Understanding Basic Neurosurgery

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Dedicated to my beloved wife, Microbiologist Sahar M.H. Khalil, M.B.Ch.B., M.P.H. and my sons, Orthopedic Surgeon Zyad O. Abdelaziz, M.B.Ch.B., M.Ch., M.D. and Periodontist Gaser O. Abdelaziz, D.D.S. who made my career successful.

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PREFACE

The vast experience gained throughout the author's dedicated career in neurosurgery, for more than 30 years, encouraged him to deliver this precious knowledge to undergraduate and postgraduate medical students, registrars, residents, fellows and medical practitioners caring for patients with neurological problems.

This book presents an up-to-date knowledge base in the field of neurosurgery in such a concise, comprehensive and well-balanced approach. This book provides a readily available source for understanding the basic aspects of neurosurgery.

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CHAPTER I

NEUROLOGICAL ASSESSMENT

I. History

A precise description of the patient's symptoms is essential for establishing the diagnosis. It is important to consider these symptoms in conjunction with a comprehensive evaluation that includes information from the patient's previous medical history, family and social history, and any current medications. The patient's reported symptoms are often directly linked to the underlying neurological disturbances. The key neurological symptoms to consider include:

• Headache

- Onset and course (sudden/gradual)
- Duration
- Frequency
- Severity: rated on a scale from 1 to 10 (10 being the severest headache in the patient's life e.g. headache due to subarachnoid hemorrhage from ruptured intracranial aneurysm)
- Timing: morning headaches are more common in brain tumors
- Site: is it migraine? Is it related to the nasal sinuses?
- Character: throbbing, band like
- Aggravating and alleviating factors
- Associated features: e.g. vomiting, visual disturbances, excessive lacrimation

• Visual disorders

- Onset, course, duration, frequency, aggravating and alleviating factors
- Impairment:
  - One/both eyes
  - Partial/total visual loss

  - Whole/partial field loss
- Hallucinations and illusions

• Speech/language disorders

- Difficulty in articulation (**dysarthria**)
- Difficulty in expression (**expressive dysphasia**)
- Difficulty in understanding spoken words (**receptive dysphasia**)
- Difficulty in reading (**dyslexia**)
- Difficulty in writing (**dysgraphia**)
- Difficulty in calculating (**dyscalculia**)

• Motor disorders

- Incoordination
- Weakness:
  - Progressive/stationary
  - Proximal/distal
  - Painful/painless
- Involuntary movements

• Sensory disorders

- Pain
- Numbness/tingling
- Hyperesthesia

• Sphincteric disturbances

- Frequency
- Urgency
- Incontinence
- Retention
- Diarrhea or stool incontinence
- Constipation

• Lower cranial nerves

- Deafness/tinnitus
- Vertigo
- Balance/staggering
- Swallowing difficulty
- Change in voice

• Mental disorders

- Memory deficits
- Personality changes
- Behavioral changes

• Endocrine disturbances

- Menstrual irregularities
- Galactorrhea (milk-like breast secretion)
- Impotence
- Infertility
- Weight gain
- Hirsutism
- Change in body shape
- Change in facial complexions

II. Neurological Examination

A. Conscious level assessment

The Glasgow coma scale (**GCS**) score is the most used scoring system to assess consciousness. It evaluates three key responses: eye opening, verbal response and motor response. The GCS scores are consistent and reproducible regardless of the observer's experience or status. **(Table 1-1)**

Table 1-1: The Glasgow coma scale (GCS)

Parameter	Response	Scale
Eye opening	Spontaneous	**4**
	To speech	**3**
	To pain	**2**
	None	**1**
Verbal response	Oriented	**5**
	Confused (**disoriented**)	**4**
	Inappropriate words	**3**
	Incomprehensible sounds	**2**
	None	**1**
Motor response	Obeys Commands	**6**
	Localizes pain	**5**
	Withdraws to pain (**flexion to pain**)	**4**
	Abnormal flexion (**decorticate**)	**3**
	Extension (**decerebrate**)	**2**
	None (**flaccid**)	**1**

B. Higher cerebral function assessment

• Cognitive skills

▪ Dominant hemisphere

- **Dysphasia** (listen to the patient's language pattern):
  - **Expressive dysphasia:** The patient is hesitant, unable to compose phrases (non-fluent speech with intact comprehension). It signifies impairment of the Broca's area.
  - **Receptive aphasia:** Fluent speech with impaired comprehension. The patient' speech does not make sense. It signifies impairment of the Wernicke's area.
  - **Conductive Aphasia:** Poor repetition, but the patient had fluent speech and intact comprehension. It signifies impairment of the arcuate fasciculus that connects Broca's and Wernicke's areas.
  - **Global Aphasia:** Non-fluent speech with impaired comprehension. It signifies impairment of both Wernicke's and Broca's areas.
  - **Nominal aphasia:** The patient is unable to name objects.
- **Dyslexia:** The patient cannot read correctly.
- **Dysgraphia:** The patient cannot write correctly.

- **Dyscalculia:** The patient will not be able to serially subtract 7 from 100.
- **Agnosia:**
  - **Visual agnosia:** The patient is unable to identify seen objects.
  - **Tactile agnosia:** The patient is unable to identify objects in his hands with closed eyes.

▪ Non-dominant hemisphere

- **Geographical agnosia:** inability of the patient to find his way around the ward.
- **Apraxia** (inability of the patient to perform complex movements)**:**
  - **Dressing apraxia:** inability of the patient to button his shirt.
  - **Constructional apraxia:** inability of the patient to copy a geometrical pattern as the drawing of a cube.

• Memory tests

These tests cannot be done in confused or dysphasic patients.

- **Immediate memory:** ask the patient to repeat a sequence of 5 to 7 random numbers.
- **Recent memory:** ask the patient to present his illness and duration of hospital stay.
- **Remote memory:** ask the patients about events and circumstances more than 5 years old.
- **Verbal memory:** ask the patient to remember a sentence or a short story.
- **Visual memory:** ask the patient to remember objects on a tray and test after 15 minutes.

N.B.

- **Retrograde amnesia:** loss of memory of events leading up to a brain injury or insult
- **Post-traumatic amnesia:** permanent loss of memory of events for a period following a brain injury.

• Reasoning and problem solving

- Two step calculation
- Ask the patient to reverse 3 to 4 random numbers

- Ask the patient to explain proverbs

• Emotional state

- Anxiety or excitement
- Depression or apathy
- Slowness of movement or responses
- Uninhibited behaviors
- Personality type

C. Cranial Nerves (CNs) Examination

• Olfactory nerve (CN I)

Test both perception and identification using aromatic, non-irritant material (to avoid the stimulation of the trigeminal nerve) e.g. coffee, tobacco.

N.B. Each nostril should be tested separately.

• Optic nerve (CN II)

- **Visual acuity:** using Snellen's chart. Light perception, hand movements, and counting fingers are considered severe deficits in visual acuity.
- **Visual fields:** using either gross testing by confrontation or automated perimetry.
- **Fundus examination:**
  - Using the ophthalmoscope, look for the color of the optic disc, its vascularity, and the clarity of its edges.
- **Pupils:**
  - Size
  - Shape
  - Equality
  - Reaction to light: both pupils constrict when light is shone in either eye.
  - Reaction to accommodation and convergence: pupil constriction occurs when gaze is transferred to a near point object.

N.B.

- **Optic atrophy** is defined as pallor of optic disc.
- **Papilledema** is defined as edema of the optic disc. It is usually bilateral but may be asymmetric.

- **Papilledema** on one side and **optic atrophy** on the other side is called "**Foster-Kennedy syndrome**". It may be present with space occupying lesions within the anterior cranial fossa.
- A lesion of the optic nerve will abolish pupillary responses to light on the same side as well as in the contralateral eye when the light is shone to the affected eye.

• Oculomotor nerve (CN III)

A lesion of the oculomotor nerve produces disturbance of the pupillary responses to light, impairment of eye lid movement, and impairment of eye movements.

- **Pupils:** The pupil dilates with sluggish reaction to light and may become fixed due to paralysis of the constrictor pupillae muscle.
- **Eye lids:** Look for ptosis (drooping of the eyelid over the pupil when the eyes are fully open). It is due to paralysis of the levator palpebrae muscle.
- **Ocular movements:** Examine the eye movements in the six different directions of gaze. Ask the patient to look medially (medial rectus muscle), down and out (inferior rectus muscle), up and out (superior rectus muscle), and up and in (inferior oblique muscle).

• Trochlear nerve (CN IV)

Ask the patient to look down and in to test the superior oblique muscle.

• Abducens nerve (CN VI)

Ask the patient to look laterally to test the lateral rectus muscle.

N.B.

- **Diplopia:** Double vision due to impairment of eye movement as a result of weakness of extra-ocular muscles.
- **Conjugate eye movements:** Note the ability of the patient's eyes to move together in the horizontal and the vertical directions.
- **Nystagmus:** Slow drift to one direction and followed by fast "corrective" movement. Nystagmus direction is usually described in terms of the fast phase.

• Trigeminal nerve (CN V)

▪ Sensory

Test the facial sensations over the three divisions: Ophthalmic (**V1**), Maxillary (**V2**) and Mandibular (**V3**) and compare both sides for:

- Pain (pinprick)
- Temperature
- Light (crude) touch.

▪ Corneal reflex

With the palpebral fissure widely open, touch the cornea with a tapered piece of cotton. Normally, the eye blinks.

- **Afferent:** Trigeminal nerve.
- **Efferent:** Facial nerve.

▪ Motor

- Ask the patient to clamp his jaws
- Feel the temporalis and masseter muscles
- Open the jaw against resistance,
- Ask the patient to open his mouth

N.B. If the pterygoid muscles on one side are weak, the jaw will be pushed over by the unopposed pterygoid muscles of the healthy side and **the jaw will be deviated to the side of the lesion**.

▪ Jaw jerk reflex

Ask the patient to relax his jaw. Place a finger on the chin and tap with a hammer.

- Normally the jaw jerk is absent or slightly present
- Exaggerated jaw jerk signifies bilateral pyramidal lesion (**UMNL**) above the level of the pons e.g. Pseudobulbar palsy.

• Facial nerve (CN VII)

▪ Motor

- Observe the patient as he talks and smiles and watch for:
  - Eye closure
  - Asymmetrical elevation of one corner of mouth
  - Flattening of nasolabial fold
- Ask the patient to:
  - Wrinkle the forehead (**frontalis**)
  - Close his eyes while the examiner attempts to open it (**orbicularis oculi**)
  - Purse his lips while the examiner presses the cheeks (**buccinators**)
  - Show his teeth (**orbicularis oris**).

N.B. The **mouth will be deviated to the opposite side of the lesion**.

N.B. The **upper ½** of the facial nucleus in the brain stem receives bilateral upper motor neuron (**UMN**) inputs from both cerebral cortices, while the **lower ½** of the facial nucleus receives only unilateral **UMN** input from the contralateral (opposite side) cerebral cortex. So, in **UMNL** (supranuclear) on one side, only the **lower face** will be affected, and the **upper face** will be spared on the contralateral side of the lesion. On the other hand, in **LMNL** (nuclear or infranuclear) on one side, the **whole face** will be affected on the same side of the lesion.

▪ Taste

Examine for the taste on each side of the anterior ⅔ of the tongue by using a small quantity of sugar or NaCl.

• Auditory (Vestibulo-cochlear) nerve (CN VIII)

▪ Testing the cochlear component

- Whisper numbers in one ear while masking the other ear by rubbing the external meatus.
- Differentiate between **conductive** (middle ear) and **perceptive** (nerve) deafness by:
  - **Weber's test:** hold the base of a vibrating (512 Hz) tuning fork against the vertex and ask the patient if the sound is heard more

loudly in one ear. In conductive deafness, the sound will be louder in the affected ear.
    - **Rinne's test:** hold the base of a vibrating (512 Hz) tuning fork against the mastoid bone. When the note disappears, hold the tuning fork near the external meatus. Patient should hear sound again since the air conduction via the ossicles is better than bone conduction.
- In **conductive deafness**, bone conduction will be better than air conduction.
- In **nerve deafness**, both bone and air conduction are impaired.

▪ Testing the vestibular component

- **Caloric test** (**vestibule-ocular reflex**): Both eyes normally move ipsilateral to the cold irrigated ear and contralateral to the warm irrigated ear.

• Glossopharyngeal nerve (CN IX) and Vagus nerve (CN X)

Both nerves are examined together, and their actions are seldom individually impaired.

- Note the patient's voice: record hoarseness or nasal tone
- Note any swallowing difficulty or nasal regurgitation of fluids
- Ask the patient to open his mouth and say "**Ah**" to check the asymmetry of palatal movements or deviation of the uvula (**uvula is normally in midline**).

N.B. The muscles of the uvula act by **pulling**. So, the **uvula will be deviated (pulled) to the opposite side of the lesion**.

- **Gag reflex:** Depress the patient's tongue and touch the palate, pharynx or tonsil on one side with a tongue depressor and check if the patient gags. Compare the sensitivity on each side.
    - **Afferent:** Glossopharyngeal nerve.
    - **Efferent:** Vagus nerve.
- **Taste** in the posterior ⅓ of the tongue is impractical to test.

• Accessory nerve (CN XI)

- **Sternocleidomastoid:** ask the patient to rotate his head against resistance. Compare the power and muscle bulk on each side

  N.B. The left sternocleidomastoid turns the head to the right side and vice versa.
- **Trapezius:** ask the patient to shrug his shoulders and to hold them in this position against resistance. Compare the power and bulk on both sides.

• Hypoglossal nerve (CN XII)

- Ask the patient to open his mouth and inspect the tongue for:
  - Evidence of tongue atrophy (increased folds, wasting)
  - Tongue fasciculation (small wriggling movements)
- Ask the patient to protrude his tongue and inspect the tongue for any deviation.
- Ask the patient to push your fingers through his cheeks by his tongue. Note any difficulty or weakness.

N.B. The muscles of the tongue act by **pushing**. So, the **tongue will be deviated (pushed) to the same side of the lesion.**

D. Motor System Examination

• Muscle state

By inspection, note:

- **Muscle atrophy and wasting**
- **Muscle hypertrophy**
- **Muscle fasciculation:** irregular, non-rhythmical contractions of groups of motor units, increased after exercise and on smacking muscle surface.

N.B. Fibrillation is excessive activity of a single motor unit and is only detectable with electromyography (**EMG**).

• Muscle tone

- Tested by alternate passive flexion and extension of the wrist, elbow, knee, and ankle joints.
- Decreased tone (**Hypotonia**) occurs in:
  1. Lower motor neuron lesion (**LMNL**).
  2. Cerebellar lesion.
- Increased tone (**Hypertonia**) occurs in:
  1. Upper motor neuron lesion (**UMNL**):
     - **Clasp-knife spasticity:** the initial resistance to the movement is suddenly overcome.
  2. **Extrapyramidal lesion:**
     - **Lead pipe rigidity:** a steady increase in resistance throughout the movement.
     - **Cog-wheel rigidity:** a ratchet-like increase in resistance.

N.B. Clonus (ankle and patellar clonus): is indicative of marked hypertonia.

• Muscle power

- The muscle power is graded from **0-5**. Normal muscle power is Grade **5**. No muscle movement is Grade **0**.
- If upper motor neuron (**UMN**) weakness is suspected, **pronator (pyramidal) drift test** is simple, quick and sensitive: ask the patient to hold arms outstretched with the hands supinated for one minute. The eyes are then closed to remove visual compensation. The weak arm gradually pronates and drifts downwards. Positive test on one side (**Barré sign**) signifies contralateral UMNL.
- If lower motor neuron (**LMN**) weakness is suspected, individual muscle groups should be tested in all limb and both sides compared to help localize the lesion.

E. Sensory System Examination

• Superficial sensations

- Pain (pinprick)
- Temperature
- Light (crude) touch

• Deep (proprioceptive) sensations

- Joint position and movement sense
- Vibration sense.

• Cortical sensations

- Tactile localization.
- Two-point discrimination.
- Stereognosis.
- Graphesthesia

F. Reflexes

• Superficial reflexes

- Plantar reflex **S1**
- Abdominal reflex **T7-T12**
- Cremasteric reflex **L1**
- Anal reflex **S4-S5**

• Deep tendon jerk reflexes

- Biceps jerk **C5-C6**
- Triceps jerk **C6-C7**
- Brachioradialis jerk **C5-C6**
- Knee (patellar) jerk **L3-L4**
- Ankle jerk **S1**

N.B.

- If deep tendon jerk reflexes are **diminished** or **not elicited** (as in **LMNL**) or difficult to elicit, do **enhancement** or **re-enforcement** by asking the patient to clench his teeth (for upper limb testing) or to pull apart the interlocked flexed fingers (for lower limb testing).
- If deep tendon jerk reflexes are **exaggerated** or **brisk** (as in **UMNL**), test for **clonus** (knee clonus, ankle clonus).

• Pathological reflexes

Pathological reflexes are abnormal responses to normal stimuli. These include:

A. Pyramidal reflexes

These reflexes are present in **UMNLs** of the pyramidal (Cortico-spinal) tract(s).

1. **Hoffman reflex (Finger flexor reflex): (C7-C8)**
- The test involves tapping the nail or flicking the terminal phalanx of the middle or ring finger.
- A positive response (**Hoffman's sign**) is flexion of the terminal phalanges of thumb and index.
2. **Finger jerk reflex: (C8)**
- The test involves tapping (with the tendon hammer) on the examiner's index and middle fingers placed across the palmar surface of the patient's proximal phalanges.
- **Normally**, there should be slight flexion of the patient's fingers. If there is **hyperreflexia**, this flexion is exaggerated.
3. **Babinski sign: (S1)**
- Normally, during the planter reflex, stroking the outer aspect of the sole results in flexion (planter flexion) of the big toe and adduction of the other toes.
- Babinski sign is present if there is extension (dorsiflexion) of the big toe and fanning (abduction) of the other toes.
- **In infants**, Babinski sign is normally present because the pyramidal tract is not fully myelinated yet. The extensor response disappears and gives way to the flexor response around 12 to 24 months of age.
- A positive Babinski sign is considered pathological if present in **adults** or in children older than 12 to 24 months of age.

B. Primitive reflexes (Frontal release signs)

Primitive reflexes are infantile or newborn reflexes, which are already present at birth and mediated by extrapyramidal functions. They are lost with progressive myelination of the pyramidal tract. They may reappear in adults or children with loss of function of the pyramidal system in frontal lobe lesions. Primitive reflexes include:

1. **Grasp reflex**
2. **Glabellar reflex**
3. **Palmo-mental reflex**

N.B. The distinguishing clinical manifestations of upper motor neuron lesions (**UMNLs**) and lower motor neuron lesions (**LMNLs**) are outlined in **(Table 1-2)**.

Table 1-2: Differences in clinical manifestations between UMNLs and LMNLs

Parameter	UMNLs	LMNLs
Muscle tone	Hypertonia	Hypotonia
Muscle wasting	Minimal (disuse atrophy)	Maximal
Muscle tone	Increased (hypertonia)	Decreased (hypotonia or atonia)
Muscle fasciculation	Absent	Present
Deep tendon reflexes	Increased (hyperreflexia)	Decreased (hyporeflexia or areflexia)
Clonus	Present	Absent
Hoffman's sign	Positive	Negative
Finger jerk reflex	Exaggerated	Normal
Planter reflex	Extensor response (Positive Babinski sign)	Flexor response
Sphincters	Urge Incontinence (Hypertonic, Spastic, or automatic bladder)	Retention with overflow incontinence (Hypotonic, atonic, or flaccid bladder)

G. Balance and Coordination

- Look for **ataxia** (incoordination of voluntary movements):
  - **Upper limbs:**
    - Finger-nose test
    - Finger-finger test
  - **Lower limbs:**
    - Heel-knee-shin test

- Look for **dysdiadochokinesia** (inability to perform rapid alternating movements):
  - **Upper limbs:**
    - Ask the patient to rapidly supinate and pronate the forearms or to perform rapid and repeated tapping movements.
  - **Lower limbs:**
    - Ask the patient to relatedly tap the floor with the foot.

H. Stance, Balance and Gait

Normal balance (equilibrium) requires correct input from sensory modalities (i.e., **visual**, **vestibular**, and **proprioceptive** inputs). These inputs are integrated in the cerebral cortex and cerebellum, and then a response is sent to the musculoskeletal system to maintain the center of gravity. Closure of the eye removes visual sensory compensation of underlying cerebellar (central) or proprioceptive (peripheral) deficits.

• Romberg's balance test

Ask the patient to stand with the feet together and arms at sides, first with the eyes open, then with the eyes closed for 20-30 seconds. The test is positive if the patient shows postural swaying or imbalance (instability) with tendency to fall towards the side of lesion.

- **Positive Romberg's test** with open or closed eyes: in cerebellar (**central**) deficits i.e., **Cerebellar ataxia**.
- **Positive Romberg's test** with closed eyes only: in proprioceptive (**peripheral**) deficits due to lesions of dorsal column of the spinal cord i.e., **Sensory ataxia**.
- **Negative Romberg's test:** (i.e., no sway or imbalance with either open or closed eyes), do **Sharpened Romberg's test**
- **Sharpened Romberg's test:** ask the patient to stand with one heel in front of toes and the arms folded across the chest.
  - Ask the patient to walk and look for any abnormal gait or instability (**gait ataxia**). If the gait is normal, repeat with **tandem walking** (i.e., walk in a straight line in a heel to toe fashion), which will exaggerate any instability.