Big Bits and Little Tips of the Veterinary Neurological Examination

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Abbreviations: Neuro Exam = NEX, Neuroanatomical localisation = NAL, nervous system = NS, peripheral nervous system = PNS, central nervous system = CNS, spinal cord = SC, upper motor neuron = UMN, lower motor neuron = LMN, cranial nerves = CNN, neuromuscular junction = NMJ; cutaneous trunci reflex = CTR, Cervical = C, Thoracic = T, Lumbar = L, Sacral = S, vestibular disease = VD

Overview

Aim of a NEX: To identify

- if neurological disease is present
- if the disease is focal, multifocal or diffuse
- the NAL – needed because
    - diseases are region specific
    - can target diagnostic imaging
- See Figure 1

Key points:

- Both the normal and abnormal findings are important in NAL
- Lesions can occur anywhere along a pathway and result in similar signs (battery, wiring, light bulb analogy.

Neuroanatomy

- Brain
    - forebrain (telencephalon, diencephalon),
    - brainstem (midbrain, pons, medulla oblongata (mesencephalon, ventral metencephalon, myelencephalon),
    - cerebellum (dorsal metencephalon)
- Spinal cord functional regions
    - C1-5,
    - C6-T2 – supplying the thoracic limb
    - T3-L3
    - L4-S3 – supplying the pelvic limb and pelvic viscera
    - Caudal 1-5 – supplying the waggly bit.

- PNS
  - Spinal nerves – C1-5, T3-L3, Cd 1-5
  - Named nerves of the limbs – from the intumescences e.g. radial and femoral or sciatic
  - CNN I-XII
  - Visceral nerves (afferent and efferent; efferent visceral nerves = autonomic NS)

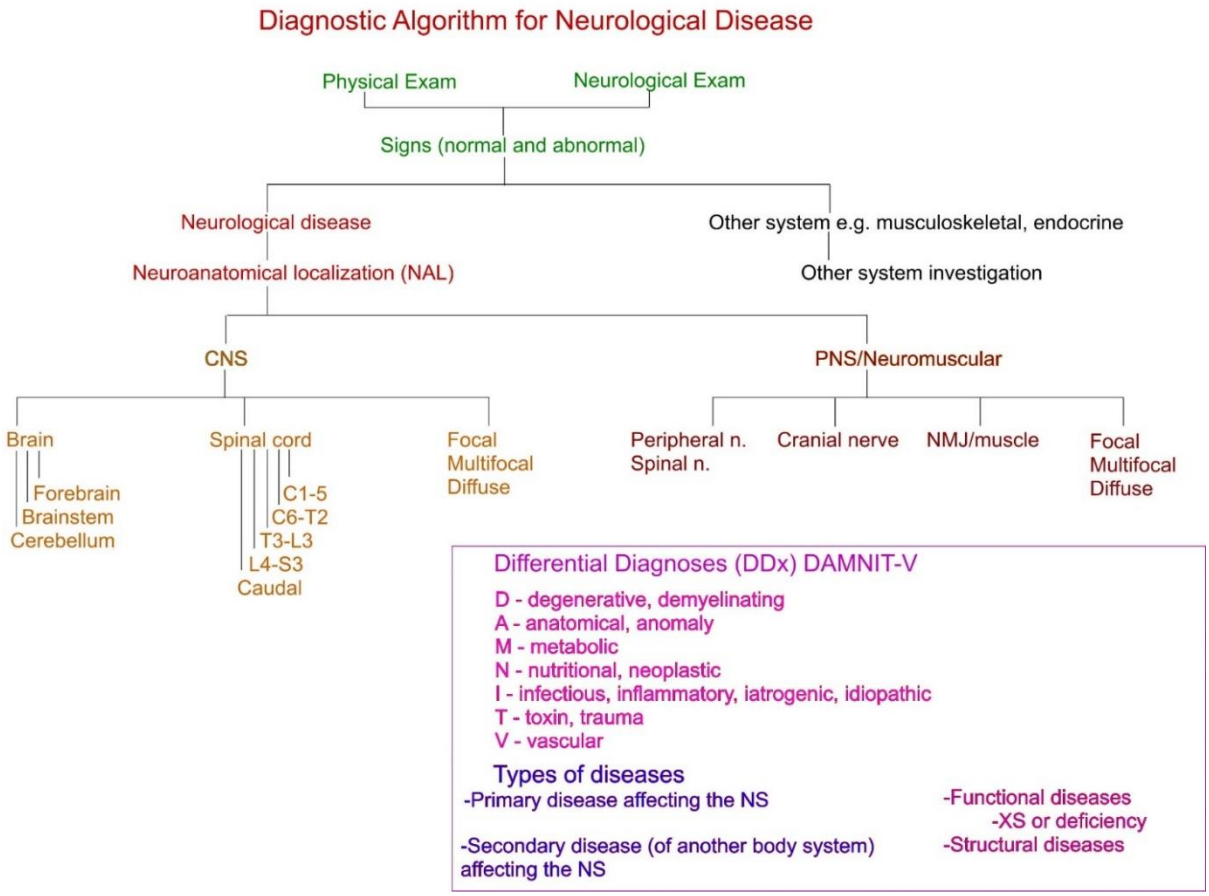

Figure1: Diagnostic algorithm for neurological disease

The NEX

Six functions to be tested:

1. **Mentation and behaviour**: best assessed by observing the animal and its response to environmental stimuli. Do this before stimulating the animal with hands on assessment.
   - Decreased mentation can occur with brain dz (brainstem or forebrain) or systemic dz. Levels of mentation:
     - Normal
     - Dull/obtunded – tends to sleep, but can be roused with non-noxious stimulation
     - Stupor – tends to sleep but can be aroused with noxious stimulation
     - Coma – cannot be roused with noxious stimuli

2. **Posture and Gait:** observe the animal moving around freely – each limb, trunk head and neck. Ataxia often more noticeable when just pottering around, and less obvious when moving fast.
   a) **Proprioception**
   rom limbs – also requires motor function to perform
   - Tactile receptors (e.g. knuckling = paw position response) – PNS, SC to contralateral cerebrum, hopping; conscious proprioception. Primarily used for executing learned/skilled motor function e.g. Kitten swatting at dangly object.
   - Stretch and joint receptors (e.g. sliding paper test = reflex step) – PNS, SC to ipsilateral cerebellum: subconscious proprioception. Key aspect of normal posture and gait (keeping centre of gravity over the props at rest and during movement)

   From head – vestibular system (see later)

   b) Motor systems
   - UMN – 'managers', central – confined to the CNS, tell the LMN what to do
   - LMN – 'workers', peripheral – primarily in the PNS (cell body in the CNS) and interface with muscle at NMJ. Found in spinal and cranial nerves. Includes visceral efferents (autonomic NS)
   - Limb innervation from cervicothoracic (C6-T2) and lumbar (L4-S3) intumescence
   - Motor Unit = LMN + NMJ + muscle
   - Differentiating UMN and LMN disease = Neuro RAT – see Table 1

Table 1: Differentiating UMN and LMN disease

Sign	UMN dz = central MN damaged	LMN dz = peripheral MN damaged
Reflexes	Intact (increased)	Decreased/absent
Atrophy	Disuse - mild, generalised caudal to the lesion	Neurogenic – severe, affecting specific muscles (those that are denervated)
Tone	Intact (increased	Decreased/absent

Grading system myelopathy:
Grade 0 – normal
Grade 1 – spinal hyperpathia +/- proprioceptive deficits only
Grade 2 – decreased voluntary motor function, but can stand and ambulate
Grade 3 – cannot stand or walk, still has some voluntary motor function
Grade 4 – paraplegia, intact deep pain perception
Grade 5 – paraplegia, no deep pain perception

3. Continence

- To differentiate UMN and LMN bladder think of the neuro 'RAT' considering reflexes and tone
- UMN bladder = lesion cranial to L4 SC segment: intact LMN to both the sphincter and bladder wall – therefore good tone – full turgid bladder that is difficult to express. Pudendal reflex and anal tone intact
- LMN bladder = lesion affecting S1-3 SC segments: decreased/absent LMN function in sphincter and bladder wall – therefore decreased tone – large floppy bladder, easy to express. Pudendal reflex and anal tone decreased/absent.
- Continence (UMN or LMN) tends to be lost with Grade 3-4 lesions (severe enough to cause marked paraparesis or paraplegia)

4. Spinal Reflexes

- Limb reflexes
    - Pedal/withdrawal, assesses limb PNS and the associated SC intumescence.
    - Patellar reflex: Note: the patellar reflex may be absent in normal geriatric dogs.
- Pudendal reflex – stroking/tapping either side of the anus – anal sphincter contraction, dipping of the tail head (pudendal nerve and S1-3 SC).
- Cutaneous trunci reflex – pinching thoracolumbar skin, afferent via SC to C8-T1 bilaterally, efferent LMN lateral thoracic nerve, resulting in bilateral skin twitch.
    - Assists NAL with lesions in the T3-L3 lesion.
    - CTR tends to be lost with severe paraparesis or paraplegia
    - NOTE: when lost ('CTR cut-off'), this implies a lesion approximately 2 SC segments cranially, e.g. CTR cut off at L2 vertebra = transverse myelopathy at T13-L1.

5. Cranial nerves

- Arise from different regions of the brain. Deficits in CNN function help localise brain lesions.
- Testing of most CNN can be done at the same time as a physical exam.
- See Table 2

Table 2: Cranial nerves, where they arise and their main functions.

Cranial nerves, attachment and main functions

Cranial nerve	Brain attachment	Function sensory, parasympathetic, motor
I Olfactory	Forebrain	Olfaction
II Optic	Forebrain	Vision
III Oculomotor	Midbrain (Rostral brainstem)	Pupil constriction, extraocular muscles (dorsal, medial and lateral rectus, ventral oblique mm.)
IV Trochlear	Midbrain	Extraocular muscles (dorsal oblique m.
V Trigeminal	Mid brainstem	Facial sensation, masticatory muscles
VI Abducens	Mid brainstem	Extraocular muscles (lat. rectus, retr. bulbi mm.
VII Facial	Mid brainstem	Taste, salivary, lacrimal glands, Muscles of facial expression Masticatory muscle (caudal digastricus)
VIII Vestibulocochlear	Mid brainstem	Hearing, balance
IX Glossopharyngeal	Caudal brainstem	Taste, salivary glands, Swallowing,
X Vagus	Caudal brainstem	Taste, parasympathetic to body viscera swallowing, laryngeal,
XI Accessory	Caudal brainstem	Laryngeal function, neck muscles
XII Hypoglossal	Caudal brainstem	Tongue muscles

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- Vestibular system
    - Pathway: originates in the inner ear, via CN VIII to mid brainstem, from there to the: cerebellum; SC; CNN III, IV, VI (eyeball position and movement); vomiting centre (motion sickness); forebrain (conscious awareness).
    - Typical signs of peripheral and central VD – e.g. left side lesion causes left head tilt and left staggering/circling towards the side of the lesion; right fast phase nystagmus (away from the lesion), strabismus ipsilateral eye.
    - During the NEX, as always, noting other aspects that are normal, and aspects that are abnormal, help determine which part of the vestibular system is affected
        - Peripheral VD – inner ear/CN VIII
            - May also affect CN VII (LMN damage causing facial paresis, decreased tear production) and sympathetic supply to the eye (Horner syndrome)
        - Central VD – brainstem
            - May affect other brainstem functions including CN VII (LMN, facial paresis) and CN V (facial sensation, LMN

masticatory muscle atrophy), proprioceptive tracts, UMN motor function (hemi or tetra paresis), mentation

- Cerebellar VD – can cause paradoxical signs
  - e.g. left side lesion causing right head tilt, circling towards the right (away from the side of the lesion) left fast phase nystagmus (towards the side of the lesion). May see other cerebellar signs (ataxia, truncal sway, hypermetria, tremor).
  - May see postural reaction deficits ipsilateral to the side of the lesion; in this example, left side.

5. Nociception

- Assessing for pain perception – squeezing on the digits and looking for a conscious response – e.g. animal vocalising, turning to look at you, or trying to move away.
- A pedal/withdrawal reflex should be present if the lesion is cranial to the intumescence of the tested limb. A pedal reflex without a conscious response, does not indicate intact pain perception.
- Specific regions of the distal limbs can be tested to check for innervation by specific nerves
  - Thoracic limb – radial n. = dorsal aspect of the foot (manus); ulnar n. = lateral aspect digit V; musculocutaneous n. = medial aspect antebrachium
  - Pelvic limb – femoral n. = medial aspect of crus (tibial region); peroneal n. = dorsal aspect of the foot; tibial n. = plantar aspect of the foot (pes)

6. Spinal Hyperpathia (back pain)

- Trunk: over the sacral and TL region a) palpation of paraspinal muscles, then b) between the spinous processes; tail base manipulation, +/- lumbosacral extension and flexion manoeuvres.
- Neck: palpation of the epaxial muscles and vertebral column; testing cervical range of motion (to both sides, dorsally and ventrally) – DO NOT DO THIS if potential cervical instability e.g. trauma, atlanto-axial subluxation.)

Lesion localisation:

- Aim of the NEX is to a) assess which parts of the NS are functioning normally (no overt clinical lesion) and abnormally (lesion present).
- Need to know where the different functions arise in the NS (See Table 3)
- Having observed and identified normal and abnormal, the aim is to determine if all signs can be explained by a lesion in one area of the NS – i.e. a focal lesion, e.g. paraplegia with loss of pelvic limb reflexes and a urinary bladder that is flaccid and easy to express – L4-S3 lesion.
- If you can't explain all signs with one lesion, then it may be multifocal or diffuse.
- Example: left head tilt, left hemiparesis and loss of vision in the left eye (non ocular cause). These signs would suggest left brainstem and right forebrain.

- Diffuse lesions – affecting widespread areas of the NS. Example: most common would be 'motor unit' disease with a lesion affecting all four limbs and possibly the neck or even some CNN. This would cause tetraparesis with decreased/absent limb reflexes, reduced limb tone, maybe facial paresis – e.g. tick envenomation or polyradiculoneuritis.

Table 4: possible neurological signs with lesions in different parts of the SC

Table of possible signs with spinal cord localisations

Lesion location	Sensory dysfunction	UMN signs (RAT)	LMN signs (RAT)	Continence
C1-5	TL, trunk, PL, bladder, tail	TL, PL	None, reflexes intact	UMN bladder
C6-T2	TL, trunk, PL, tail	PL	TL (decreased reflexes, specific muscle atrophy, decreased tone)	UMN bladder
T3-L3	Trunk, PL, bladder, tail	PL	Loss of cutaneous trunci reflex caudal to lesion	UMN bladder
L3-S1	PL, bladder, tail	Bladder	PL	UMN bladder
S1-S3	Bladder, perineum, tail	No UMN signs	Bladder Anal spincter	LMN bladder Loss of perineal reflex
Cd1-5	Tail	No UMN signs	Tail	Intact

Table 5: possible neurological signs with lesions in different parts of the SC

Possible neuro signs with lesions in the brain

Lesion Location	Sensory dysfunction	Motor dysfunction	CNN	Mentation	Spinal reflexes
Forebrain	PPR conscious proprioception (contralateral) Nociception (e.g. contralateral nares)	UMN skilled motor function (gait and posture relatively normal)	CN I CN II	Decreased with diffuse lesions Seizures	Intact
Brainstem (midbrain, pons medulla oblongata)	PPR conscious proprioception* Nociception (e.g. contralateral nares) Subconscious proprioception (ipsilateral) if caudal brainstem	UMN deficits (paresis / weakness)	CN III, IV (midbrain) CN V-XII (pons and medulla oblongata)	Decreased	Intact
Cerebellum	Subconscious proprioceptive deficits (ipsilateral) ataxia	Intact / excessive UMN (strong) hypermetria Loss of coordination	CN VIII (vestibular) Menace response deficit	Intact	Intact

* PPR deficit – contralateral if rostral brainstem lesion; ipsilateral if caudal brainstem lesion

Complete NeuroMap SC

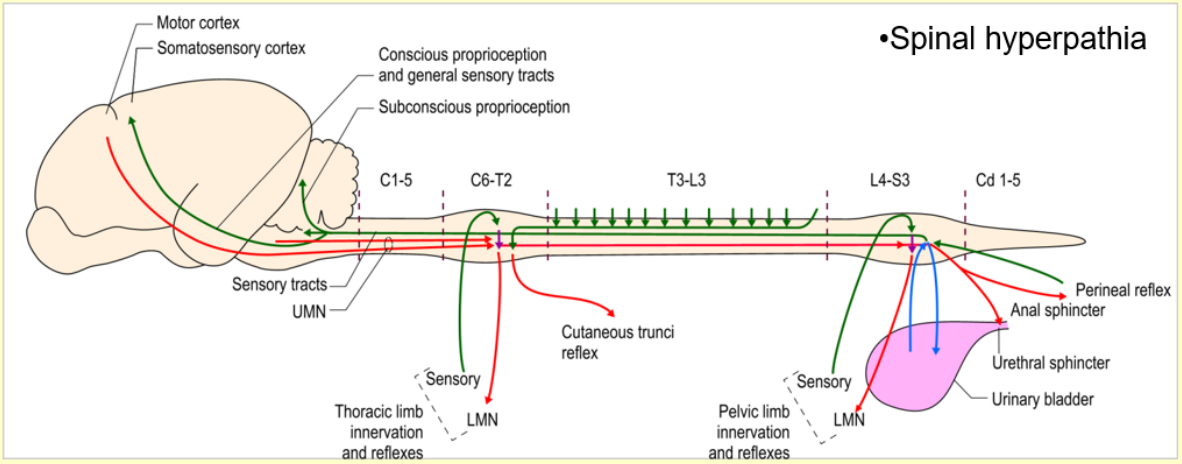

Fig 13.15 Thomson and Hahn

Complete Brain NeuroMap

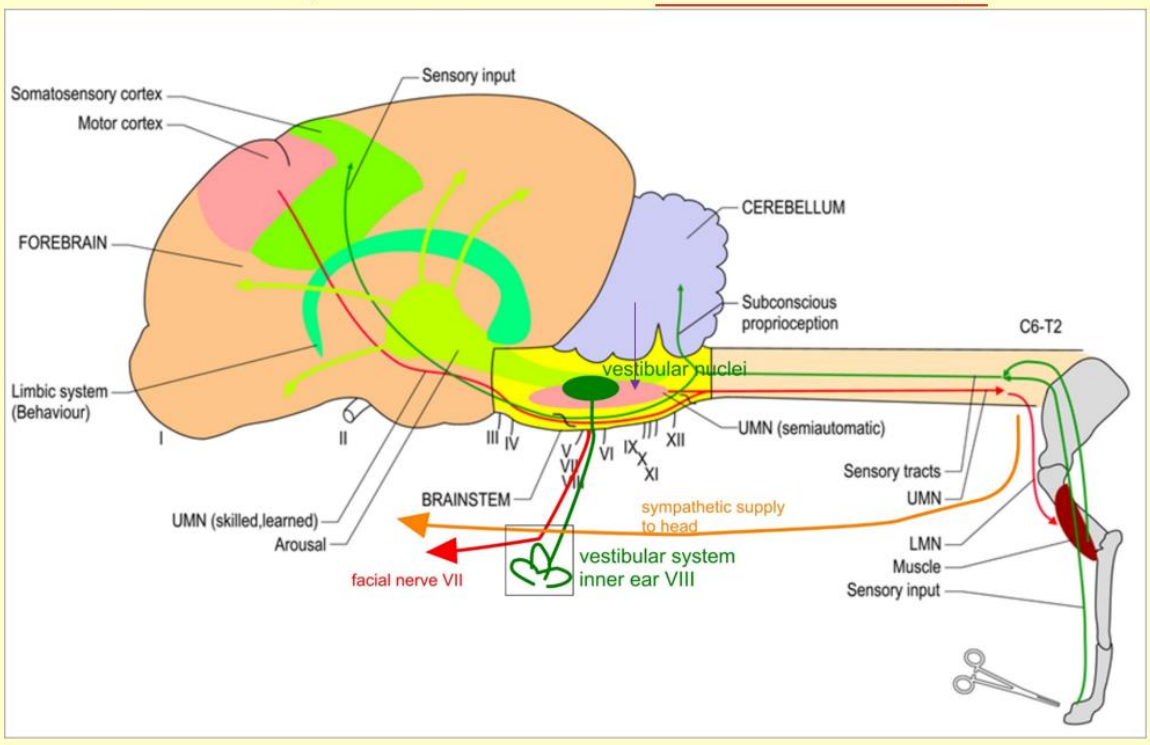

Fig 13.14 Thomson and Hahn (modified)

To use the NeuroMap, identify a region of the nervous system and you can see what functions could be compromised (neurological deficits) and which functions will be intact (neurologically normal).

Example 1. Thoracolumbar lesion – could affect motor (UMN) tracts to the PL, sensation from the PL (proprioception). If a more severe lesion, then deficits also in the cutaneous trunci reflex and possibly nociception. But the PL spinal reflexes will be intact as will thoracic limb sensory and motor function, cranial nerves and mentation.

Example 2: inner/middle ear lesion causing vestibular signs, could also affect CN VII causing facial paresis and decreased tear production, sympathetic pathway to the face (Horner syndrome) but the animal should be strong (no paresis), mentation should be intact, no other cranial nerve deficits and no postural reaction deficits.

Summary Part 1

- Both normal and abnormal neuro function is important for lesion localisation
- Lesions cause similar signs at pathway origin, midpoint and termination
- Spinal cord is divided into functional regions based on limb innervation
- Sensory and motor signs are specific for lesions in the different functional areas
- Key proprioceptive tests – PPR, hopping, reflex step
- UMN (central) and LMN (peripheral) motor neurons
- The NeuroRAT (reflexes, atrophy and tone) differentiates between lesions affecting UMN and LMN
- Presence / absence of spinal reflexes are important for localising lesions
  - Pedal and patellar reflexes are the most reliable
- Determining lesion location causing bladder dysfunction also uses the NeuroRAT
  - UMN lesion (cranial to S1) intact tone (bladder wall and sphincter) and perineal reflex. LMN lesion (S1-3 or PNS) decreased/loss of tone and reflex

Summary Part 2

- Brain is divided into three functional regions (forebrain, brainstem and cerebellum)
- Specific signs are associated with each brain region
- Mentation and behaviour – evaluate first
  - Severely decreased mentation will compromise other neuro functions.
- Proprioception
  - subconscious – CoG over the props, used in posture and gait
    - Caudal brainstem to ipsilateral cerebellum
  - conscious – tactile receptors, used in skilled movement
    - Brainstem to contralateral cerebrum
- Motor function – use NeuroRAT
  - UMN centres
    - Skilled/learned motor – forebrain
    - Gait and posture (semi-automatic) – brainstem
  - LMN
    - Cranial nerves
    - Spinal reflexes – will be intact with brain disease
- Cranial nerves – sensory, motor, mixed, parasympathetic function
  - region specific: dysfunction can help localise to a specific brain region
- Spinal hyperpathia – may get neck pain with brain dz
- Observational NEX
  - great for dodgy dogs and cantankerous kitties