Anatomy of the cranial nerves

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Abstract

The cranial nerves are described, emphasizing their intracranial and extracranial relationships. Their function and distribution are emphasized as is the assessment of their integrity. A summary of how their clinical assessment is made and the consequences of their most common pathology are included. Their relevance in the diagnosis of brainstem death is made. Learning objectives focus on the practicalities of diagnosing brainstem death.

Keywords Assessment of cranial nerves; cranial nerves; distribution of cranial nerves; injury

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Learning objectives

After reading this article you should be able to:

- list the contribution of the examination of the cranial nerves to the diagnosis of brainstem death
- describe the results of injury to the recurrent laryngeal nerve and the superior laryngeal nerve
- describe the cutaneous distribution of the three divisions of the trigeminal nerve (CN V).

The cranial nerves

The 12 pairs of cranial nerves (CNs) originate in the brain and leave the cranial cavity through its basal foramina. Each has motor and sensory fibres. The attachments of the nerves to the brainstem are shown in Figure 1.

CN I The olfactory nerve

The olfactory nerve is an outgrowth of the forebrain and supplies the upper olfactory mucous membrane. Its fibres originate in the mucosa and join to form 15–20 bundles, which pass through the cribriform plate of each ethmoid to reach the olfactory bulb. There is an extension of the meninges surrounding them. Fractures of the anterior cranial fossa involving the cribriform plates may be accompanied by a loss of cerebrospinal fluid (CSF) from the nose (rhinorrhoea) and, if the nerves are also damaged, long-term anosmia.

CN II The optic nerve

The fibres of the optic nerve originate in the ganglion layer of the retina and converge on the posterior part of its vitreous surface. They emerge through the posterior part of the eyeball as the optic nerve and pass through the orbit and optic canal surrounded by CSF and the meninges to the middle cranial fossa. There it decussates with that of the opposite side to form the optic chiasma where the nasal retinal fibres decussate. The chiasma lies above and anterior to the pituitary gland. The macula, the most sensitive part of the retina, accounts for about 25% of the visual cortex. The nerve within the orbit is surrounded by a cone of extraocular muscles. The ciliary ganglion is posterolateral, and the ophthalmic artery and nasociliary nerve medial. The central artery of the retina (a branch of the ophthalmic artery) enters the nerve in this part of its course. The intracranial course is short and lies on the sphenoid bone medial to the internal carotid artery.

An increase in CSF pressure within the meningeal sheath causes venous stasis and oedema (swelling) of the optic nerve and retina, recognized ophthalmoscopically as papilloedema. Visual defects may result from pressure on the optic nerves or chiasma from pituitary tumours or aneurysms of the internal carotid arteries. Figure 2 illustrates the specific visual field defects that follow section of the optic nerves, optic chiasma and optic tracts.

CN III The oculomotor nerve

The oculomotor nerve has somatic motor and parasympathetic motor fibres. The somatic fibres supply the extraocular muscles, except for superior oblique and lateral rectus. The parasympathetic fibres synapse in the ciliary ganglion and supply sphincter pupillae (papillary constriction) and the ciliary muscle (accommodation). The nerve leaves the midbrain between the cerebral peduncles and passes through the posterior and middle cranial fossae to divide into superior and inferior divisions near the superior orbital fissure.

In the posterior cranial fossa the nerve is close to the tentorium cerebelli. In the middle cranial fossa it passes forwards on the lateral wall of the cavernous sinus. Its superior division traverses the superior orbital fissure within the tendinous ring of the extraocular muscles and supplies superior rectus and levator palpebrae superioris. The inferior division also passes through the fissure, and supplies medial and inferior recti and inferior oblique muscles. It also carries a parasympathetic branch to the ciliary ganglion.

Its close relationship to the edge of the tentorium cerebelli means that the oculomotor nerve may be damaged when lateral shift of the brain occurs, such as may follow an intracranial haemorrhage. One of the earliest localizing signs of this may be a selective palsy of the parasympathetic fibres causing dilatation of the pupil due to damage to the parasympathetic fibres passing to the ciliary ganglion.

Signs of a complete palsy of the nerve are ptosis (drooping eyelid), loss of pupillary light reflexes, dilatation of pupil, abduction and downward deviation of eye because of unopposed action of superior oblique and lateral rectus muscles, and loss of accommodation in the eye because of paralysis of ciliary muscles (Figure 3).

CN IV The trochlear nerve

This is the thinnest cranial nerve and supplies the superior oblique muscle. Emerging from the lower dorsal midbrain, the

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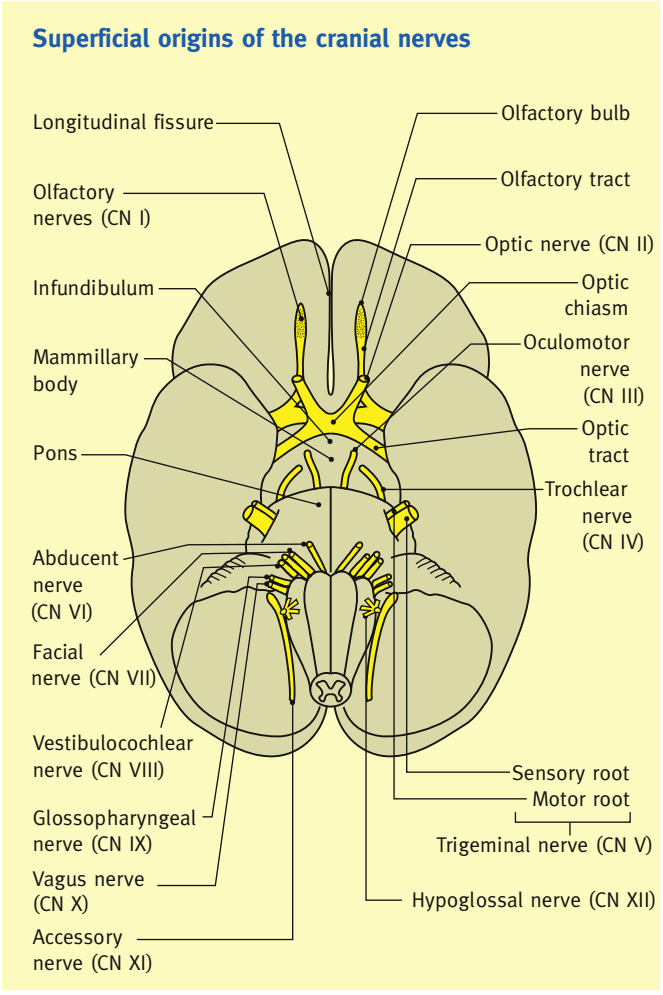

Figure 1

nerve passes forwards through the posterior and middle cranial fossae to enter the orbit through the superior orbital fissure.

In the posterior cranial fossa it passes forwards around the midbrain, following the edge of the tentorium, lateral to the oculomotor nerve. In the middle cranial fossa it lies in the lateral wall of the cavernous sinus. It traverses the superior orbital fissure and gains the roof of the orbit to supply the superior oblique muscle. The nerve has a long intracranial course and may be injured if a severe head injury and intracranial bleeding produces lateral shift of the brain. If the superior oblique muscle is paralysed and no other extraocular muscle is affected (this is rare), then diplopia occurs when the patient is looking downwards. The affected eye is pulled downwards only by the inferior rectus and thus in a slightly different direction to that of the uninjured side.

CN V The trigeminal nerve

The trigeminal nerve conveys somatic sensory and visceral motor fibres. The sensory fibres innervate the anterior part of the scalp and the dura, the face, nasopharynx, nasal and oral cavities, and the paranasal air sinuses. They are derived from cell bodies in the trigeminal ganglion and form a large sensory root from which fibres enter the lateral side of the pons. The motor fibres emerge from the pons as a smaller motor root and supply the muscles of mastication. The dural sheath containing the two roots crosses the petrous bone from the posterior into the middle cranial fossa.

The trigeminal ganglion, which can be thought to be equivalent to the dorsal sensory ganglion of a spinal nerve, is crescent-shaped and lies partly within an evagination of the dura mater of the middle cranial fossa, the cavum trigeminale. The motor root of the nerve and the greater superficial petrosal nerve both lie deep to the ganglion. Above it lies the temporal lobe of the cerebrum, medially is the internal carotid artery and the cavernous sinus. The dural sheath partially enveloping the nerve fuses with that of the middle cranial fossa to form the lateral wall of the cavernous sinus. It covers only the posterior half of the ganglion so that the posterior half of the ganglion and the sensory and motor roots are bathed in CSF. The ganglion receives ophthalmic, maxillary and mandibular divisions from their wide peripheral distribution. The motor root passes by the ganglion to join the mandibular division.

The ophthalmic division: the ophthalmic division is the smallest division, passes forwards on the lateral wall of the cavernous sinus and, near the superior orbital fissure, divides into lacrimal, frontal and nasociliary nerves, which each pass through the fissure into the orbit.

- The lacrimal nerve supplies the lacrimal gland and supplies the skin and conjunctiva of the lateral part of the upper lid and adjacent conjunctiva. Parasympathetic secretomotor fibres are carried to the gland by a branch of the zygomaticotemporal nerve.
- The frontal nerve divides into supraorbital and supratrochlear nerves. The former leaves the orbit by the supraorbital notch to supply the upper eyelid, frontal sinuses and scalp as far back as the vertex. The supratrochlear nerve supplies the skin of the upper eyelid and medial forehead.
- The nasociliary nerve traverses the superior orbital fissure to gain the medial wall of the orbit, where it divides into anterior and posterior ethmoidal, infratrochlear and ciliary nerves.
- The ethmoidal nerves leave the orbit through a foramen on its medial wall to reach the anterior cranial fossa, and descend through the cribriform supplying anterior cranial fossa dura, ethmoidal and sphenoidal air sinuses, the upper anterior nasal cavity and the skin of the tip of the nose.
- The infratrochlear nerve supplies the medial part of the upper eyelid, conjunctiva and adjacent nose and the long ciliary nerves supply the sclera and cornea. Sympathetic fibres are conveyed to the dilator pupillae muscle. Ophthalmic herpes zoster (shingles) involving the corneal branch gives a sensory loss that may lead to ulceration of the cornea.

The maxillary division: the maxillary division passes forwards through the middle cranial fossa, for a short distance in the cavernous sinus to the pterygopalatine fossa, where the pterygopalatine ganglion is attached to it. It then passes through the inferior orbital fissure to become the infraorbital nerve.

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