# Cranial Nerves

A 59-year-old man comes to the office due to diplopia and a drooping right eyelid. His symptoms began a day earlier and have since worsened. Physical examination shows a dilated right pupil that is nonreactive to both light and accommodation. There is vertical and horizontal diplopia. When the patient is asked to stare straight ahead, the right eye is directed inferiorly and laterally with respect to the left eye. MRI of the brain reveals an aneurysm involving the right posterior communicating artery. Which of the following muscles is most likely to remain functionally intact in this patient?

A. Inferior oblique
B. Inferior rectus
C. Lateral rectus
D. Levator palpebrae
E. Medial rectus
F Superior rectus

This patient has a right oculomotor nerve (CN Ill) palsy secondary to a compressive aneurysm. Lesions involving CN Ill cause ptosis (drooping of the upper eyelid) and impair adduction, depression, and elevation of the eye. As a result, diagonal (e.g., horizontal and vertical) diplopia is frequently present. The eye rests in a "down and out" position due to the unopposed action of the superior oblique (CN IV) and lateral rectus (CN VI) muscles. Pupillary constriction and accommodation can also be affected as CN Ill carries parasympathetic fibers to the ciliary muscle and the iris sphincter. CN Ill palsy can be due to a variety of causes, including intracranial tumors or aneurysms, nerve ischemia, and head trauma. Aneurysms causing CN Ill palsy most often involve the posterior communicating artery. When due to an aneurysm, symptoms that develop acutely are especially worrisome as they suggest active aneurysn1al dilation and possible impending rupture.

(Choices A, B, D, E, and F) All of these muscles are innervated by CN Ill, so their function will be impaired in this patient.

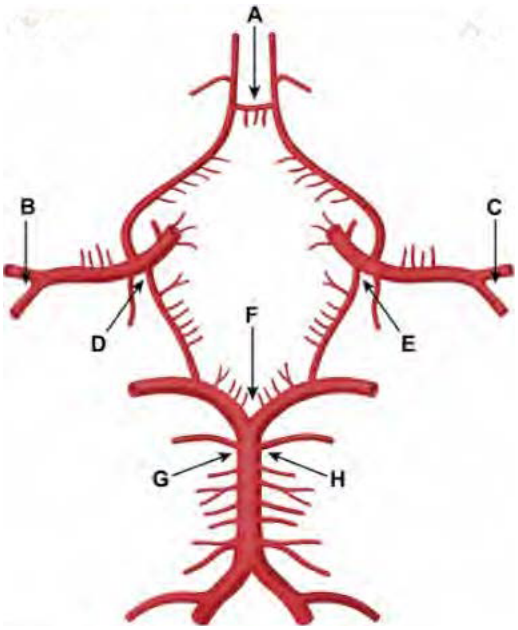
A 36-year-old woman comes to the office due to firm, nontender swelling of her right cheek for the past 4 months. The patient has had no fever, runny nose, sore throat, or cough. She drinks a glass of wine with dinner on most nights but does not use tobacco. Physical examination shows fullness of the preauricular space on the right side. An MRI of the region identifies a 2.2-cm mass in the right parotid gland, and a follow-up core needle biopsy shows the lesion to be neoplastic. If left untreated, this patient is most likely to develop which of the following?

B. Facial droop
C. Facial numbness
D. Hoarseness
E. Horner syndrome
F Strabismus

The extracranial portion of the facial nerve (CN VII) carries motor innervation to the muscles of facial expression. This nerve exits the skull through the stylomastoid foramen and courses within the substance of the parotid gland. Within this gland, the facial nerve divides into its 5 terminal branches (temporal, zygomatic, buccal, mandibular, and cervical). Parotid gland tumors can compress and disrupt the ipsilateral facial nerve and its branches, causing facial droop. In fact, most parotid gland tumors causing facial nerve paralysis are malignant neoplasms.

(Choice C) The trigeminal nerve (via its 3 branches) provides sensation to the face and motor innervation to the muscles of mastication. This nerve follows a deep course and is unlikely to be damaged by a tumor of the parotid gland.
(Choice D) The recurrent laryngeal nerve is a branch of the vagus nerve that loops below the aortic arch on the left and below the subclavian artery on the right to provide motor innervation to the laryngeal muscles. During thyroid surgery, this nerve may be damaged due to its proximity to the inferior thyroid artery. Unilateral nerve injury often causes hoarseness, whereas bilateral injury may cause inspiratory strider and respiratory distress due to complete vocal cord paralysis.
(Choice E) Horner syndrome presents with partial ptosis, miosis, and anhidrosis due to interruption of the sympathetic innervation to the head. This can occur with lesions affecting the lateral hypothalamus, hypothalamospinal tract, paravertebral sympathetic chain/stellate ganglion (e.g., Pancoast tumor), or internal carotid artery (e.g., carotid dissection).
(Choice F) Strabismus (improper alignment of the eyes) can result from disorders of the extraocular muscles or the nerves that innervate them
(CN Ill, IV, or VI).

A 55-year-old, right-handed man comes to the emergency department due to recent onset of severe, throbbing, right-sided orbitofrontal headache and double vision. His medical problems include poorly controlled hypertension and chronic tobacco use. Neurologic examination shows that he is awake, alert, oriented, and follows both simple and complex commands. Cranial nerve testing shows intact visual acuity bilaterally. Visual fields and optic fundi are normal. There is anisocoria with the right pupil dilated and nonreactive to both light and accommodation. There is also evidence of both vertical and horizontal binocular diplopia. The right eye is down and out with ipsilateral ptosis. The rest of the examination is within normal limits. Based on this patient's neurologic deficits, CT angiography of the head is most likely to reveal a large aneurysm arising from which of the following locations in the image shown below?



This patient has right oculomotor (CN Ill) palsy secondary to a compressive aneurysm arising from the junction of the right posterior communicating artery with the internal carotid artery. Saccular aneurysms typically arise from branch points on the circle of Willis, and most (85%) affect the anterior circulation (e.g., anteriorcomn1unicating, posterior communicating, middle cerebral arteries). Chronic smoking and poorly controlled hypertension are risk factors. Unruptured aneurysms are usually asymptomatic, but patients may experience headache and cranial neuropathies due to mass effect. CN Ill courses between the posterior cerebral and superior cerebellar arteries as it exits the midbrain in the interpeduncular space and is particularly susceptible to injury from ipsilateral posterior communicating artery aneurysms (Choice E). CN III is a pure motor nerve that carries general visceral efferent fibers on its surface (that mediate the pupillary light and near-reflex pathways) and general son1atic efferent fibers within its interior (that innervate superior rectus, inferior rectus, medial rectus, inferior oblique, and levator palpebrae superioris muscles). Consequently, aneurysmal compression of CN Ill produces mydriasis (due to superficial parasympathetic fiber damage) with diplopia, ptosis, and "down and out" deviation of the ipsilateral eye (due to somatic efferent fiber injury).

A 26-year-old previously healthy man is brought to the emergency department following a motorbike accident. He is found to have a maxillofacial injury. His condition is stabilized, and surgical repair is performed. While recovering, the patient develops difficulty chewing food. On examination, the jaw deviates to the right side when the patient is instructed to open his mouth. The nerve that has been injured in this patient exits the skull through which of the following foramina?

A. Foramen lacerum
8. Foramen ovale
C. Foramen rotundum
D. Foramen spinosum
E. Jugular foramen

This patient has symptoms consistent with injury of the third division of the trigeminal nerve (cranial nerve [CN] V3, mandibular nerve), which provides sensory innervation to the face and motor innervation to the muscles of mastication. These include the 3 muscles that close the jaw (masseter, medial pterygoid, temporalis) and the single muscle that opens the jaw (lateral pterygoid). Unilateral injury to CN V3 will result in unopposed action of the contralateral pterygoid muscles; because of the plane of action of these muscles, this leads to deviation of the mandible toward the paralyzed side on opening the mouth. Bilateral paralysis would cause mandibular drop and lack of jaw movement. CN V3 exits the skull through the foramen ovale, which also contains the lesser petrosal nerve, the accessory meningeal artery, and the emissary veins. The second division of the trigeminal nerve (CN V2, maxillary nerve) exits the skull via the foramen rotundum (Choice C). The foramen spinosum contains the middle meningeal artery, middle meningeal vein, and the meningeal (recurrent) branch of CN V3, which supplies the dura and contains sympathetic fibers (Choice D). The first branch of the trigeminal nerve (CN V1, ophthalmic nerve) passes through the superior orbital fissure.

(Choice A) The foramen lacerum contains only a few, small vessels (meningeal branch of ascending pharyngeal artery, emissary veins) and is otherwise occluded by fibrous tissue and cartilage. The internal carotid artery passes along its superior surface but does not traverse it.

(Choice E) The jugular foramen contains CNs IX, X, and XI; the inferior petrosal and sigmoid sinuses; and the posterior meningeal artery

A 65-year-old man is brought to the emergency department after he suddenly became unresponsive at home. On arrival, paramedics found him pulseless with ventricular fibrillation. After 10 minutes of cardiopulmonary resuscitation, the patient regains spontaneous circulation. In the hospital, he is intubated and placed on mechanical ventilation. His vitals remain stable. A therapeutic hypothermia protocol is initiated. After 72 hours following rewarming, he remains comatose with fixed and dilated pupils. There is no direct or consensual pupillary response to light. MRI of the brain reveals diffuse loss of grey-white matter differentiation with sulcal effacement. Damage to which of the following areas of the brain is the most likely cause of this patient's pupillary findings?

A. Medulla
B. Midbrain
C. Occipital lobe
D. Parietal lobe
E. Pons
F. Temporal lobe
G. Thalamus

The presence of nonreactive pupils to light stimulation following cardiac arrest carries a poor prognosis and indicates anoxic damage to the brainstem at the level of the upper midbrain. During the normal pupillary reflex, the retina as well as the optic nerve and tract transmit the light stimulus to the midbrain at the level of the superior colliculus where it is received by the pretectal nucleus and subsequently relayed to the bilateral Edinger-Westphal nuclei. These nuclei subsequently project preganglionic parasympathetic fibers through the oculomotor nerve (CN Ill) to the ciliary ganglion, which then projects postganglionic fibers that innervate the sphincter pupillae muscle (constricts the pupil). When light is shone in one eye, both the ipsilateral pupil (direct response) and contralateral pupil (consensual response) constrict

(Choice A) The medulla contains the glossopharyngeal (CN IX) and vagus (CN X) nerves, which provide the afferent and efferent limbs of the gag reflex, respectively.

(Choice C) The occipital lobe contains the primary visual cortex. Unilateral occipital lobe damage can cause contralateral homonymous hemianopia, whereas bilateral occipital lesions may result in cortical blindness.

(Choice D) The parietal lobes process and interpret visual, auditory, and motor signals received from other brain areas. Parietal lobe damage results in difficulties with spatial and visual perception. Nondominant (e.g., right-sided) lesions result in hemi-neglect and constructional apraxia, whereas dominant (e.g., left-sided) lesions result in Gerstmann syndrome (e.g., right-left confusion, agraphia, acalculia).

(Choice E) The pons contains the horizontal gaze center, which helps mediate the oculocephalic (doll's eye) reflex. It also contains the trigeminal

(CN V) and facial (CN VII) nerves, which mediate the afferent and efferent limb of the corneal reflex, respectively. Bilateral pontine injury is associated with pinpoint pupils due to damage of the descending sympathetic fibers.

(Choice G) The thalamus is a major sensory relay station. The ventral posterolateral nucleus mediates somatic sensation of the body, the ventral posteromedial nucleus mediates facial sensation and taste, the lateral geniculate nucleus mediates vision, and the medial geniculate nucleus mediates hearing.

A 51-year-old woman comes to the physician complaining that the right side of her face has felt "funny" for the past 12 hours. Her past medical history is significant for type 2 diabetes mellitus. Physical examination reveals asymmetry of her face when she smiles, puffs out her cheeks, and closes her eyes tightly. There is also effacement of the right nasolabial fold, and her mouth is drawn toward the left side. Which of the following additional findings is most likely associated with this patient's condition?

A. Attenuated sense of touch on the right side of face
8. Decreased tearing from the right eye
C. Failure to elevate the palate when saying "ah"
D. Inability to sweat on the right side of face
E. Loss of taste sensation from the posterior 1/3 of the tongue

This patient's presentation is consistent with Bell's palsy, an idiopathic paresis of the facial nerve. To understand the pathophysiology of Bell's palsy, it is important to understand the function of the facial nerve (CN VII). The facial nerve is a mixed nerve, consisting of the following:
1. Motor output to the facial muscles
2. Parasympathetic innervation to the lacrimal, submandibular, and sublingual salivary glands
3. Special afferent fibers for taste from the anterior 2/3 of the tongue
4. Somatic afferents from the pinna and external auditory canal

Patients with Bell's palsy typically present with sudden onset of unilateral facial paralysis. Specific findings include impaired eye closure, eyebrow sagging, inability to smile and frown on the affected side, disappearance of the nasolabial fold, and the mouth being drawn to the non-affected side. Patients afflicted with Bell's palsy may also have decreased tearing, hyperacusis, and/or loss of taste sensation over the anterior two-thirds of the tongue.

(Choice A) Trigeminal nerve (CN V) somatic afferents are responsible for providing general sensation over the face; the motor branch of the trigeminal nerve (V3) innervates the muscles of mastication and the tensor tympani.

(Choice C) Palate elevation and the gag reflex involve the glossopharyngeal (CN IX) and vagus (CN X) nerves.

(Choice D) Horner's syndrome occurs due to interruption of sympathetic innervation and clinically presents with ptosis, miosis, anhydrosis, and enophthalmos. Post-synaptic sympathetic axons travel in a perivascular plexus along the carotid arteries to reach and innervate the face.

(Choice E) Taste sensation from the posterior 1/3 of the tongue is provided by the glossopharyngeal nerve (CN IX}.

A 53-year-old man comes to the office due to double vision. The patient lives in a two-story house and has had difficulty walking downstairs because he sees duplicates of every step and doesn't "know which ones are real." He does not have significant problems walking up stairs. The patient is also frustrated because he has trouble reading certain things, such as the morning newspaper and work-related documents. He has had no eye trauma, headache, focal weakness, or numbness. The patient has a history of hypertension and type 2 diabetes mellitus. He exercises regularly and does not use tobacco, alcohol, or illicit drugs. A lesion affecting which of the following structures is most likely responsible for this patient's visual symptoms?

A. Abducens nerve
B. Medial longitudinal fasciculus
C. Oculomotor nerve
D. Optic nerve
E. Trochlear nerve

This patient likely has trochlear nerve (CN IV) palsy. The trochlear nerve innervates the superior oblique muscle, which causes the eye to intort (internally rotate) and depress while adducted. The nerve is particularly susceptible to injury due to its long course and small caliber. Most cases of neuropathy are traumatic or idiopathic in origin, although a proportion of idiopathic cases may actually be due to microvascular nerve ischemia in the setting of diabetes mellitus. Patients with trochlear nerve palsy typically present with vertical diplopia, which is most noticeable when the affected eye looks down and toward the nose (e.g., up-close reading, walking downstairs). Examination may show, impairment of downgaze with the eye in the adducted position. In severe cases, the affected eye can appear vertically deviated (hypertropia). Symptoms often improve when the chin is tucked, and the head is tilted away from the affected eye as this compensates for hypertropia and extorsion.

(Choice A) The abducens nerve (cranial nerve [CNJ VI) innervates the lateral rectus, which is responsible for abduction of the eye. Palsies of this nerve can cause horizontal diplopia and inward deviation (esotropia).

(Choice B) Lesions of the medial longitudinal fasciculus are associated with internuclear ophthalmoplegia. This typically presents with impaired horizontal eye movement and weak adduction of the affected eye with simultaneous abduction nystagmus of the contralateral eye.

(Choice C) The oculomotor nerve (CN Ill) innervates the superior rectus, medial rectus, inferior rectus, and inferior oblique. These muscles collectively perform most eye movements. Palsies of this nerve can cause vertical and horizontal diplopia, ptosis, and an enlarged and nonreactive pupil.

{Choice D) The optic nerve (CN II) transmits visual information to the brain. Damage to this nerve causes loss of vision.

A 37-year-old previously healthy man comes to the office for evaluation of enlarged lymph nodes. He has an 8-week history of progressively enlarging cervical lymph nodes associated with subjective fevers, fatigue, and drenching night sweats. After initial assessment, the patient undergoes excisional biopsy of enlarged lymph nodes in the left posterior triangle of the neck. Two weeks later, during a follow-up visit, he describes difficulty with overhead activities such as combing his hair or placing dishes on overhead shelves. Examination shows a left shoulder droop with weakness of left arm abduction above the horizontal position. Other shoulder movements are normal, and there is no sensory loss. Which of the following muscles is most likely paralyzed in this patient?

A. Deltoid
B. Latissimus dorsi
C. Levator scapulae
D. Rhomboid n1ajor
E. Serratus anterior
F Trapezius

The spinal accessory nerve (CN XI) is composed of fibers from cranial and cervical spinal nerve roots. It is a pure motor nerve that passes through the posterior triangle of the neck and provides innervation to the stemocleidomastoid and trapezius. The trapezius has a large origin extending from the occipital bone and the spinous processes and ligaments of the cervical and thoracic vertebrae down to T12. It inserts on the lateral one-third of the clavicle, acromion, and spine of the scapula. The trapezius acts to elevate the scapula, rotate it upward, and stabilize the shoulder. The spinal accessory nerve follows a superficial course through the posterior triangle and is vulnerable to penetrating trauma and iatrogenic injury (e.g., from cervical lymph node dissection). Symptoms of trapezius weakness include drooping of the shoulder, impaired abduction of the arm above horizontal (due to weakness in rotating the glenoid upward), and winging of the scapula. If the injury involves the proximal portions of the nerve, weakness of the stemocleidomastoid may be seen as well.

A 67-year-old woman with a known history of lung cancer comes to the office due to hoarseness and difficulty swallowing. She has no disturbances in vision or hearing. On examination, there is loss of the gag reflex on the left side; when the patient is prompted to say "ah," the uvula deviates to the right side. Her left shoulder is drooped, and strength is reduced during left shoulder shrug testing. Chest x-ray shows a right lower lobe lung mass and several osteolytic rib lesions. MRI of the head also demonstrates multiple lesions consistent with metastasis. A lesion involving which of the following anatomical structures is most likely responsible for this patient's symptoms?

A. Cerebellopontine angle
B. Foramen magnum
C. Foramen ovale
D. Foramen rotundum
E. Hypoglossal canal
F Jugular foramen

This patient's symptoms are consistent with a lesion involving the jugular foramen, a large aperture located in the base of the skull behind the carotid canal. It is formed by the petrous portion of the temporal bone and the occipital bone. Passing through the jugular foramen are cranial nerves (CN) IX, X, and XI. Lesions of the jugular foramen (e.g., due to tumors, trauma, or infection) can result in jugular foramen (Vernet) syndrome, which is characterized by CN IX, X, and XI dysfunction. Symptoms are related to the nerve affected:

- Loss of taste from the posterior 1/3 of the tongue (CN IX)
- Loss of gag reflex (CN IX, X)
- Dysphagia (CN IX, X)
- Dysphonia/hoarseness (CN X)
- Soft palate drops with deviation of the uvula toward the normal side (CN X)
- Sternocleidomastoid and trapezius muscle paresis (CN XI)

A 66-year-old man develops transient, painless vision loss in the left eye. He has a history of hypertension, hyperlipidemia, and type 2 diabetes mellitus. Evaluation reveals significant stenosis of the left internal carotid artery due to atherosclerotic plaque. Carotid endarterectomy is performed. During the surgery, the left glossopharyngeal nerve is accidentally transected. Which of the following is most likely to be seen due to the nerve injury?

A. Deviation of the protruded tongue toward the left
B. Hoarseness due to left vocal cord dysfunction
C. Impaired taste sensation from the anterior two-thirds of the tongue
D. Loss of general sensation at the tonsillar lining
E. Reduced salivary secretion from the submandibular gland

The glossopharyngeal nerve, or cranial nerve (CN) IX, originates in the medulla and exits the cranial cavity via the jugular foramen. This nerve has numerous functions, including:
• Somatic motor: Stylopharyngeus muscle only (elevates larynx during swallowing)
• Parasympathetic: Inferior salivatory nucleus_. CN IX-, otic ganglion_. travels along auriculotemporal nerve (CN V) _. parotid gland secretion
• General sensory: Tympanic membrane (inner surface), eustachian tube, posterior third of tongue, tonsillar region, upper pharynx (afferent portion of gag reflex), carotid body, and carotid sinus, Special sensory (taste): Posterior third of tongue Glossopharyngeal nerve lesions therefore result in loss of the gag reflex (afferent limb); loss of general sensation in the upper pharynx, posterior tongue, tonsils, and middle ear cavity; and loss of taste sensation on the posterior third of the tongue.

(Choice A) Protrusion of the tongue is mediated by motor efferent fibers carried by the hypoglossal nerve (CN XII).

(Choice B) The muscles of the larynx are innervated predominantly by the vagus nerve and its branches (particularly the recurrent laryngeal
nerve).

(Choice C) Taste sensation from the anterior two-thirds of the tongue is mediated by the chorda tympani branch of the facial nerve (CN VII).

(Choice E) Salivary secretion from the submandibular and sublingual glands is mediated by parasympathetic fibers originating in the superior salivatory nucleus carried on the facial nerve (CN VII) via the chorda tympani and lingual nerves across the submandibular ganglion