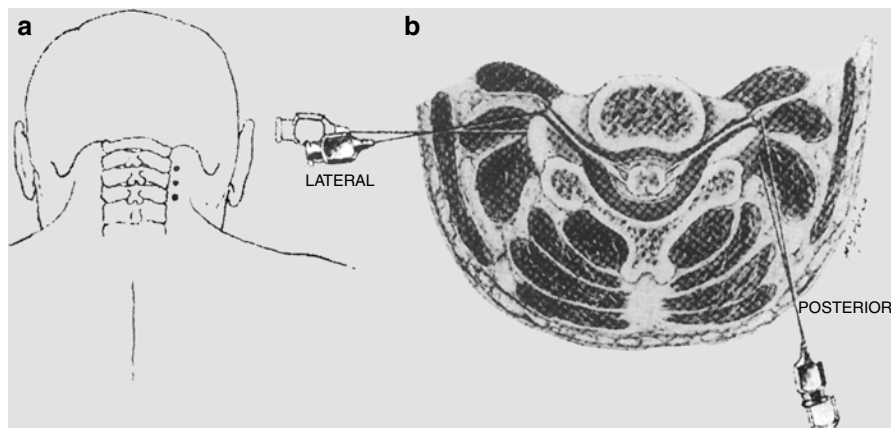
**Fig. 2.38** Deep cervical plexus block – anatomic drawing. *Right to left*, the needles are noted at the sulci of the transverse processes of C2, C3, and C4 (Carron et. al. 1984)

triangle formed by the sternocleidomastoid antero-medially, the trapezius posterolaterally, and the omohyoid muscle inferiorly. The dorsal scapular nerve should also be avoided. It arises from the brachial plexus (spinal nerve C4 & C5); this supplies motor innervation to the rhomboid and levator scapulae muscles. The internal and external jugular veins should also be avoided (Figs. 2.40–2.41).

### 2.5.5 Cross-Sectional Anatomy: Deep Cervical Plexus Block Lateral Approach

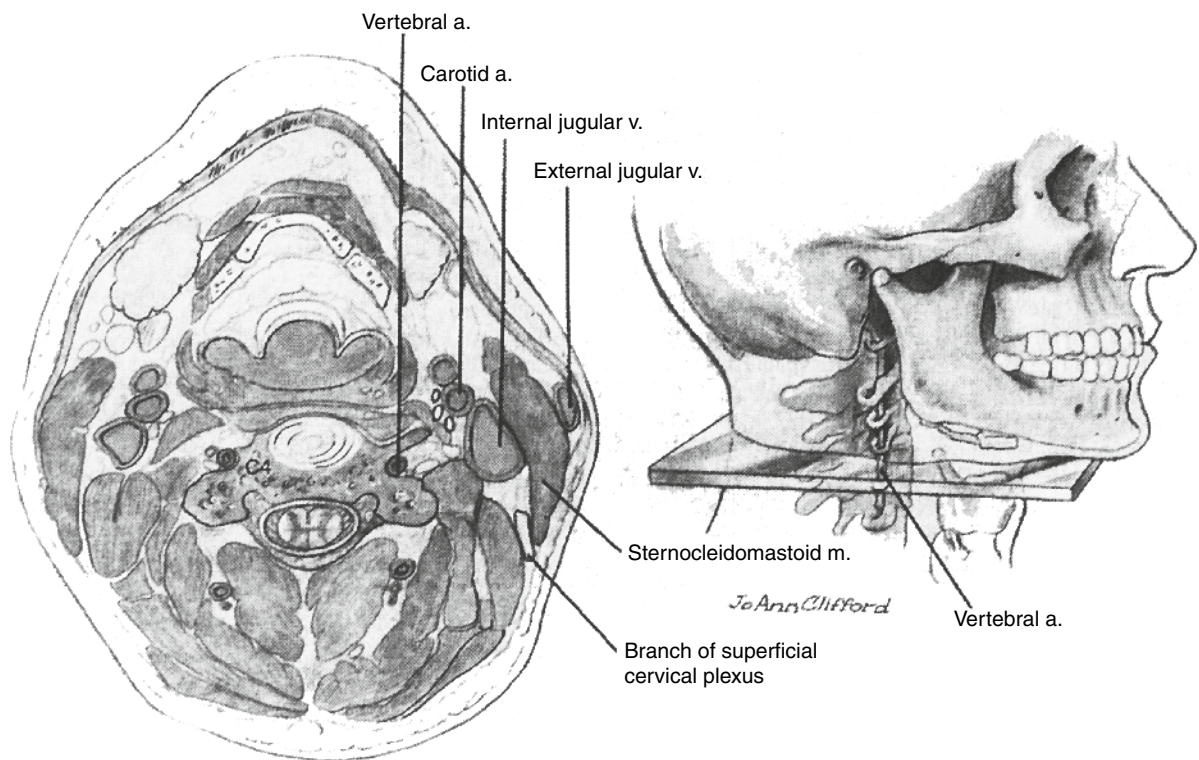
#### 2.5.5.1 What Does the Needle Traverse?

The needle enters the skin and traverses the sternocleidomastoid and the superficial layer of the deep cervical fascia, which surrounds the sternocleidomastoid. Next, the middle scalene muscle and/or anterior scalene muscle is crossed until the anterior tubercle of the transverse process is contacted at its lateral most aspect (Figs. 2.38–2.39 and 2.41).



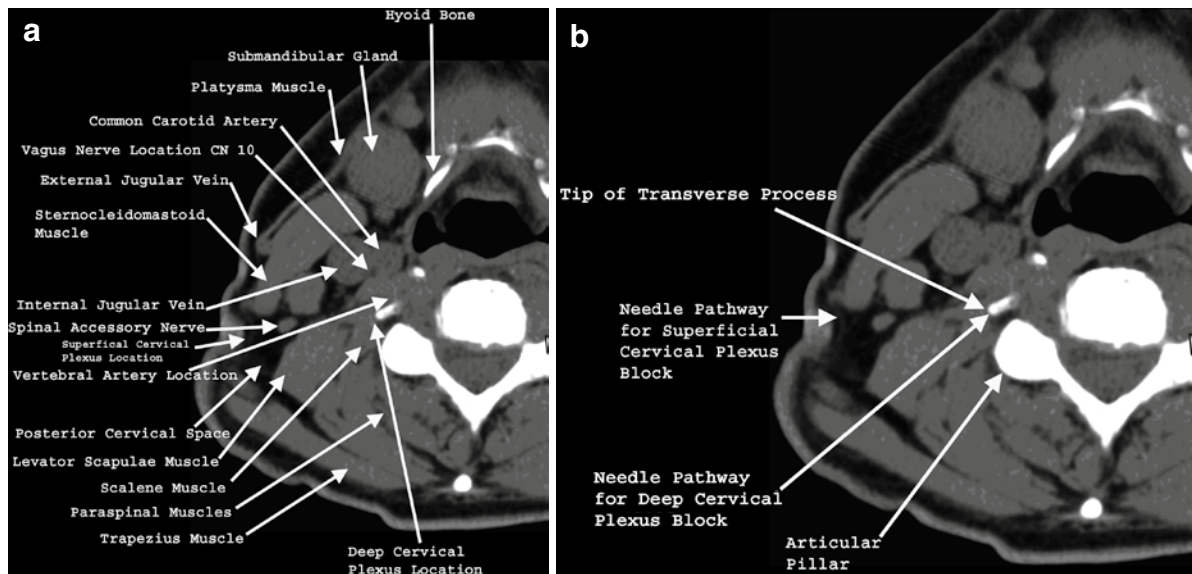
**Fig. 2.39** “Deep cervical block” by the original posterior (Kappis) and lateral (Heidenheim) routes. **(a)** With the posterior approach, the needles are inserted 3 cm from the midline and advanced until the articular pillar is contacted, whereupon the needles are withdrawn and reinserted farther laterally until they “walk off” the lateral margin of the transverse processes. At that point the local anesthetic

is injected. With the lateral approach, a line is drawn from the mastoid process above to the transverse process of C6 below, indicating the location of the cervical transverse processes. **(b)** Then, using either two or three needles, the lateral margins of the second, third, and fourth cervical transverse process are contacted, whereupon the anesthetic solution is injected (Winnie et al. 1975)



**Fig. 2.40** Cervical plexus cross-sectional anatomy: midpoint of sternocleidomastoid muscle (Brown 1992)





**Fig. 2.41** (a) CT image of cervical plexus cross-sectional anatomy – midpoint of sternocleidomastoid muscle (at same level as Fig. 2.38). (b) CT image depicts needle pathway for cervical plexus blocks

#### 2.5.5.2 Which Structures the Needle Should Avoid?

The vertebral artery should be avoided within the transverse foramen. Care should be taken to limit the volume of anesthetic injected anterior to the transverse processes as this may cause compression of the carotid sheath and anesthesia of cranial nerves 9 and 10. Avoid the intravertebral foramina so as to prevent epidural or subarachnoid injection and even spinal cord injury. The phrenic nerve located ventral to the anterior scalene muscle should also be avoided.

#### 2.5.6 Cross-Sectional Anatomy: Deep Cervical Plexus Block Posterior Approach

This approach is technically more difficult to perform than the lateral approach, but useful when the lateral approach is technically impossible, i.e., neck tumor (Waldman 2001b).

#### 2.5.6.1 What Does the Needle Traverse?

The needle enters the skin and traverses trapezius and the superficial layer of the deep cervical fascia (surrounding the trapezius). The deep layer of the deep cervical fascia is then entered, followed by the posterior paraspinal muscles. Next, the posterior and middle scalene muscles are traversed by the needle until the lateral margin of the transverse process is contacted.

#### 2.5.6.2 Which Structures the Needle Should Avoid

The brachial plexus root lies near the needle path between the anterior and middle scalene muscles.

#### 2.5.7 Imaging/Radiology (Jacobsen et al. 2006)

**Ultrasound:** This method is useful for characterizing palpable masses (thyroglossal duct cysts, branchial

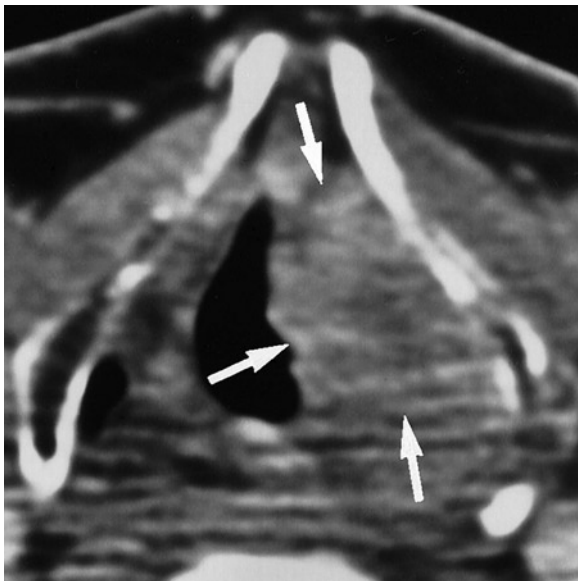
cysts, cystic hygromas, salivary gland tumors, abscesses, carotid body tumors, vascular tumors, and thyroid masses). It is able to characterize vascularity in real-time and in duplex mode.

**CT:** This represents the first-line imaging technique for masses/lymphadenopathy. Superior to MRI in evaluating bony cortex. It is helpful for staging cancer, including capsular penetration and extension beyond the lymph nodes (Fig. 2.42). CTA is recommended for vertebral/carotid artery injury.

**MRI:** This modality is superior to CT for evaluating intracranial pathology, especially infarcts of the posterior fossa. It is also valuable in assessing the superior extent of nodal involvement of malignancy (intracranial extension). Although is capable of detecting bone marrow invasion, it is not able to detect bone cortex destruction, unlike CT. MRA is useful for vertebral/carotid artery injury.

### 2.5.8 Indications

The following are common indications (double asterisks indicate that the pathology can be imaged) (Smoker



**Fig. 2.42** Transverse CT image in a patient with T3 supraglottic carcinoma. Pretreatment image shows a mass (arrows) in the region of the left false vocal cord and paraglottic space (Hermans et al. 2000)



**Fig. 2.43** Multispatial tularemia. Enhanced CT scan shows a large suppurative node in external aspect of superficial space (N) with thickening and enhancement of overlying skin (white arrows) and underlying platysma muscle (black arrow). Suppurative adenopathy is also present bilaterally in deep cervical chain nodes of carotid spaces (arrowheads), and smaller, reactive-appearing nodes are present in spinal accessory nodes of posterior cervical spaces (dots) (Smoker, 1991)

and Harnsberger 1991; Holliday et al. 1995; Parker and Harnsberger 1991):

- Painful infections (tuberculosis) affecting the lymph nodes in the neck (Fig. 2.43)
- Pain after laryngectomy and/or radiation therapy following laryngectomy for cancer
- Surgery involving the inferior or lateral aspect of the neck:
- Dissections of the neck\*\*
- Excisions of masses\*\*
- Tumors\*\*
- Thyroglossal cysts\*\*
- Branchial cysts\*\*
- Operations of the thyroid\*\*
- Parathyroid or lymph nodes\*\*
- Operations on the blood vessels including ligations of the carotid and lingual arteries and carotid endarterectomy\*\*
- Pharyngeal cancer and metastases\*\*
- Occipital and posterior auricular neuralgias associated with acute inflammation or compression of the cervical plexus by tumors\*\* or aneurysms\*\*
- Hiccups

### 2.5.9 Contraindications

The following represent the main unique contraindications: significant respiratory disease due to potential blockage of the phrenic nerve (diaphragm paralysis), especially in bilateral cervical plexus block.

### 2.5.10 Complications

The range of possible complications is relatively wide, including:

- Intravascular injections of the local anesthetic
- Internal or external jugular vein injections (systemic toxicity, hematoma due to wall tear, air embolism)\*\*
- Vertebral artery injury resulting in convulsions, apnea, total reversible blindness and unconsciousness due to dissection,\*\* thrombosis,\*\* and/or infarction\*\*
- Occlusion of the PICA (Wallenberg syndrome)\*\*
- Compression of the carotid sheath, especially with carotid artery disease\*\*
- Injection into the epidural or subarachnoid spaces – anesthesia of the upper limbs and thorax with bilateral phrenic nerve paralysis
- Spinal cord injury\*\*
- Recurrent laryngeal nerve block\*\* occurs in 2–3% of unilateral cervical plexus block
- Vagus nerve block
- Bilateral hypoglossal nerve block
- Bilateral phrenic nerve block\*\*
- Blockade of the ninth and tenth cranial nerves or a combination of both through the pharyngeal plexus
- Bilateral stellate ganglion blocks
- Occipital headaches

## 2.6 Stellate Ganglion Block

### 2.6.1 Anatomy

The stellate ganglion is located ventral to the C7 transverse process. It is ventral to the first rib, medial to the vertebral artery and superior to the subclavian artery, and cupula/apex of the lung (Fig. 2.44).

### 2.6.2 Function

The stellate ganglion provides sympathetic innervation to the head, neck, upper extremity, and heart. It also receives input from the paravertebral sympathetic trunk. The stellate ganglion is involved in sympathetically mediated pain (i.e., complex regional pain syndrome).

### 2.6.3 Injection Site

*Fluoroscopic:* An anterior approach is utilized to the junction between the C6 and/or C7 vertebral body and their respective transverse processes (Fig. 2.45).

*CT:* An anterolateral approach is utilized with the tip of the needle adjacent to the first rib head (Fig. 2.46).

### 2.6.4 Cross-Sectional Anatomy: Anterior Approach

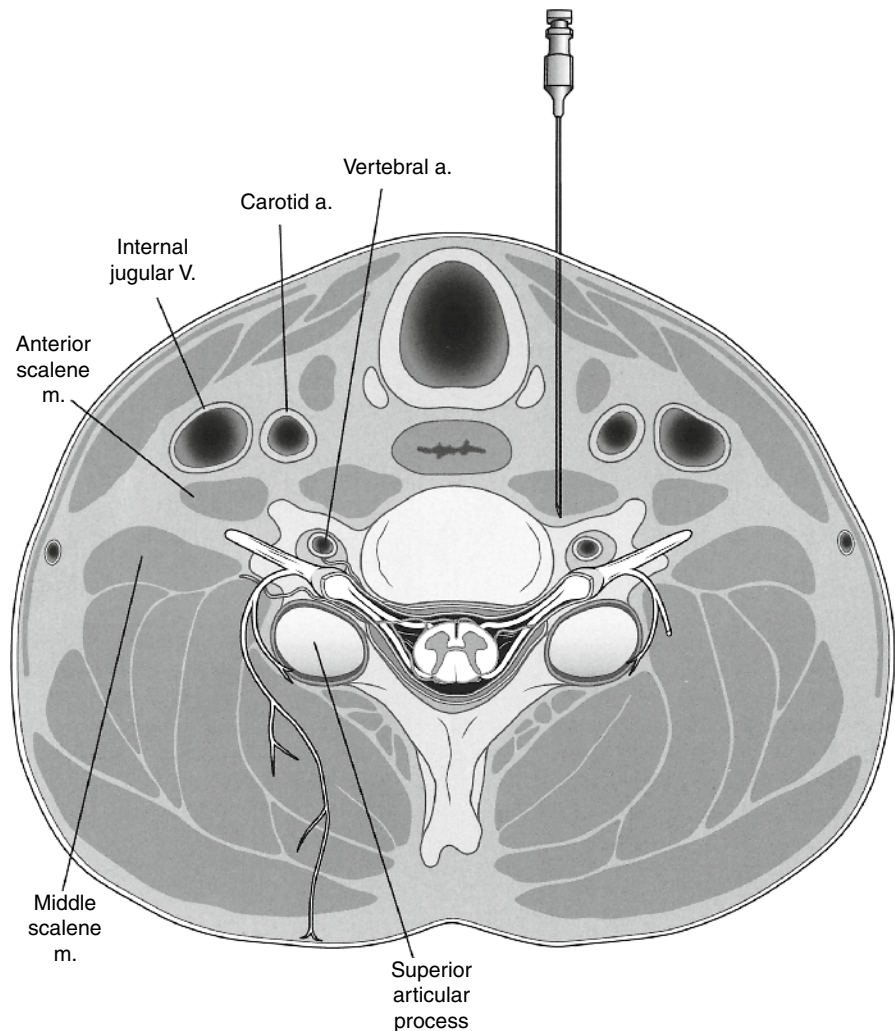
#### 2.6.4.1 What Does the Needle Traverse?

After traversing the skin, the needle penetrates the platysma and the infrahyoid strap muscle that is surrounded by the superficial layer of the deep cervical fossa. The middle layer of the deep cervical fascia that surrounds the visceral space is then traversed. The needle may then traverse the thyroid gland and the posterior margin of the middle layer of the deep cervical fascia to enter the retropharyngeal space. The needle is kept medial to the carotid sheath. The deep layer of the deep cervical fascia is then traversed (perivertebral space prevertebral component). The longus coli is then traversed to contact the anterior tubercle of the C6 transverse process (Chassaignac's tubercle) (Fig. 2.47).

#### 2.6.4.2 Which Structures the Needle Should Avoid

It is advisable to avoid the following structures: Carotid artery (carotid artery sheath); vertebral artery (transverse foramen); esophagus (posterior and to the left of trachea); phrenic nerve (anterior to the anterior scalene); recurrent laryngeal nerves (tracheoesophageal groove) (Figs. 2.47 and 2.50).

**Fig. 2.44** Axial diagram of stellate ganglion block. The needle is positioned in the vertebral gutter, a shallow depression where the transverse process joins with the vertebral body. Note the position of the vertebral artery within the foramen transversarium, the exiting nerve root, and the carotid artery (Rathmell 2006)



### 2.6.4.3 Imaging/Radiology

**Fluoroscopy:** This method allows accurate needle placement at the level of the C6 transverse process, since many individuals lack a bony transversarium at C7 and thus the needle may enter the vertebral artery at this level (C7).

**Arteriography** is useful for evaluating upper extremity arterial insufficiency.

**CT** (Erickson and Hogan 1993): Intravenous contrast allows accurate identification of vascular structures (vertebral artery and carotid sheath). CT also enables identification of the esophagus and allows one to avoid critical nerves such as the phrenic nerve and recurrent laryngeal nerve, and spinal cord/nerve roots. The pneumothorax can also be avoided. It is useful in excluding other sources of upper extremity pain where bony pathology is suspected. Temporal bone CT is

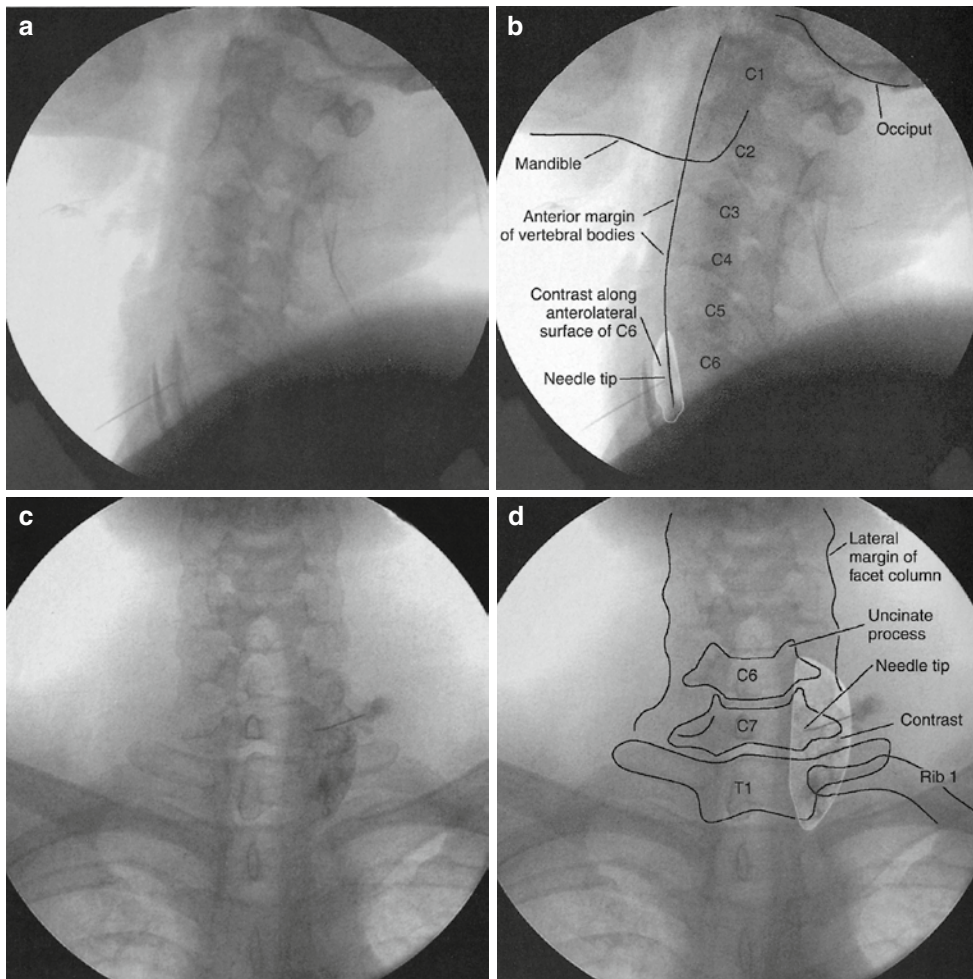
useful in excluding other sources of inner ear pathology in the setting of Ménière's disease.

**Ultrasound:** This imaging modality allows identification of the esophagus in the left-sided approach. It also allows accurate identification of vascular structures (carotid artery, vertebral artery, thyroid arteries) (Fig. 2.49). However, it cannot monitor spread of contrast agent as well as CT or fluoroscopy to prevent intrathecal or recurrent laryngeal nerve involvement.

**Nuclear medicine bone scan** is useful for evaluating complex regional pain syndrome (reflex sympathetic dystrophy) (Fig. 2.51).

**MRI:** This method is useful in excluding other sources of upper extremity pain. MRI of the internal auditory canal is useful in excluding other sources of inner ear pathology in the setting of Ménière's disease (Fig. 2.48). The stellate ganglion may be directly imaged.





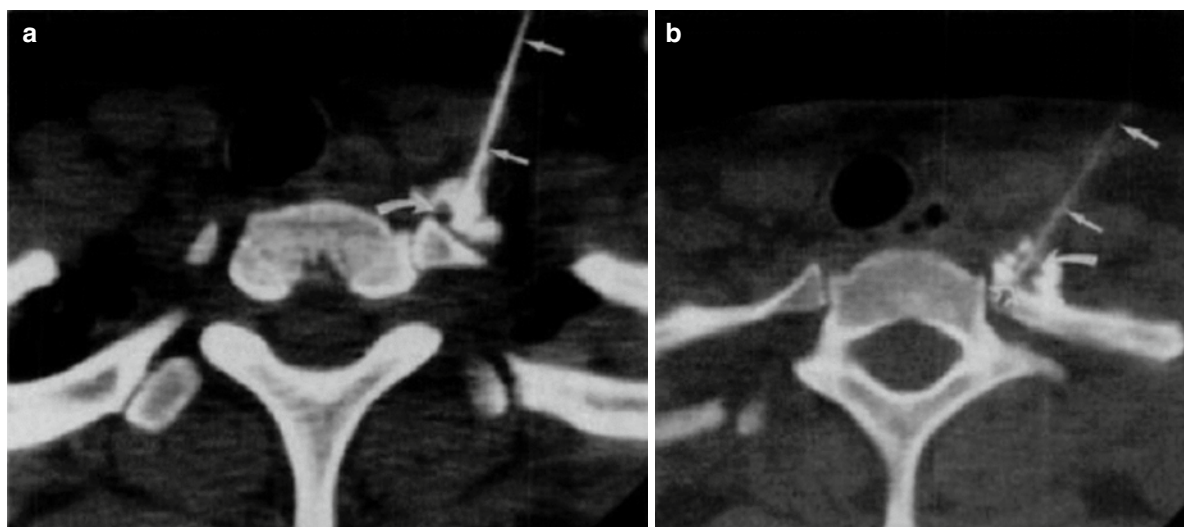
**Fig. 2.45** (a, b) Lateral radiograph of the cervical spine during stellate ganglion block at C6. (a) The needle is seated against the anterior surface of C6. Radiographic contrast (1.5 mL of iohexol 180 mg/mL) has been injected and spreads along the anterolateral surface of C6 to reach the adjacent vertebra. A small amount of contrast is seen in a more superficial plane and was placed before the needle was firmly seated against the vertebral body. (b) Labeled image. (c, d) Posterior–anterior radiograph of the cervical spine during stellate ganglion block at C7. (c) The needle is in position at the junction of the C7 transverse process and

the vertebral body, just inferior to the uncinate process of C7. Particular care must be taken when performing stellate ganglion block at the C7 level. The needle tip must remain aligned below the uncinate process or more medial to avoid the vertebral artery, which courses unprotected over the anterior surface of the C7 transverse process in many individuals. Radiographic contrast (1.5 mL of iohexol 180 mg/mL) has been injected, followed by 10 mL of 0.25% bupivacaine, and spreads along the anterolateral surface of C6 to T2. (d) Labeled image (Rathmell 2006)

### 2.6.5 Indications

The following are common indications for stellate ganglion block:

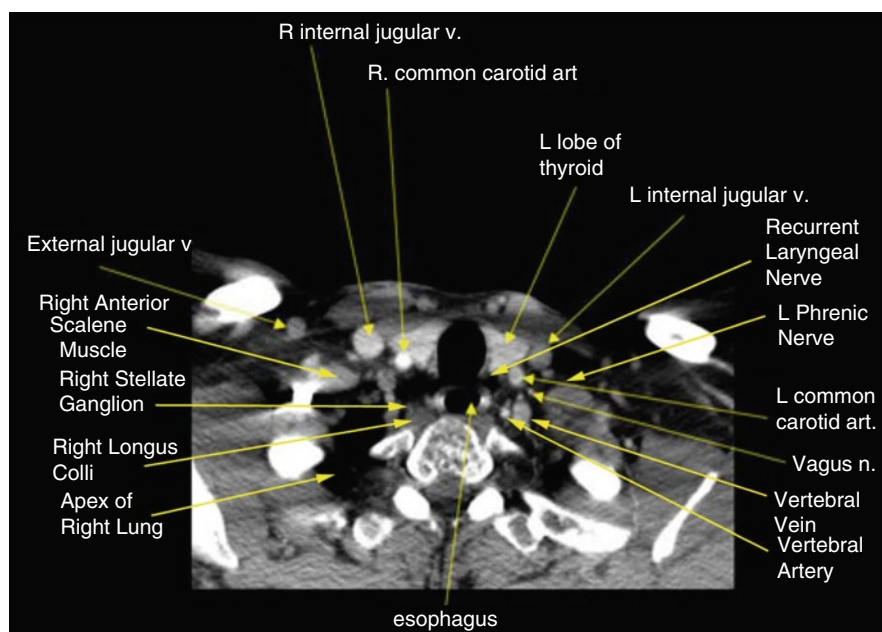
- Sympathetically maintained pain syndromes (reflex sympathetic dystrophy or complex regional pain syndrome) (Schweitzer et al. 1995)
- Vascular disease\*\*
- Raynaud's disease\*\*
- Raynaud's phenomenon\*\*
- Frost bite
- Vasospasm\*\*
- Occlusive vascular disease\*\*
- Embolic vascular disease\*\*
- Scleroderma\*\*
- Chronic pain syndromes involving the upper limb, thoracic structures, and head and neck.
- Phantom limb pain
- Paget's disease\*\*



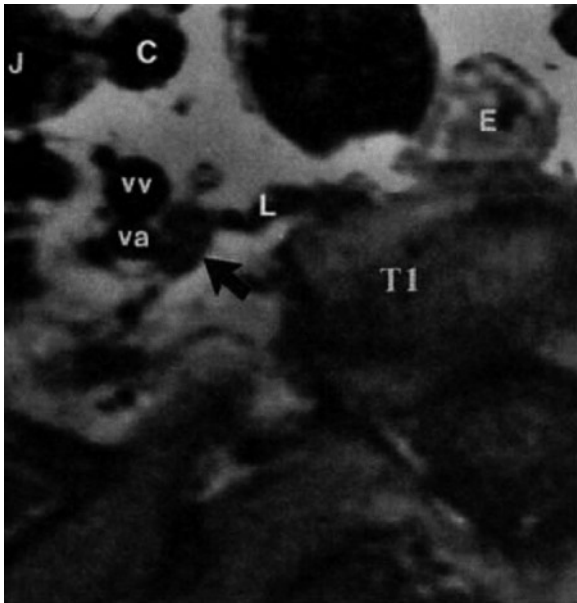
**Fig. 2.46** CT-guided stellate ganglion injections in a 32-year-old-woman. (a) CT image shows needles (*straight arrows*) and high-attenuation contrast material surrounding the stellate ganglion (*curved arrow*). (b) CT image shows the entire course of

the needle (*straight solid arrows*), with its tip (*open arrow*) residing on the head of the first rib. Contrast material surrounds the stellate ganglion (*curved arrow*) (Erickson and Hogan 1993)

**Fig. 2.47** CT showing important anatomic structures at the level of the stellate ganglion block. Similar anatomy is also encountered with brachial plexus block (modified from [[http://www.urmc.rochester.edu/smd/Rad/neuroanatomy/neck\\_anatomy.htm](http://www.urmc.rochester.edu/smd/Rad/neuroanatomy/neck_anatomy.htm)])



- Neoplastic disorders
- Postradiation neuritis\*\*
- Diabetic neuropathy
- Pain from cranial nerve disorders (tic douloureux, Bell's palsy)\*\*
- Postherpetic neuralgia/acute herpes zoster\*\*
- Severe refractory angina\*\* (Chester et al. 2000)
- Hyperhidrosis
- Ménière's syndrome\*\* (Valvassori and Dobben 1984)
- Vascular headaches



**Fig. 2.48** Axial T1-weighted MR image of a 42-year-old woman shows ovoid stellate ganglion (arrow) reaching cephalad beyond the first rib. *C* common carotid artery; *J* internal Jugular vein; *vv* vertebral vein; *va* vertebral artery; *L* longus coli; *E* esophagus; *T1* T1 vertebral body (Hogan and Erickson 1992)

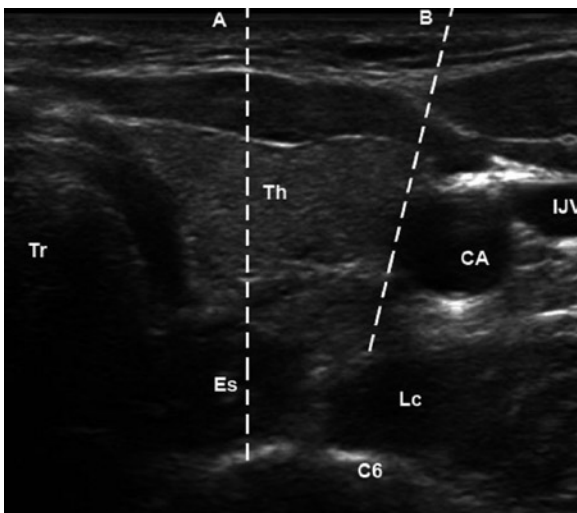
### 2.6.6 Contraindications

Contraindications of stellate ganglion block include myocardial infarction,\*\* bradycardia, glaucoma, contralateral pneumothorax\*\* or compromised function or absence of the contralateral lung.\*\*

### 2.6.7 Complications (Neal et al. 2007)

The following are uncommon complications of stellate ganglion block:

- Recurrent laryngeal and phrenic nerve block\*\*
- Brachial plexus blockade
- Pneumothorax\*\*
- Generalized seizure
- Total spinal anesthesia
- Severe hypotension
- Transient locked-in syndrome
- Paratracheal hematoma\*\*
- Vertebral artery injection causing dissection/thrombosis or infarction\*\* (Makiuchi et al. 1993) (see Fig. 2.52)



**Fig. 2.49** Ultrasound imaging of the left stellate ganglion. *A* the needle path with the anterior paratracheal approach (with fluoroscopic guidance). *B* the needle path with ultrasound guidance. *Tr* trachea; *Es* esophagus; *Th* thyroid; *Lc* longus coli muscle; *CA* carotid artery; *IJV* internal jugular vein. (Reprinted with permission from the Cleveland Clinic Foundation (Narouze et al. 2007))

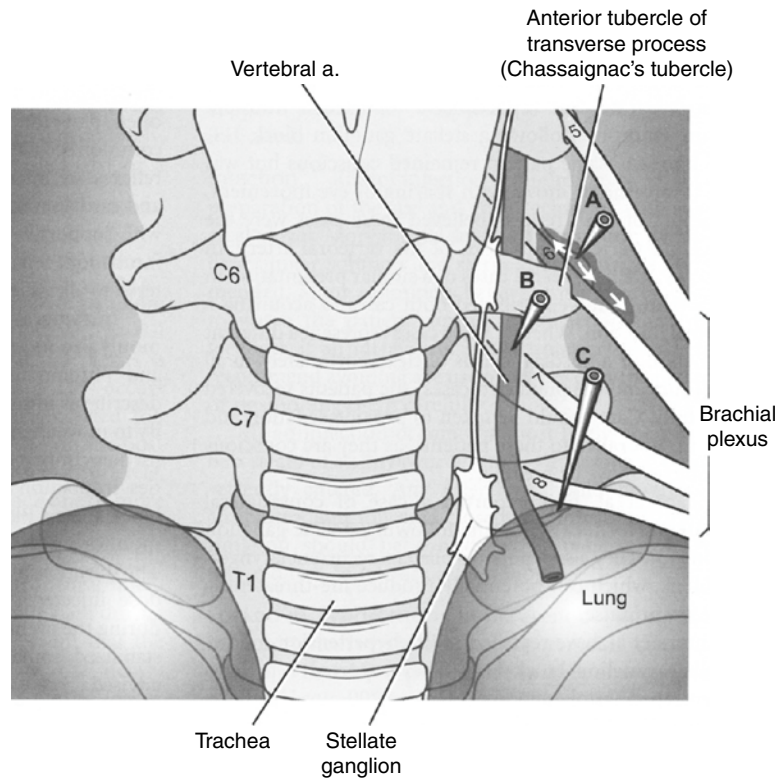
## 2.7 Brachial Plexus Block: For Brachial Plexopathy

### 2.7.1 Anatomy

The brachial plexus is a complex system of nerves, which originates from the C4 through T1 nerve roots. The brachial plexus then travels through the neck between the anterior and middle scalene muscles posterior to the clavicle and cephalad to the first rib next to the subclavian artery, through the axilla into the arm (Figs. 2.53 and 2.54).

### 2.7.2 Function

The brachial plexus innervates all skin sensation and motor supply to the upper extremity except for the trapezius and the skin adjacent to the axilla (supplied by the intercostobrachialis nerve).



**Fig. 2.50** Complications of stellate ganglion block. The stellate ganglion conveys sympathetic fibers to and from the upper extremities and the head and neck. The ganglion is comprised of the fused superior thoracic ganglion and the inferior cervical ganglion and is named for its fusiform shape (in many individuals, the two ganglia remain separate). The stellate ganglia lie over the head of the first rib at the junction of the transverse process and uncinat process of T1. The ganglion is just posteromedial to the cupola of the lung and medial to the vertebral artery, and these are the two most vulnerable structures. Stellate ganglion block is typically carried out at the C6 or C7 level to avoid pneumothorax, and a volume of solution that will

spread along the prevertebral fascia inferiorly to the stellate ganglion is employed (usually 10 mL). When radiographic guidance is not used, the operator palpates the anterior tubercle and the transverse process of C6 (Chassaignac's tubercle), and a needle is seated in the location. With radiographic guidance, it is simpler and safer to place a needle over the vertebral body just inferior to the uncinat process of C6 or C7. Incorrect needle placement can lead to: *A* spread of the injectate adjacent to the spinal nerves where they join to form the brachial plexus; *B* damage to the vertebral artery or intra-arterial injection; or *C* pneumothorax. Local anesthetic can also course proximally along the spinal nerves to the epidural space (Rathmell 2006)

### 2.7.3 Clinical Presentation

Brachial plexopathy presents as pain and decreased sensation in the upper extremity and shoulder as well as weakness.

### 2.7.4 Etiology

Etiologies include trauma,\*\* stretching injury, tumor,\*\* radiation therapy, birth defects, toxins, drugs, thoracic outlet syndrome,\*\* and acute idiopathic/viral plexitis\*\* as well as autoimmune plexitis.\*\*

### 2.7.5 Differential Diagnosis

Differential diagnoses include adhesive capsulitis,\*\* amyotrophic lateral sclerosis,\*\* cervical radiculopathy,\*\* herniated nucleus pulposus,\*\* and spondylosis,\*\* polymyalgia rheumatica, rotator cuff disease,\*\* and thoracic outlet syndrome.\*\*

### 2.7.6 Injection Site

Supraclavicular, infraclavicular, axillary, and interscalene (Fig. 2.53) approaches are used. The axillary approach is described in the upper extremity nerve section.





**Fig. 2.51** A patient with RSDS shows the typical pattern of increased periarticular activity in the affected hand. Two distal interphalangeal joints on the opposite hand show increased activity at the sites of osteoarthritis (Kozin et al. 1981)

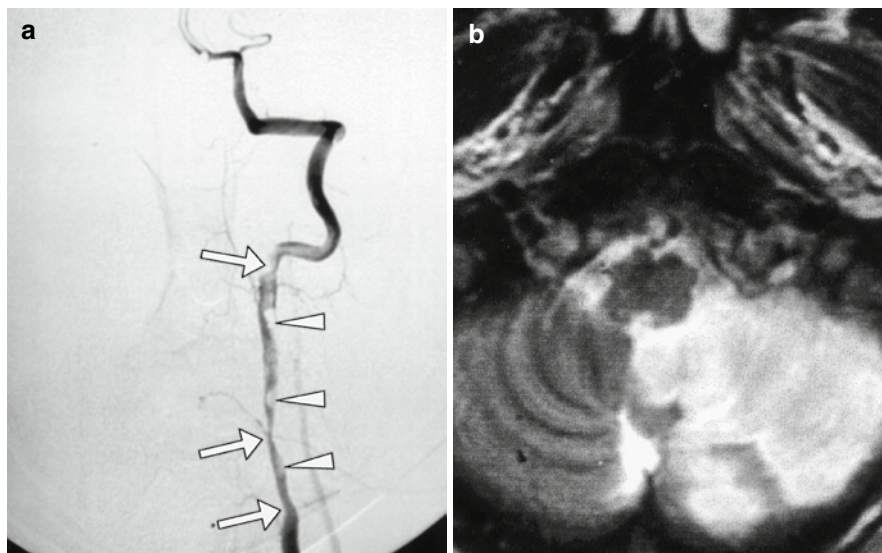
## 2.7.7 Cross-Sectional Anatomy: Interscalene Approach

### 2.7.7.1 What Does the Needle Traverse?

The needle enters the skin and traverses the platysma. It then crosses the sternocleidomastoid muscle, which is surrounded by the superficial layer of the deep cervical fascia. The needle then penetrates the deep layer of the deep cervical fascia surrounding the anterior scalene muscle. It then traverses the anterior scalene muscle to the target point between the anterior and middle scalene muscle (Fig. 2.55).

### 2.7.7.2 Which Structures the Needle Should Avoid

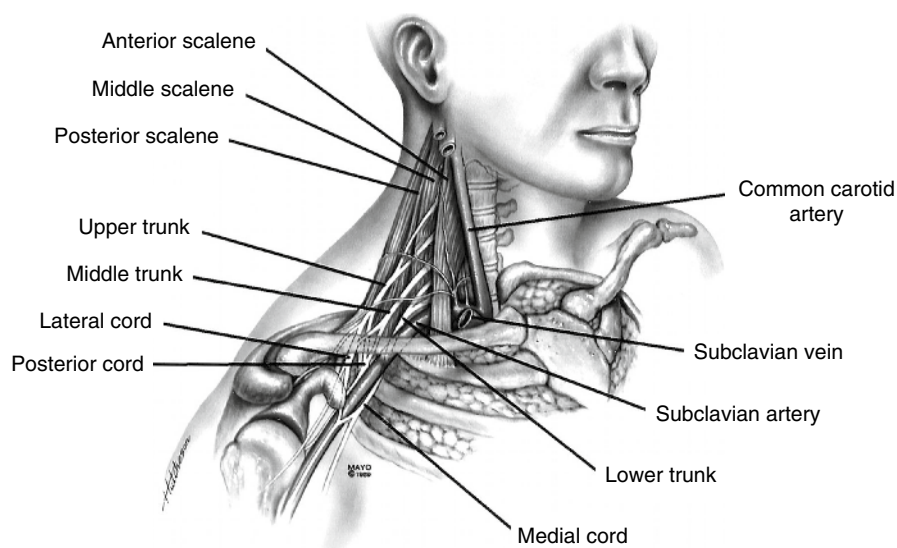
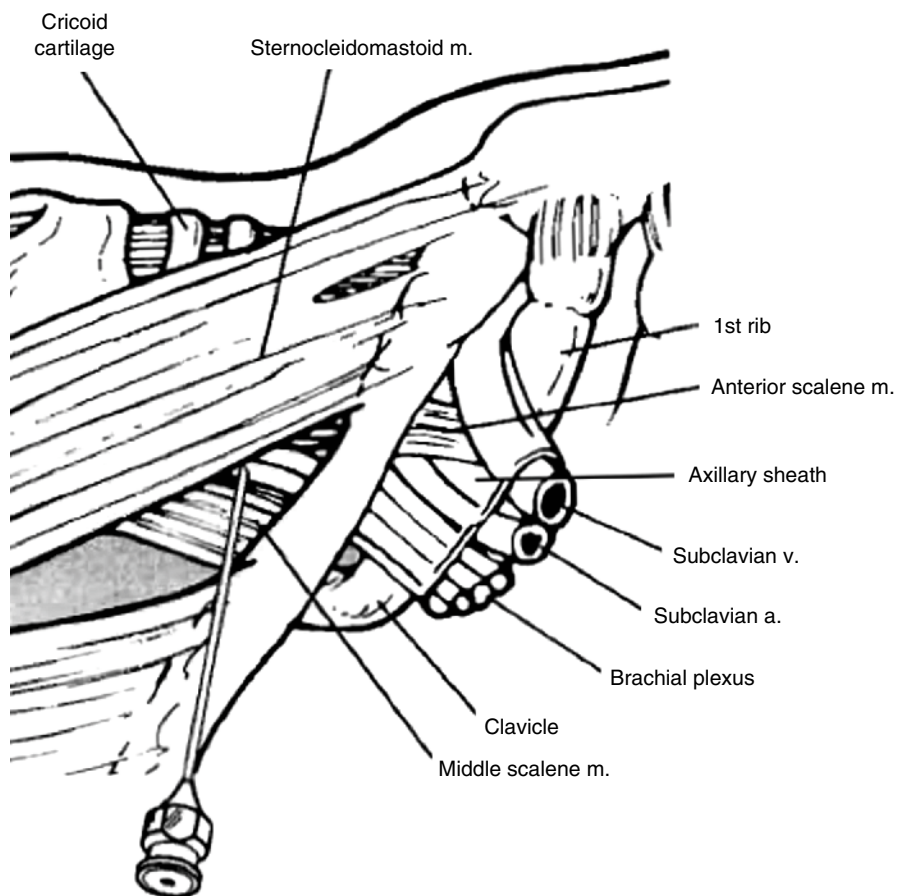
It is advisable that the needle avoid the following structures: phrenic nerve, recurrent laryngeal nerve, pneumothorax (lung apex), and central neuroaxial structures (see Fig. 2.47 for relevant anatomy).



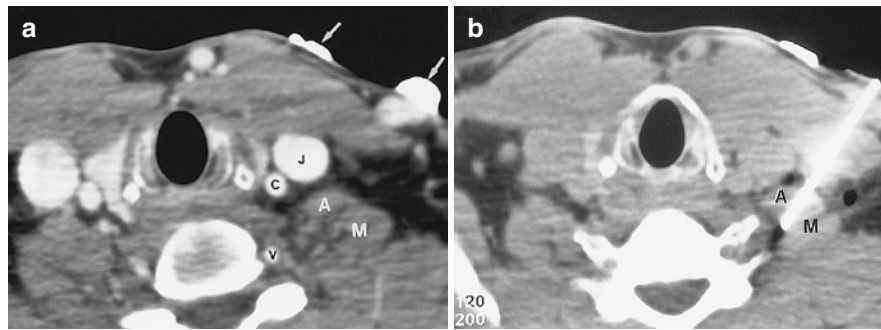
**Fig. 2.52** Irregular stenosis with multiple filling defects involving the left VA in a 37-year-old man with dizziness and ataxia (patient 17). (a) Anteroposterior left vertebral angiogram shows an irregular long segmental stenosis (arrows) and multiple filling defects (arrowheads) in left V2, which represent intramural or intraluminal thrombi. The left posterior inferior cerebellar artery was

occluded on later angiograms. (b) Axial T2-weighted MR image shows regions of high signal intensity, which represent multiple infarcts. The infarcts involve the territory of the left posterior inferior cerebellar artery and middle cerebellar peduncle, an appearance that suggests the embolic nature of the infarction (Shin et al. 2000)

**Fig. 2.53** Needle placement for interscalene brachial plexus block. Lateral view of patient lying supine with head to the left. (Waldman 2001c)



**Fig. 2.54** Normal anatomy of the brachial plexus (Wittenberg and Adkins 2000)



**Fig. 2.55** Brachial plexus block to treat a left C7 mononeuropathy. (a) Transverse contrast-enhanced CT scan, obtained after the skin over the brachial plexus was marked with barium paste (arrows), was acquired to help identify the locations of the common carotid artery (C), internal jugular vein (J), and vertebral

artery (V). A anterior scalene muscle; M middle scalene muscle (Mukherji et al. 2000). (b) Transverse CT scan demonstrates the tip of the needle inserted within the plane separating the anterior (A) and middle (M) scalene muscles (Mukherji et al. 2000)

### 2.7.8 Imaging/Radiology

*Plain film radiographs:* Plain films are useful to rule out shoulder impingement syndrome. Chest radiographs are useful to evaluate for sarcoidosis, granulomatous disease, and Pancoast tumor. Cervical ribs may also be excluded.

*Image guidance:* Although palpable anatomic landmarks may be used for guidance, image guidance may be useful in patients with short thick necks, prior history of surgery or radiation (Mukherji et al. 2000).

*Fluoroscopy* is the method most commonly used.

*CT* is safe (avoidance of pneumothorax and neurovascular structures) and can be useful for obese patients and patients with altered anatomy (i.e., neoplastic invasion) (Fig. 2.55). It is capable of imaging thin slices with 2D coronal and sagittal reconstruction. CT myelography may be useful in preganglionic injury evaluation.

*Ultrasound* can be useful to provide guidance for brachial plexus block. It is helpful with adjunctive color Doppler in altered vascular anatomy/vascular pathology (AVM) and coagulopathy. However, it is limited in neoplastic invasion. It is not able to document spread of contrast solution prior to injection as in CT or fluoroscopy.

*MRI* excludes cervical radiculopathy within the cervical spine. Furthermore, MRI of the brachial plexus

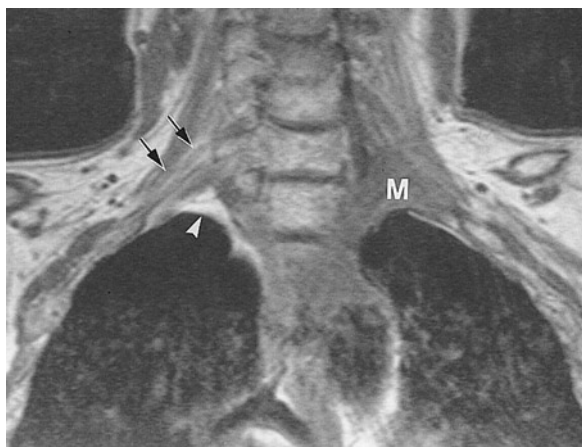
is useful to evaluate for carcinoma or granulomatous disease. It can directly evaluate the brachial plexus for the signal intensity of its nerves, enhancement, and perineural pathology (masses) (Figs. 2.56–2.57). MRI (brachial plexus and cervical spine) is the study of choice in visualizing preganglionic and postganglionic injury to the brachial plexus. MR myelography may be useful in preganglionic evaluation.

### 2.7.9 Indications

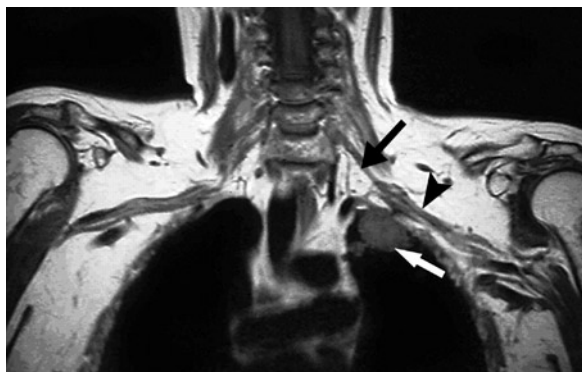
The following are common indications for brachial plexus block: Preoperative analgesia, postsurgical pain, and brachial plexopathy.\*\*

### 2.7.10 Complications

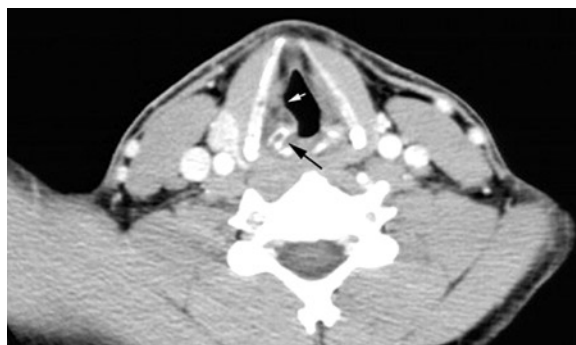
The five main complications of brachial plexus block are: (1) Intravascular injection of the subclavian artery \*\*; (2) phrenic nerve block\*\*; (3) recurrent laryngeal nerve paralysis\*\* (Fig. 2.58); (4) pneumothorax\*\*; (5) epidural, subdural, and subarachnoid spread of anesthetic\*\*.



**Fig. 2.56** Brachial plexus block for pain relief for recurrent Pancoast tumor. Note the normal appearance of the apical fat (arrowhead) and brachial plexus (arrows). *M* a mass situated in the apex of the left lung (Mukherji et al. 2000)



**Fig. 2.57** Small left Pancoast's tumor in a 60-year-old woman. Coronal T1-weighted image shows small bilobed mass (white arrow) in left lung apex. Note preservation of normal interscalene fat pad (black arrow), which on coronal images has triangular appearance. Left brachial plexus (arrowhead) is nicely seen "Pancoast's tumor" is a term used to describe a bronchogenic neoplasia that arises in the apical pleuropulmonary groove (the superior sulcus); most are nonsmall cell cancers (squamous cell carcinomas, adenocarcinomas, or large cell carcinomas). They generally progress by direct extension and invasion of the brachial plexus, intercostal nerves, stellate ganglion, neighboring ribs, and vertebrae. Involvement of the brachial plexus and of the adjacent vertebrae is seen in fairly advanced cases. Supraclavicular lymphadenopathy denotes an N3 stage (according to the TNM classification) and also represents an advanced stage of the disease. Perhaps the earliest sign of extrathoracic and brachial plexus involvement is invasion of the interscalene fat pad by the tumor. This fat pad normally lies between the anterior and the middle posterior scalene muscles just cephalad to the lung apex. The trunks of the brachial plexus are found in this fat pad. On coronal T1-weighted MR images, the interscalene fat pads have a triangular appearance and should always be present, bright in signal intensity, and bilaterally symmetric. Obliteration of this normal bright fat signal by a mass arising in a lung apex generally implies invasion of the brachial plexus, and surgical resection may no longer be feasible (Castillo 2005)



**Fig. 2.58** A 45-year-old woman with hoarseness and right recurrent laryngeal nerve paralysis who underwent axial contrast-enhanced CT. The white arrow shows dilatation of the right laryngeal ventricle. The black arrow shows anterior positioning of the right arytenoid cartilage (Chin et al. 2003)

## 2.7.11 Contraindications

The contraindications to brachial plexus block are prior neck surgery,\*\* radiation,\*\* phrenic nerve palsy,\*\* recurrent laryngeal nerve palsy on the contralateral side\*\* and advanced COPD.\*\* Altered thoracic anatomy\*\* or clavicle deformity\*\* may be a contraindication for the infraclavicular approach.

## References

- American College of Radiology. ACR Practice Guideline for the Performance of Computed Tomography (CT) of the Extracranial Head and Neck in Adults and Children. Reston: American College of Radiology. Revised 10/1/06
- American College of Radiology. American College of Radiology Practice Guideline for the Performance of Magnetic Resonance Imaging (MRI) of the Head and Neck. Reston: American College of Radiology. Revised 10/1/07
- American head and Neck Society. Management of Cancer of the Head and Neck Imaging: General Guidelines. Los Angeles: American head and Neck Society. <http://www.headandneck-cancer.org/clinicalresources/docs/imaginggeneral.php>
- Coleman RE. PET Refining Head and Neck Cancer Management. <http://www.medscape.com/viewarticle/439654>
- Raj PP, Lou L, Erdine S et al. Radiographic Imaging for Regional Anesthesia and Pain Management New York: Churchill Livingstone, c2003. ISBN 0-443-06596-9
- Harnsberger R, Macdonald AJ. Diagnostic and Surgical Imaging Anatomy. Brain, Head & Neck, Spine, 1st ed. Salt Lake City: Amirsys, 2006. NLM ID: 101266773, I-380, I-383, I-384
- Harnsberger R, Macdonald AJ. Diagnostic and Surgical Imaging Anatomy. Brain, Head & Neck, Spine, 1st ed. Salt Lake City: Amirsys, 2006. NLM ID: 101266773, I-218, I-266



- Harnsberger R, Macdonald AJ. Diagnostic and Surgical Imaging Anatomy. Brain, Head & Neck, Spine, 1st ed. Salt Lake City: Amirsys, 2006. NLM ID: 101266773, II-118-123
- Vallejo R, Benyamin R, Yousuf N, Kramer J. Computed tomography-enhanced sphenopalatine ganglion blockade. *Pain Pract.* 2007;7(1):44-6
- Gupta S, Henningsen JA, Wallace MJ, Madoff DC, Morello FA Jr, Ahrar K, Murthy R, Hicks ME. Percutaneous biopsy of head and neck lesions with CT guidance: various approaches and relevant anatomic and technical considerations. *Radiographics.* 2007;27(2):371-90
- Weissman JL. A pain in the ear: the radiology of otalgia. *AJNR Am J Neuroradiol.* 1997;18:1641-51
- Varghese BT, Koshy RC, Sebastian P, Joseph E. Combined sphenopalatine ganglion and mandibular nerve, neurolytic block for pain due to advanced head and neck cancer. *Palliat Med.* 2002;16(5):447-8
- Saade E, Paige GB. Patient-administered sphenopalatine ganglion block. *Reg Anesth.* 1996;21(1):68-70
- Sargeant LK. Headache, Cluster. 2007. <http://www.emedicine.com/EMERG/topic229.htm>
- Mendizabal J. Cluster Headache. 2005. <http://www.ouch-us.org/chgeneral/choverview.htm>
- Tien RD, Felsberg GJ, Osumi AK. Herpes virus infections of the CNS: MR findings. *Am J Roentgenol.* 1993;161:167-76
- Varghese BT, Koshy RC. Endoscopic transnasal neurolytic sphenopalatine ganglion block for head and neck cancer pain. *J Laryngol Otol.* 2001;115(5):385-7
- Ginsberg LE, DeMonte F. Imaging of perineural tumor spread from palatal carcinoma. *AJNR Am J Neuroradiol.* 1998;19:1417-22
- Walker AT, Chaloupka JC, Putman CM, Abrahams JJ, Ross DA. Sentinel transoral hemorrhage from a pseudoaneurysm of the internal maxillary artery: a complication of CT-guided biopsy of the masticator space. *AJNR Am J Neuroradiol.* 1996;17(2):377-81
- Waldman SD. *Interventional Pain Management*, 2nd ed. Philadelphia: Saunders, 2001a. NLM ID: 100959973
- Okuda Y, Okuda K, Shinohara M, Kitajima T. Use of computed tomography for maxillary nerve block in the treatment of trigeminal neuralgia. *Reg Anesth Pain Med.* 2000;25(4):417-9
- Koizuka S, Saito S, Kubo K, Tomioka A, Takazawa T, Sakurazawa S, Goto F. Percutaneous radio-frequency mandibular nerve rhizotomy guided by CT fluoroscopy. *AJNR Am J Neuroradiol.* 2006;27(8):1647-8
- Barakos JA, Dillon WP, Chew WM. Orbit, skull base, and pharynx: contrast-enhanced fat suppression MR imaging. *Radiology.* 1991;179(1):191-8
- Yousem DM, Gad K, Tufano RP. Resectability issues with head and neck cancer. *AJNR Am J Neuroradiol.* 2006;27(10):2024-36
- Kamel HA, Toland J. Trigeminal nerve anatomy: illustrated using examples of abnormalities. *AJR Am J Roentgenol.* 2001;176(1):247-51
- Sekimoto K, Koizuka S, Saito S, Goto F. Thermogangliolysis of the Gasserian ganglion under computed tomography fluoroscopy. *J Anesth.* 2005;19(2):177-9
- Krol G, Arbit E. Percutaneous electrocoagulation of the trigeminal nerve using CT guidance. Technical note. *J Neurosurg.* 1988;68(6):972-3
- Kaplan M, Erol FS, Ozveren MF, Topsakal C, Sam B, Tekdemir I. Review of complications due to foramen ovale puncture. *J Clin Neurosci.* 2007;14(6):563-8. Epub 2006 Dec 13
- Horiguchi J, Ishifuro M, Fukuda H, Akiyama Y, Ito K. Multiplanar reformat and volume rendering of a multidetector CT scan for path planning a fluoroscopic procedure on Gasserian ganglion block-a preliminary report. *Eur J Radiol.* 2005;53(2):189-91
- Yousry I, Moriggl B, Schmid UD, Naidich TP, Yousry TA. Trigeminal ganglion and its divisions: detailed anatomic MR imaging with contrast-enhanced 3D constructive interference in the steady state sequences. *AJNR Am J Neuroradiol.* 2005;26:1128-35
- Williams LS, Schmalfuss IM, Sistrom CL, Inoue T, Tanaka R, Seoane ER, Mancuso AA. MR imaging of the trigeminal ganglion, nerve, and the perineural vascular plexus: normal appearance and variants with correlation to cadaver specimens. *AJNR Am J Neuroradiol.* 2003;24:1317-23
- Yoshino N, Akimoto H, Yamada I, Nagaoka T, Tetsumura A, Kurabayashi T, Honda E, Nakamura S, Sasaki T. Trigeminal neuralgia: evaluation of neuralgic manifestation and site of neurovascular compression with 3D CISS MR imaging and MR angiography. *Radiology.* 2003;228(2):539-45. Epub 2003 Jun 11
- Ward L, Khan M, Greig M, Dolin SJ. Meningitis after percutaneous radiofrequency trigeminal ganglion lesion. Case report and review of literature. *Pain Med.* 2007;8(6):535-8
- James EA, Kibbler CC, Gillespie SH. Meningitis due to oral streptococci following percutaneous glycerol rhizotomy of the trigeminal ganglion. *J Infect.* 1995;31(1):55-7
- Weiss LD. *Easy Injections*. Philadelphia: Elsevier, 2007. NLM ID: 101308328, p 112, Figure 6-5
- Kapoor V, Rothfus WE, Grahovac SZ, Amin Kassam SZ, Horowitz MB. Refractory occipital neuralgia: preoperative assessment with CT-guided nerve block prior to dorsal cervical rhizotomy. *AJNR Am J Neuroradiol.* 2003;24(10):2105-10
- Curatolo M, Eichenberger U. Ultrasound-guided blocks for the treatment of chronic pain. *Tech Reg Anesth Pain Manag.* 2007;11:95-102
- Kroft LJ, Reijnierse M, Kloppenburg M, Verbist BM, Bloem JL, van Buchem MA. Rheumatoid arthritis: epidural enhancement as an underestimated cause of subaxial cervical spinal stenosis. *Radiology.* 2004;231(1):57-63. Epub 2004 Feb 27
- Hofkes SK, Iskandar BJ, Turski PA, Gentry LR, McCue JB, Haughton VM. Differentiation between symptomatic Chiari I malformation and asymptomatic tonsillar ectopia by using cerebrospinal fluid flow imaging: initial estimate of imaging accuracy. *Radiology.* 2007;245(2):532-40. Epub 2007 Sep 21
- Silva JA, Holanda MM, Pereira CB, Leiros Mdo D, Araújo AF, Bandeira E. Retropulsion and vertigo in the Chiari malformation: case report. *Arq Neuropsiquiatr.* 2005;63(3B):870-3. Epub 2005 Oct 18. Erratum in: *Arq Neuropsiquiatr.* 2005;63(4):1120
- Brown DLL. *Atlas of Regional Anesthesia*. Philadelphia: WB Saunders, 1992, pp 165-170
- Carron H: Cervical plexus blocks. In *Regional Anesthesia: Techniques and Clinical Applications*. New York, Grune and Stratton, 1984, pp 10-15.
- Winnie AP, Ramamurthy S, Durrani Z, Radonjic R. Intrascapular cervical plexus block: a single-injection technique. *Anesth Analg.* 1975;54:370-375
- Gupta S, Henningsen JA, Wallace MJ, Madoff DC, Morello FA Jr, Ahrar K, Murthy R, Hicks ME. Percutaneous biopsy of head and neck lesions with CT guidance: various approaches

- and relevant anatomic and technical considerations. *Radiographics*. 2007;27(2):371-90
- Waldman SD. *Interventional Pain Management*, 2nd ed. Philadelphia: Saunders, 2001b. NLM ID: 100959973, p 356
- Jacobsen AS, Urken ML, Teng MS. *Head and Neck Diagnostic Procedures from ACS Surgery: Principles and Practice*. 2006. [http://www.medscape.com/viewarticle/521712\\_8](http://www.medscape.com/viewarticle/521712_8)
- Hermans R, Pameijer FA, Mancuso AA, Parsons JT, Mendenhall WM. Laryngeal or hypopharyngeal squamous cell carcinoma: can follow-up CT after definitive radiation therapy be used to detect local failure earlier than clinical examination alone? *Radiology*. 2000;214:683
- Smoker WR, Harnsberger HR. Differential diagnosis of head and neck lesions based on their space of origin. 2. The infrahyoid portion of the neck. *AJR Am J Roentgenol*. 1991;157(1):155-9
- Holliday RA, Swartz JD, Hudgins PA, Dalley RW, Curtin HD, Reede DL, Smoker WR. Head and neck radiology. *Radiology*. 1995;194(2):613-6
- Parker GD, Harnsberger HR. Radiologic evaluation of the normal and diseased posterior cervical space. *AJR Am J Roentgenol*. 1991;157(1):161-5
- Rathmell JP. *Atlas of image-guided intervention in regional anesthesia and pain medicine*. Philadelphia: Lippincott Williams & Wilkins, 2006
- Erickson SJ, Hogan QH. CT-guided injection of the stellate ganglion: description of technique and efficacy of sympathetic blockade. *Radiology*. 1993;188(3):707-9
- Hogan QH, Erickson SJ. MR imaging of the stellate ganglion: normal appearance. *AJR Am J Roentgenol*. 1992;158(3):655-9. Erratum in: *AJR Am J Roentgenol* 1992;158(6):1320
- Narouze S, Vydyanathan A, Patel N. Ultrasound-guided stellate ganglion block successfully prevented esophageal puncture. *Pain Phys*. 2007;10(6):747-52
- Kozin F, Soin JS, Ryan LM, Carrera GF, Wortmann RL. Bone scintigraphy in the reflex sympathetic dystrophy syndrome. *Radiology*. 1981;138(2):437-43
- Schweitzer ME, Mandel S, Schwartzman RJ, Knobler RL, Tahmouh AJ. Reflex sympathetic dystrophy revisited: MR imaging findings before and after infusion of contrast material. *Radiology*. 1995;195(1):211-4
- Chester M, Hammond C, Leach A. Long-term benefits of stellate ganglion block in severe chronic refractory angina. *Pain*. 2000;87(1):103-5
- Valvassori GE, Dobben GD. Multidirectional and computerized tomography of the vestibular aqueduct in Meniere's disease. *Ann Otol Rhinol Laryngol*. 1984;93(6 pt 1):547-50
- Neal JM, Rathmell JP. *Complications in regional anesthesia and pain medicine*. Philadelphia, PA: Saunders/Elsevier, 2007
- Makiuchi T, Kondo T, Yamakawa K, Shinoura N, Yatsushiro K, Ichi S, Yoshioka M. [Stellate ganglion blocks as the suspected route of infection in a case of cervical epidural abscess]. *No Shinkei Geka*. 1993;21(9):805-8. Japanese
- Shin JH, Suh DC, Choi CG, Lee HK. Vertebral artery dissection: spectrum of imaging findings with emphasis on angiography and correlation with clinical presentation. *Radiographics*. 2000;20(6):1687-96
- Waldman SD. *Interventional Pain Management*, 2nd ed. Philadelphia: Saunders, 2001c. NLM ID: 100959973, p 383
- Wittenberg KH, Adkins MC. MR imaging of nontraumatic brachial plexopathies: frequency and spectrum of findings. *Radiographics*. 2000;20(4):1023-32
- Mukherji SK, Wagle A, Armao DM, Dogra S. Brachial plexus nerve block with CT guidance for regional pain management: initial results. *Radiology*. 2000;216(3):886-90
- Castillo M. Imaging the anatomy of the brachial plexus: review and self-assessment module. *Am J Roentgenol*. 2005;185:S196-204
- Chin SC, Edelstein S, Chen CY, Som PM. Using CT to localize side and level of vocal cord paralysis. *AJR Am J Roentgenol*. 2003;180(4):1165-70
- Fazekas F, Koch M, Schmidt R, Offenbacher H, Payer F, Freidl W, Lechner H. The prevalence of cerebral damage varies with migraine type: a MRI study. *Headache*. 1992;32(6):287-91

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