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Performing a cranial nerve examination and interpreting the findings

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Abstract Cranial nerve examination forms an essential part of neurological examination and is vital to identify abnormalities relating to an array of cranial pathologies. It can be performed in various settings by multidisciplinary team members to ensure the timely identification of signs and symptoms relating to neurological conditions. This article, the eighth in a series on advanced assessment and interpretation, provides a step-by-step guide to performing a systematic cranial nerve examination. Each cranial nerve has its own unique function. This is discussed, with detailed instructions on methods of testing and potential findings, to give practitioners insight into this form of examination and how to apply these techniques confidently in the settings in which they work.

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The nervous system is a complex system that responds to changes in the internal and external environment to coordinate a response in various other systems in the body (Crossman and Neary, 2019). It has a huge array of functions, including being responsible for higher mental functions – such as memory, personality and emotions – as well as processing sensory information and instigating a motor response (Tortora and Derrickson, 2020).

There are two main elements:
- The central nervous system (CNS);
- The peripheral nervous system (PNS).

The CNS comprises the brain and spine, while the PNS links the CNS with the peripheries of the body.

The nervous system is vast and complex, but practitioners need a basic understanding of it to help them recognise and treat a wide range of neurological conditions. The National Institute for Health and Care Excellence (2023) details many neurological presentations that need referral to specialist services. This makes an understanding of neurological examination essential in all settings to meet patients' needs.

Although there are many neurological assessments, one examination that is critical in this domain is the cranial nerve examination. It is integral to any neurological assessment and can be performed in a variety of environments (including pre-hospital, emergency department and inpatients) to identify a number of neurological conditions. When linked with a detailed history, cranial nerve examination can provide additional information to:
- Support or refute a differential diagnosis;
- Guide further investigation or referral to another speciality, such as neurosurgery or neurology.

Key findings from a well-performed examination can also benefit the long-term management of a patient when assessing the effectiveness of treatment.

Advanced practitioners

This series is aimed at nurses and midwives working at, or towards, advanced practice. Advanced practitioners are educated at master's level and are assessed as competent to make autonomous decisions in assessing, diagnosing and treating patients. Advanced assessment and interpretation is based on a medical model, and the role of advanced practitioners is to integrate this into a holistic package of care.

Cranial nerves

Cranial nerves originate in the brain in the cranial cavity (Tortora and Derrickson, 2020). There are 12 pairs with a primary function of receiving information from, and controlling the structures of, the head and neck (Crossman and Neary, 2019). Their role is;
- Afferent (sensory);
- Efferent (motor);
- A mixture of both.

They are identified by individual names and roman numerals in order of attachment to the brain from anterior to posterior (Tortora and Derrickson, 2020). Each nerve has its own specific functions, so examination can indicate a potential diagnosis and guide further investigations.

Olfactory nerve (cranial nerve I)

The olfactory nerve is purely sensory and involved in the sense of smell. Receptors of this nerve project into the nasal cavity and send impulses via the olfactory nerve to the olfactory bulbs (Tortora and Derrickson, 2020).

Examination

Examine the patient as follows:
- Test perception and identification of aromatic non-irritant substances, such as soap;
- Test each nostril separately.

Abnormal findings

As long as nasal congestion has been ruled out, anosmia (loss of sense of smell) may result from head injury or skull base tumour.

Fig 1. **Confrontation testing***

1a. Left eye upper temporal visual field **1b.** Left eye middle temporal visual field **1c.** Left eye lower temporal visual field

1d. Left eye lower nasal visual field **1e.** Left eye middle nasal visual field **1f.** Left eye upper nasal visual field

*Examiner is facing the camera

Optic nerve (cranial nerve II)

The optic nerve is purely sensory and transmits signals from the eye to the visual cortex. Optic nerves originate at the retina of each eye and transit through the optic foramen to form the optic chiasm (Tortora and Derrickson, 2020). In the optic chiasm, the part of the nerve from the medial side of the eyes (responsible for temporal vision) crosses to the opposite side; the portion of the nerve serving the lateral part of the eye remains on the same side (Tortora and Derrickson, 2020).

Behind the optic chiasm, some of the nerve fibres from each eye form the optic tracts, which terminate in the thalamus (Dover et al, 2023). Optic radiations are then formed, which travel through the parietal and temporal lobes of the brain, and end in the cerebral cortex where visual information is analysed (Dover et al, 2023).

Examination

Examine the patient as follows:

- Assess visual acuity using a Snellen chart (test at 6m distance). Test each eye individually with visual aids worn if needed;
- Test colour vision using Ishihara plates;
- Conduct visual field testing by confrontation, as follows:
  - Sit or stand directly facing the patient (approximately 1m away) and test each eye individually;
  - Ask the patient to look directly at you and not move their head;
  - Instruct them to cover one eye (you cover your opposing eye);
  - Hold out your arm equidistant between you and the patient, ensuring you can see your own finger;
  - Wiggle your finger and ask the patient to say when they can see it. If the patient is unable to see your finger, slowly move it towards the patient's centre of vision from the periphery until it is in the patient's field of vision;
  - Perform this in three different positions for the lateral (temporal) and medial (nasal) fields per eye, as shown in Figs 1a -1f;
- Assess pupils for size, shape and equality;
- Test pupillary reaction to light, both direct and consensual. Shine a light into the eye. The pupil into which the light is shone should constrict (direct) and the pupil in the opposite eye should also constrict (consensual);
- Test accommodation. Ask the patient to focus on a distant object, then bring your finger into their line of sight and ask them to change their focus to this. Then move your finger towards their nose. Observe the patient's eyes for convergence (both eyes moving inwards and pupillary constriction).

Abnormal findings

Abnormal findings vary depending on the location of abnormality on the visual pathway. Fig 2 shows the different types of visual field defect that are associated with the location of a leison. Pathology causing optic nerve deficit includes tumour, vascular abnormality, infection (cerebral abscess) and trauma.

Oculomotor nerve (cranial nerve III), trochlear nerve (cranial nerve IV) and abducens nerve (cranial nerve VI)

The oculomotor, trochlear and abducens nerves are exclusively motor nerves that are concerned with eye movement. The oculomotor nerve also innervates the

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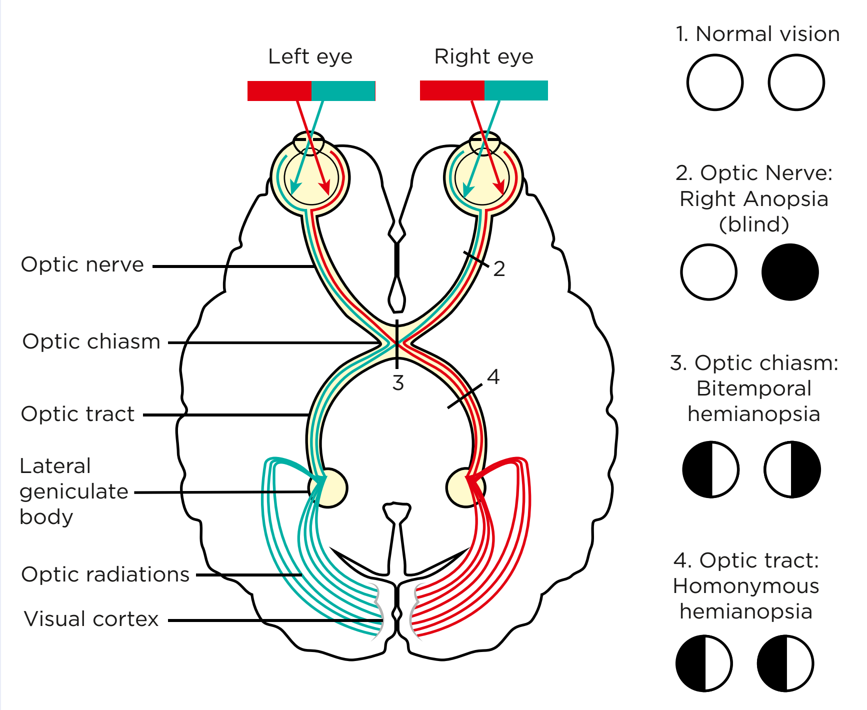
Fig 2. **Visual pathway with deficit associated with location of lesion**



Source: Human Physiology Academy (2014)

upper eyelid and provides the motor response for light reflex and accommodation, which is tested as part of the optic nerve examination. In terms of eye movements, the oculomotor nerve controls the following muscles and associated eye movement direction:

- Medial rectus – medial eye movement (adduction/inwards);
- Inferior oblique – looking up and in;
- Superior rectus – looking up and out;
- Inferior rectus – looking down and out (Lindsay et al, 2010).

This leaves only two other directions of eye movement:

- Looking down and in – controlled by the trochlear nerve, which controls the super oblique muscle;
- Lateral movement (abduction/outwards) – controlled by the abducens nerve, which controls the lateral rectus muscle (Lindsay et al, 2010).

Examination

Examine the patient as follows:

- Sit facing the patient, approximately 1m away;
- Observe for ptosis (drooping of upper eyelid);
- Ensure patient keeps their head still during the examination;
- Hold your finger or an object at the centre of the patient's vision approximately halfway between you and the patient;
- Move your finger in a HH pattern, asking the patient to remain focused on your finger while following it with their eye movement (Fig 3);
- Observe for nystagmus (involuntary oscillation of the eyes) and ask the patient to comment if they experience diplopia (double vision).

Fig 3. **Testing the oculomotor, trochlear and abducens nerve**

Hold a pen torch as an object and move in an HH pattern

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Abnormal findings

Nystagmus is usually synchronous and rhythmic (Dover et al, 2023). It can be in various directions – vertical, horizontal, rotary or multidirectional – and generally has a fast and slow phase (Bickley et al, 2023). While nystagmus can be a normal finding at the extremes of gaze, it can also be associated with cerebellar lesions, vestibular-related causes, multiple sclerosis and lesions of the upper brain stem (Dover et al, 2023).

Diplopia occurs due to a nerve palsy affecting one or more of the nerves relating to eye movement. These palsies can be caused by a lesion in the brain stem, either where the nerve originates or along the peripheral tract, and are as follows:

- Complete oculomotor nerve palsy – this presents as a drooping upper eyelid, a dilated pupil that is unresponsive to light and an inability to move the eye in a down, up and inward direction (Crossman and Neary, 2019);
- Trochlear nerve palsy – results in an inability to move the eye in an inwards and downwards direction;
- Abducens nerve palsy – affects outwards eye movement.

Other causes of diplopia include tumour, aneurysm and increased intracranial pressure (Crossman and Neary, 2019).

Trigeminal nerve (cranial nerve V)

The trigeminal nerve has both a sensory and motor function, and is divided into three branches that are responsible for carrying signals relating to touch, pain and temperature. Each branch serves the various areas of the head, as follows:

- Ophthalmic branch – forehead, upper eyelid, side of the nose and eyeball;
- Maxillary branch – lower eyelid, upper lip, mucosa of the nose and upper teeth;
- Mandibular branch – skin over the mandible and immediately anterior to the ear; anterior two-thirds of the tongue and lower teeth (Tortora and Derrickson, 2020).

The motor function of the trigeminal nerve relates to the mandibular branch and the supply of motor impulses to the masseter and temporalis muscles involved in the motion of chewing (Tortora and Derrickson, 2020). Additionally, the trigeminal nerve also has reflex connections to groups of motor cells in the brain stem (Crossman and Neary, 2019). These include the corneal reflex, which is provoked by light touch of the cornea and jaw jerk, in which percussion of the mandible stimulates the masseter and temporalis muscles (Crossman and Neary, 2019).

Fig 4. **Bilateral assessment of the ophthalmic, maxillary and mandibular branches**

4a. Testing the right ophthalmic branch to soft touch

4b. Testing the right maxillary branch to soft touch

4c. Testing the right mandibular branch to soft touch

4d. Testing the right ophthalmic branch to pin prick

4e. Testing the right maxillary branch to pin prick

4f. Testing the right mandibular branch to pin prick

Fig 5. **Assessing the masseter and temporalis muscles**

5a. Testing the masseter muscles

5b. Testing the temporalis muscles

Fig 6. **Testing jaw jerk**

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Examination
Examine the patient as follows:
- Ask the patient to close their eyes;
- Touch their skin in each of the areas relating to the ophthalmic, maxillary and mandibular branches bilaterally (Figs 4a-4f);
- Ask the patient to respond each time they feel the sensation and check this is appropriate to the type of stimulus applied;
- Test using a wisp of cotton wool or tissue for soft touch and a neurological pin for pain;
- Ask the patient to clench their teeth;
- Feel the masseter and temporalis muscles to assess bulk (Figs 5a and 5b).

To assess corneal reflex:
- Ask the patient to look up;
- Gently pull down their lower eyelid, then touch the cornea with a wisp of wet cotton wool.

You should see the patient give a bilateral blink response.

The corneal reflex test is the most sensitive one when it comes to predicting trigeminal nerve damage (Lindsay et al, 2010).

To assess jaw jerk:
- Ask the patient to open their mouth and relax their jaw;
- Place your finger on their chin and gently tap your finger with a tendon hammer (Fig 6).

A normal response is no jaw movement or a slight closing of the jaw.

Fig 7. **Assessing the facial nerve**

7a. Testing the frontalis muscle

7b. Testing the orbicularis oculi muscle – perform the test on both eyes (this can be done simultaneously)

7c. Testing the buccinator muscles

7d. Testing the orbicularis oris muscles

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Abnormal findings
Unilateral loss of sensation in one or more branches can be due to facial trauma or malignant lesion invasion (Dover et al, 2023). Herpes zoster infection (shingles) can affect the trigeminal nerve in any branch; it results in pain and the presence of vesicles in the distribution of the nerve affected (Crossman and Neary, 2019).

Facial nerve (cranial nerve VII)
The facial nerve has both sensory and motor components. The sensory element originates at the taste buds of the anterior two-thirds of the tongue and supplies signals on the sensation of taste (Tortora and Derrickson, 2020). The motor aspect innervates multiple muscles in the neck and middle ear and – from an examination perspective – the muscles of facial expression.

Importantly, motor signals that supply the facial nerve originate from the motor cortex of the brain and travel to the facial nerve via the corticobulbar tract (Crossman and Neary, 2019). This tract spanning from the motor area of the brain bilaterally innervates the upper face via the facial nerve, while the lower part of the face is supplied by the opposite side of the brain only. Understanding this variation is key to ascertaining whether the facial nerve abnormality originates in the brain before it connects with the facial nerve or in the facial nerve itself.

Examination
Examine the patient as follows:

- Instruct the patient to frown or look up, resulting in muscle movement of the forehead (frontalis muscle). Observe for asymmetry (Fig 7a);
- Ask the patient to close their eyes (which uses the orbicularis oculi muscle) then, as the examiner, try to open them against resistance. Assess for weakness (Fig 7b);
- Instruct the patient to puff out their cheeks and purse their lips (which uses the buccinator muscles) then, as the examiner, press their cheeks and assess for air leaking from the lips (Fig 7c);
- Ask the patient to show their teeth (which uses the orbicularis oris muscle) (Fig 7d). Observe for asymmetry.

Abnormal findings
A unilateral facial nerve palsy involving the upper and lower parts of the face is called a lower motor neurone palsy; it is caused by an issue with the facial nerve itself (Bickley et al, 2023). Bell's palsy is an idiopathic condition that presents in this way but should always be a diagnosis of exclusion. Other causes of unilateral lower motor neurone palsy are trauma involving a temporal bone fracture, Ramsay Hunt syndrome and parotid gland abnormalities. Stroke, affecting the motor cortex of the brain, results in a contralateral lower facial weakness with sparing of the forehead (Greenberg, 2023).

Vestibulocochlear nerve (cranial nerve VIII)
The vestibulocochlear nerve is a sensory nerve that carries signals relating to hearing, head position and movement. The nerve is split into two branches:

- Vestibular branch – carries impulses involved in equilibrium;
- Cochlear branch – carries impulses relating to hearing (Tortora and Derrickson, 2020).

Examination
Examine the patient as follows:

- Test hearing by whispering numbers in one of the patient's ears while occluding/rubbing the tragus (small bump in front of the ear canal) of their other ear and asking them to repeat the numbers. Test at approximately 15cm and 60cm distance, examining each ear individually;
- Directly examine the auditory canal and tympanic membrane to assess for wax or infection. Perform Rinne's and Weber's tests, if needed, to differentiate between conductive and sensorineural hearing loss (this is not part of the cranial nerve examination and may require referral to the ears, nose and throat team).

Abnormal findings
Damage to the vestibular branch may result in vertigo, ataxia or nystagmus; injury to the cochlear branch can present as deafness or tinnitus (Tortora and Derrickson, 2020). Acoustic neuroma (tumour) is a pathology causing compression of the vestibulocochlear nerve that results in symptoms including dizziness and hearing loss (Crossman and Neary, 2019).

Glossopharyngeal nerve (cranial nerve IX) and vagus nerve (cranial nerve X)
The glossopharyngeal and vagus nerves have both sensory and motor actions, and are examined together owing to their close association in function.

The glossopharyngeal nerve is involved in sensing taste and sensation in the posterior third of the tongue, and in proprioception of the muscles relating to swallowing

Fig 8. **Testing the trapezius muscle**

Fig 9. **Testing the sternocleidomastoid muscles**

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(Tortora and Derrickson, 2020). It also has a role in the transfer of signals for monitoring blood pressure, oxygen levels and carbon dioxide in the blood, and the control of breathing effort (Tortora and Derrickson, 2020). From a motor perspective, it has a role in speech and control of the pharynx during swallowing (Tortora and Derrickson, 2020).

The vagus nerve transports sensory nerve impulses from the pharynx, larynx and oesophagus (Crossman and Neary, 2019). Like the glossopharyngeal nerve, it also conveys signals relating to blood pressure, oxygen and CO_2 levels, and breathing rate and effort (Tortora and Derrickson, 2020). It has a further role in sensation transmission of the thoracic and abdominal organs and in autonomic function in relation to contraction of the gastrointestinal tract and slowing of the heart rate (Tortora and Derrickson, 2020).

In terms of motor function, the vagus nerve transmits signals that instigate swallowing, coughing and voice production (Tortora and Derrickson, 2020).

Examination

Examine the patient as follows:

- Note the patient's voice and ask whether they have noticed any changes;
- Note any swallowing difficulties – ask the patient to swallow a small amount of water;
- Ask the patient to open their mouth and say 'aaah'. Inspect the soft palate for equal rise each side and for uvula (the fleshy extension at the back of the soft palate hanging above the throat) deviation. The uvula will deviate away from the side linked to the problem;
- Test the patient's gag reflex by touching the soft palate/pharynx with a tongue depressor.

Professional responsibilities

This procedure should be undertaken only after approved training, supervised practice and competency assessment, and carried out in accordance with local policies and protocols.

Abnormal findings

Damage to the vagus nerve can be caused by tumour or neck surgery. Motor neurone disease can cause difficulty swallowing and problems with phonation (production of speech sounds) and articulation (Crossman and Neary, 2019). Skull base tumours and skull base fractures can cause one-sided glossopharyngeal and vagus nerve deficit (Dover et al, 2023). Stroke at the brain stem can cause glossopharyngeal and vagus nerve palsy.

Accessory nerve (cranial nerve XI)

The accessory nerve has only motor function and is involved in moving the muscles that control head movement. These include the trapezius muscle (large triangular muscle in the nape and upper back) and sternocleidomastoid muscle (paired muscle in the front portion of the neck).

Examination

Examine the muscles for wasting as follows:

- Trapezius muscle – place your hands on the patient's shoulders and ask them to shrug their shoulders. Assess for weakness (Fig 8);
- Sternocleidomastoid muscle – place your hand on the patient's cheek and ask them to turn their head against your hand while you provide resistance to the movement (Fig 9). Test with the patient turning their head left and right. Note any weakness.

Abnormal findings

Local tumour, neck surgery and motor neurone disease may cause palsy of the accessory nerve, causing weakness in raising the shoulders or turning the head (Dover et al, 2023).

Hypoglossal nerve (cranial nerve XII)

The hypoglossal nerve has purely motor function and controls the tongue muscles.

Examination

Examine the patient as follows:

- Ask the patient to open their mouth and assess the tongue at rest for wasting and involuntary movements;
- Ask the patient to stick out their tongue and look for deviation to the left or right. The direction of deviation indicates the side of the problem.

Abnormal findings

A local tumour affecting one side of the hypoglossal nerve results in wasting of the tongue and deviation to the side of wasting (Dover et al, 2023). Tremor involving the tongue may be due to Parkinson's disease (Dover et al, 2023). Spasticity of the tongue can be a sign of motor neurone disease (Crossman and Neary, 2019).

Conclusion

Cranial nerve examination is an essential skill for advanced clinical practitioners across a variety of settings. Understanding the pathology and potential associated signs and symptoms of neurological conditions is vital when linking these to examination findings and formation of a differential diagnosis. This equally requires a well-structured and accurate approach to examination to support the identification of the most pronounced and subtle findings. This contributes to a comprehensive neurological assessment and supports the management or referral to definitive care. **NT**

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