Questions
1. How could a scalp infection over the parietal bone lead to a subsequent meningitis?
2. Would you expect to find blood in the cerebrospinal fluid following the intracranial laceration of the middle meningeal artery?
3. Why would the 6th cranial nerve (abducens n.) be more susceptible to dysfunction in a cavernous sinus thrombosis?
4. Which cranial nerve(s) could be affected by tumor growth into the superior orbital fissure?
5. While playing baseball, a player was struck on the right side of the head with the ball. The player fell to the ground, but did not lose consciousness. After resting for an hour and then getting up, he was seen to be confused and irritable. Later, he staggered and fell to the floor. On questioning, he was seen to be drowsy, and twitching of the lower left half of his face and left arm was noted. A diagnosis of extradural hemorrhage was made. Which artery is likely to have been damaged? What is responsible for the drowsiness and muscle twitching?
6. A 62-year-old man complained to his dentist about sudden short bouts of excruciating pain on the left side of his face. They were of about 2 months duration and had been increasing in severity. Following examination, the dentist informed him that there was no dental cause for the pain. He stated that it was probably a neurological disorder and that he should see a physician. The man told the physician that the stabbing pains, lasting 15 to 20 seconds, occurred several times a day and were so severe that he had once contemplated suicide. He said that the onset of pain seemed to be triggered by chewing and by a cold wind blowing on his upper lip. When the physician asked him to point out the area where the pains occurred, he pointed to his left upper lip, left cheek, and inferior to his left eye. He said the pain also radiated to his lower eyelid, the lateral side of his nose, and the inside of his mouth. The physician applied firm, steady pressure over the patient’s left cheek and over his infraorbital area but detected no tenderness indicative of inflammation of the maxillary sinus. Radiographs of the patient’s skull showed nothing abnormal. On evaluation, the physician detected an acuteness of sensitivity to touch (hyperesthesia) on the left upper lip and to pinpricking over the entire left maxillary region, but he found no abnormality of sensation in the forehead or mandibular regions. Diagnosis. Trigeminal neuralgia. Problems. Which branch of what major nerve supplies the area of skin and mucous membrane where the paroxysms (sudden recurring attacks) of stabbing pain were felt? Where does this nerve leave the skull? What are its branches and how are they distributed?
7. A 22-year-old medical student was struck by a puck on the left "temple" during an hockey game. He fell to the ice unconscious but regained consciousness in about 1 minute. There was some bleeding from a laceration located about 3 cm superior to his left zygomatic arch. The gash extended from the top of his auricle almost to his eyebrow. As you helped him to the bench, he said that he felt rather weak and unsteady. Realizing that he may have sustained a skull fracture, you asked a classmate to call a
physician while you took him to the dressing room. The deep tendon reflexes in his upper and lower limbs were equal. His pupils were equal in size and both contracted to light. As you waited, you observed that the injury site started to swell, but your friend otherwise seemed well. In about half an hour, he said that he was sleepy and wanted to lie down. His left pupil was now moderately dilated and reacted sluggishly to light. By the time the physician arrived, he was unconscious. The pupil on the left was widely dilated and did not respond to light, whereas the pupil on the right was slightly dilated but showed a normal reaction to light. The physician said, "We must get him to the hospital right away!" In hospital, several skull radiographs were made and a CT scan of his head was taken. As the physician was almost certain that there was an intracranial hemorrhage, she called a neurosurgeon. When the specialist arrived, the radiologist reviewed the radiographs and CT images with him. Diagnosis. Fracture of the temporal squama posterior to the pterion and an extradural (epidural) hematoma. Problem. Define the area known as the pterion. In what part of the temporal fossa is it located? Why is the pterion clinically important? What artery was most likely torn? What other vessel may have been torn? Where would the blood collect? Differentiate between an extradural and a subdural hemorrhage.

8. A 49-year-old woman developed a throbbing headache; it lasted for about 30 minutes and then slowly faded away. Similar headaches occurred occasionally for the next week. One day as she was lifting a heavy chair, she experienced a sudden, severe headache that was accompanied by nausea, vomiting, and a general feeling of weakness. She decided to see her physician immediately. The physical examination detected nuchal rigidity and an elevation in blood pressure. Visualization of her optic fundus through an ophthalmoscope showed subhyaloid hemorrhages (bleeding between the retina and vitreous body). Her deep tendon reflexes were symmetrical and all modalities of sensation were normal. On the basis of these distinct signs and symptoms, the physician made a tentative diagnosis of a subarachnoid hemorrhage. Arteriograms showed a saccular aneurysm of the anterior communicating artery. A lumbar puncture was performed. Examination demonstrated bloody CSF. After centrifugation, the supernatant fluid was xanthochromatic (yellow-colored). Diagnosis. Subarachnoid hemorrhage owing to rupture of an aneurysm in the anterior communicating artery of the cerebrarterial circle. Problems. Where would blood from the ruptured aneurysm most likely go? How do you explain anatomically the formation of subhyaloid hemorrhages? Why was the supernatant part of the CSF xanthochromatic?

**Answers**

1. Infection spread through an emissary vein to a dural sinus.
2. No—it is in the epidural space.
3. Cranial nerve VI is within the sinus and not in the wall like III, IV and V1. Therefore, CN VI is more subject to initial pressure increases within the sinus.
4. CN III, IV, V1 and VI
5. A minor blow on the side of the head can easily fracture the thin anterior part of the parietal bone or the squamous part of the temporal bone. The anterior branch of the middle meningeal artery commonly enters a bony canal in this region and is sectioned at the time of the fracture. The resulting hemorrhage causes the gradual accumulation of blood under pressure outside the meningeal layer of the dura mater. As the blood clot enlarges, pressure is exerted on the underlying brain, and the symptoms of confusion and irritability become apparent. This is followed later by drowsiness. Pressure on the lower end of the right precentral gyrus or motor area causes twitching of the facial muscles on the left and later twitching of the left arm muscles. As the blood clot progressively enlarges, the intracranial pressure rises and the patient's condition deteriorates. The accurate placing of a burr hole in the skull and the tying off of the middle meningeal artery will save the patient's life.

6. The area of skin and mucosa in which the stabbing pain was felt is supplied by the maxillary nerve, the second division of the trigeminal nerve (CN V\(^2\)). This wholly sensory nerve leaves the skull through the foramen rotundum. At its termination as the infraorbital nerve, it gives rise to branches that supply the ala (side) of the nose, the lower eyelid, and the skin and mucous membrane of the cheek and upper lip. Branches of the maxillary nerve also innervate the teeth in the maxilla and the mucous membranes of the nasal cavities, palate, mouth, and tongue. The symptoms described by this patient are characteristic of trigeminal neuralgia (tic douloureux). It occurs most often in middle-aged and elderly persons. The pain may be so intense that the patient winces; hence, the common term tic (twitch). In some cases the pain may be so severe that mental changes occur; there may be depression and even suicide attempts. The maxillary nerve distribution, as in the present case, is most frequently involved, then the mandibular, and least frequently the ophthalmic. The paroxysms of sudden stabbing pain, as in the present case, are of sudden onset and are often set off by touching the face, brushing the teeth, drinking, or chewing. Often there is an especially sensitive "trigger zone," e.g., the left upper lip in the present case. The complete cause of trigeminal neuralgia is unknown. Some persons believe the condition is caused by a pathological process affecting neurons in the trigeminal ganglion, whereas others believe that neurons in the nucleus of the spinal tract may be involved. Medical or surgical treatment, or both are used to alleviate the pain. Only the anatomical aspects of these treatments are discussed here. Attempts were made to block the nerve at the infraorbital foramen by using alcohol; this usually gives temporary relief of pain. The simplest surgical procedure is avulsion or cutting of the branches of the nerve at the infraorbital foramen. Radiofrequency selective coagulation of the trigeminal ganglion by a needle electrode passing through the cheek and the foramen ovale is also used. To prevent regeneration of nerve fibers, the sensory root of the trigeminal nerve may be partially cut between the ganglion and the brain stem (rhizotomy). Although the axons may regenerate, they do not do so within the brain stem. Attempts are made to differentiate and cut only the sensory fibers to the division of the trigeminal nerve involved. The same result may be achieved by sectioning the spinal tract of CN V (tractotomy). After this operation the sensation of pain, temperature, and simple (light) touch are lost over the area of skin.
and mucous membrane supplied by the maxillary nerve. This may be annoying to the patient who does not recognize the presence of food on the lip and cheek or feel it within the mouth on the side of the nerve section, but these disabilities are preferable to the excruciating pain.

7. The temple is the area between the temporal line and the zygomatic arch, where the skull is thin and is covered by the temporalis muscle and the temporal fascia. The blood vessels of the temple are very numerous. The pterion is a somewhat variable H-shaped area that lies deep to the temporalis muscle. Here, four bones approach each other or meet (frontal, parietal, temporal, and sphenoid). The pterion is an important bony landmark because it indicates the location of the frontal branch of the middle meningeal artery. The center of the pterion is 4 cm superior to the zygomatic arch and 3.5 cm posterior to the frontozygomatic suture. It lies in the anterior part of the temporal fossa. The thin squamous part of the temporal bone is grooved by the middle meningeal artery and its branches. The temporal squama is easy to fracture, and the broken pieces may tear the artery and its branches as they pass superiorly on the external surface of the dura mater. This results in a slow accumulation of blood in the extradural space, forming an extradural hematoma (epidural hematoma). The hematoma forms relatively slowly because the dura is firmly attached to the bone by Sharpey fibers. These fibers resist stripping of the dura from the bone to a certain extent. A subdural hematoma is a localized mass of extravasated blood that is located on the surface of the brain, deep to the dura. The middle meningeal artery, a branch of the first part of the maxillary artery, enters the skull through the foramen spinosum. It divides within the first 4 or 5 cm of its intracranial course. The frontal branch passes superiorly from the pterion, more or less parallel to the coronal suture of the skull. The parietal branch passes posterosuperiorly, with its exact site depending on its point of origin. In the present case, the frontal branch of the middle meningeal artery was almost certainly torn. This artery is usually accompanied by a meningeal vein which may have also been torn. The lucid interval that followed the patient's recovery from the brief loss of consciousness (resulting from cerebral concussion) occurs because of the slow formation of the extradural (epidural) hematoma. In addition, this kind of a space-occupying intracranial lesion can be tolerated for a short time because some blood and CSF are squeezed out of the calvaria through the veins and subarachnoid space. However, as the cranium is nonexpansible, the intracranial pressure soon rises, producing drowsiness and then coma. The increased intracranial pressure forces the supratentorial part of the brain, usually the uncus, through the tentorial incisure, squeezing the oculomotor nerve (CN III) between the brain and the sharp, free edge of the tentorium. Compression of CN III causes third nerve palsy, which results in a dilated, nonreacting pupil on the side of the lesion. An extradural hemorrhage in the characteristic position, illustrated by the present case, primarily causes compression of the temporal lobe underlying the pterion. Immediate surgical intervention is necessary to relieve the intracranial pressure so that further compression of the brain will not occur, which could cause death by interfering with the cardiac and respiratory centers in the medulla.
8. Unruptured saccular aneurysms are usually asymptomatic. In the present case the initial headaches were probably caused by intermittent enlargement of the aneurysm or by slight bleeding from it into the subarachnoid space (the so-called warning leak). Her subsequent severe, almost unbearable headache was the result of gross bleeding from the aneurysm into the subarachnoid space. Blood in the CSF causes meningeal irritation, which produces a headache. As the anterior communicating artery is in the longitudinal fissure, rostral to the optic chiasma, blood escaping from the ruptured aneurysm would enter the chiasmatic cistern and other subarachnoid spaces around the brain and spinal cord. This explains why there was blood in the CSF obtained by lumbar puncture. Some authorities recommend against a lumbar puncture in a case of subarachnoid hemorrhage that is so obvious as the present case because of the possibility of causing herniation of the brain. The lowering of CSF pressure in the spinal subarachnoid space by removing CSF might cause inferior movement of the brain resulting in herniation (e.g., of the cerebellar tonsils). Rupture of an aneurysm of the anterior communicating artery into the adjacent part of one frontal lobe may cause symptoms of a mass lesion in one hemisphere. In some cases, the intracranial hematoma may break into the ventricular system, causing an acute expansion of the ventricle, and may cause death. Blockage of subarachnoid spaces by large amounts of blood in the CSF could impair circulation of this fluid, resulting in a further increase in intracranial pressure. This could force the medial part of the temporal lobe (usually the uncus) through the tentorial notch and the cerebellar tonsils through the foramen magnum. Herniation of the cerebellar tonsils compresses the medulla containing the vital respiratory and cardiovascular centers and produces a life-threatening situation. The subhyaloid hemorrhages observed during funduscopic examination resulted from the abrupt rise in intracranial pressure transmitted to the subarachnoid space around the optic nerve. This compressed and obstructed the central retinal vein where it crosses this space. This results in increased pressure in the retinal capillaries and hemorrhages between the retina and vitreous body. After centrifugation of the CSF, the supernatant fluid was yellow because it contained serum bilirubin and products of hemolyzed red blood cells.

**Cases without printed interpretations**

*Patient Mark M.* This 16-year old motorcyclist was brought to the emergency room following a collision with a car. Among other injuries, he has a skull fracture of his left parietal bone, a depressed fracture of the left zygoma (“cheek bone”), a broken nose, and severe lacerations on his scalp and face on the left. You accompany your clinical tutor, a plastic surgery specialist, who is treating this case. You assist in the repositioning of the zygoma and nose and suturing of the skin. Three days later when you visit him, he has bilateral blackened eyes and is unable to completely close his left eye. Sensation to the skin over the scalp and face is found to be normal 10 days after the accident, but the orbicularis oculi muscle encircling the left eye remains weak and the lower eyelid droops.
• Patient Andrew W. This young driver suffered a closed head injury following a collision with another car. He arrives in the emergency room in a semicomatose state. An x-ray reveals a skull fracture in the temporal area and an underlying epidural hematoma. The neurosurgeon, whom you assist, removes a core of cortical bone from the calvaria overlying the hematoma and flushes the extravasated blood from the epidural site. He also ligates a lacerated middle meningeal artery to prevent further bleeding. The next day, the patient is recovering normal consciousness and is expected to be discharged in a few days.

• Patient John R. This 20-year-old farmer’s son, home from college for the summer, began feeling severely dizzy and developed headaches during the day while working on a tractor. He told his father he thought he was going blind. The headaches became so severe that he was admitted to the neurology clinic of the University Medical Center. Radiology quickly revealed the presence of an abnormal mass in the hypophyseal (pituitary) fossa. The neurosurgeon called in on the case plans to explore and remove a pituitary tumor believed by all to be the diagnosis. As your clinical tutor, he quizzes you on the anatomy of the middle cranial fossa, relationship of all the nerves and venous sinuses surrounding the hypophysis (pituitary gland), and the possible surgical approaches to the area through the nasal cavity, orbit, forehead, or temporal region.

• A patient presents with the following symptoms: inability to completely close his left eye, excessive tearing from his left eye, and saliva dripping from the left corner of his mouth. The physician finds taste deficiencies at the anterior two-thirds on the left side of the patient's tongue. She also notices that the patient grimaces when loud noises occur (hyperacusis, hypersensitivity to loud sounds). What cranial nerve is damaged? Where along the path of the nerve did the damage most likely occur? If all of the symptoms existed except hyperacusis, where along the path of the nerve did the damage most likely occur?

• A boy drove into a low branch while riding his dirt-bike resulting in a deep laceration to his scalp. His mother brought him to the doctor the next day worried that the cut did not appear to be healing well. Give an anatomical reason for why deep lacerations to the scalp gape widely and bleed profusely?

• A teenager had a habit of picking the spots on her face, particularly those around her nose. Although one spot above her right upper lip became infected, she continued to pick at it. Several days later, she became very ill and was admitted to the hospital complaining of drowsiness, high temperature, headache and nausea. Her right eye was swollen and she complained of double vision (diplopia) when looking to the right. The physician diagnosed thrombophlebitis of the cavernous sinus. How was the infection on the face related to that in the cavernous sinus?

• While participating in a bar room brawl, a man was inadvertently poked in the nose with a long object. Afterwards, there was a continuous oozing of fluids from the nose. The
color of the fluid gradually changed from red to strawberry to straw color. What is the fluid?