GENERAL PRINCIPLES OF NEUROLOGY- John W. Day, M.D., Ph.D.

I. **TAKE HOME POINTS FOR THIS LECTURE**

A. Localizing the disease is the first step in diagnosing a neurological disorder.

B. Time course of the disease (acute, subacute, or chronic) indicates the pathophysiological process.

C. Anatomical pattern of neurological diseases can be focal, multifocal or diffuse.

D. Neurological diseases produce symptoms that are positive (e.g., pain) or negative (e.g., weakness).

E. Neurological disorders follow recognizable patterns: upper v. lower motor neuron; hemiplegia v. paraplegia; root v. nerve; cerebellar v. extrapyramidal.

II. **Definitions**

A. **Symptoms** – the patient’s own report of the problem, hence subjective. It is important to explore what the patient means when using words like “dizzy,” “numb,” “weak.” The domain of symptoms is the history.

B. **Signs, findings** – observations made by the physician, hence objective. The domain of signs is the examination.

C. **Deficit** – loss of neurologic function defined objectively by signs or findings on neurologic examination.

D. **Lesion** – the pathologic basis of the clinical problem.

E. **Localization** – the process of identifying the site of the lesion in the nervous system by inference using symptoms, findings of examination, concepts of clinical neuroanatomy, and the principle of economy.

F. **Localization Pattern** – the spatial characteristic of a given disease process: focal, multifocal or diffuse.

G. **Clinical Profile** – the identifying features of the neurologic problem in terms of localization pattern, mode of onset, and time course. Different categories of etiology (e.g., vascular processes, degenerative processes, etc.) typically present problems having characteristic clinical profiles (e.g., vascular: focal/sudden/improving; degenerative: diffuse/insidious/progressive; etc.). These differences are helpful in diagnosing the etiological basis of neurologic deficits.

H. **Type of clinical problems** – a way of classifying neurological problems.

   1. “Deficit” – a loss of function that may be defined on examination (e.g., a right hemiparesis, a left sixth nerve palsy).

   2. “Spell” – transient (seconds, minutes, hours or days) and self-limited abnormalities that are, therefore, usually defined only by history (e.g., seizures, transient ischemic attacks, headaches).

   3. “Positive” symptoms – spontaneous pain, tingling, stiffness, shaking

III. **Basic Concepts**

A. **Deficits**

Diagnosing the cause of deficits is approached by considering the clinical profile of the problem itself (location, localization pattern, onset, course) and the risk factor profile of
the patient (e.g., patients age, gender, medical background, etc.) in developing and prioritizing an etiologic differential diagnosis.

The tools for diagnosis of neurological problems are the history (onset and course of problem, risk factor profile of patient) and examination (findings/localization). Diagnosis is usually apparent or probabilities can be assigned on the basis of these bedside processes. Special diagnostic procedures and laboratory tests usually play a confirmatory role.

1. Localization patterns
   a. Focal – discrete (usually asymmetric)
   b. Multifocal – though multiple, discrete
   c. Diffuse – not discrete but rather continuous (usually symmetric and involving susceptible neurologic “systems,” e.g., the cerebral cortex)

   Typical Localization Patterns for Different Etiologic Categories

<table>
<thead>
<tr>
<th>Focal</th>
<th>Diffuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular</td>
<td>Toxic</td>
</tr>
<tr>
<td>Traumatic</td>
<td>Metabolic</td>
</tr>
<tr>
<td>Neoplastic</td>
<td>Nutritional</td>
</tr>
<tr>
<td></td>
<td>Infectious</td>
</tr>
<tr>
<td></td>
<td>Degenerative</td>
</tr>
</tbody>
</table>

2. Types of Temporal Onset
   a. Sudden, abrupt, acute – seconds to hours
   b. Subacute – days to weeks
   c. Insidious, gradual – months to years

   Typical Onsets for Etiologic Categories

<table>
<thead>
<tr>
<th>Sudden</th>
<th>Subacute</th>
<th>Insidious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular</td>
<td>Infectious</td>
<td>Degenerative</td>
</tr>
<tr>
<td>Traumatic</td>
<td>Toxic</td>
<td>Neoplastic</td>
</tr>
<tr>
<td>“Physiologic”</td>
<td>Metabolic</td>
<td>Nutritional</td>
</tr>
</tbody>
</table>

3. Type of Temporal Course
   a. Stationary, stable, static – deficit unchanging with time
   b. Improving, remitting – deficit improving with time
   c. Progressive – deficit worsening with time

   Typical Courses for Etiologic Categories Without Treatment

<table>
<thead>
<tr>
<th>Stationary-Improving</th>
<th>Progressive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular, traumatic, physiologic</td>
<td>degenerative, neoplastic</td>
</tr>
</tbody>
</table>
4. Types of nervous system pathophysiological processes
   a. Processes common to all of medicine
   Vascular, infectious, neoplastic and toxic disease processes of the nervous system follow
time courses that are similar to the effects of these disease processes on other organ
systems.
   b. Processes unique to the nervous system
      i. Degenerative processes
      Although degenerative disorders in all tissues follow similar time courses, degenerative
      disorders in other systems often result from wear and tear on particular tissues whereas
      nervous system degeneration result from intracellular flaws, often genetic, that leads to
deterioration of specific nerve cells (e.g. ALS vs. Parkinson’s vs. Alzheimer’s).
      ii. Physiological processes
      Some neurological disorders are accompanied by no discernable anatomic, histological or
      biochemical abnormalities, and are thus best simply described as physiological disorders
      (e.g. migraines, seizures), which are often acute in onset and self-limited in time course.

5. Typical profiles of etiologic categories

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Localization</th>
<th>Onset</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degenerative</td>
<td>diffuse</td>
<td>insidious</td>
<td>progressive</td>
</tr>
<tr>
<td>Infectious</td>
<td>diffuse</td>
<td>subacute</td>
<td>progressive</td>
</tr>
<tr>
<td>Neoplastic</td>
<td>focal</td>
<td>insidious</td>
<td>progressive</td>
</tr>
<tr>
<td>Nutritional</td>
<td>diffuse</td>
<td>insidious</td>
<td>varies</td>
</tr>
<tr>
<td>Physiologic</td>
<td>focal/diffuse</td>
<td>acute</td>
<td>stable/improving</td>
</tr>
<tr>
<td>Toxic/met.</td>
<td>diffuse</td>
<td>subacute</td>
<td>varies</td>
</tr>
<tr>
<td>Vascular</td>
<td>focal</td>
<td>acute</td>
<td>stable/improving</td>
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B. Localization Principles
1. Basics
   a. Accurately defining symptoms and signs
   As indicated already, localization is the cornerstone of clinical
diagnosis of neurological problems. Localization depends on data
acquired during the history and the examination. The acquisition and
interpretation of findings requires clinical judgment, with consideration
for the range of normal, the influence of non-neurological factors (e.g.,
pain, systemic illness), and the interplay of neurological deficits on one
another (e.g., the effect of abnormal cognition on sensory and motor
testing).

   b. Pattern recognition
   Once symptoms and findings are clarified, the clinician uses them to
localize the disease process. This process requires familiarity with
neuroanatomy and application of Ockham’s razor (after a 14th century
English philosopher), which proposes that the simplest explanation is
likely the correct explanation. In neurology, Ocham’s razor leads
clinicians to explain a deficit by lesions of the smallest size and
number.

   c. Levels of confidence
   Certain symptoms and signs are more dependable localizers than others
(provide “harder” data). For example, lesions responsible for aphasia in
a right-handed patient (left cerebral cortex), complete unilateral ptosis
and mydriasis (III nerve) and complete facial paresis (VIIth nerve) can
be unequivocally localized in the nervous system. Examples of poorly
localizing findings include dysarthria, clumsiness and fatigue. Sign and symptoms that are less dependent on patient cooperation or subjective reporting; for example motor abnormalities are more objective than sensory.

d. Longitudinal and segmental localization in the nervous system

The neurologic examination allows us to identify interruptions of “long tracts” in the CNS (e.g., corticospinal tract, spinothalamic tracts) by patterns characteristic of the longitudinal organization of the nervous system. These patterns are discussed below. The precise location in the transverse plane can usually not be identified by the long tract findings alone. For transverse localization, segmental findings are most helpful (e.g., “lower motor neuron” cranial nerve or spinal anterior horn cell deficits).

2. Localization in several important longitudinal systems

a. Central motor system.

i. **Upper v. Lower Motor Neuron**

Interruption of corticospinal (or corticobulbar) tracts gives rise to “upper motor neuron” weakness. Involvement of the spinal anterior horn (or cranial nerve motor neuron) itself and all parts distal (e.g., cell, anterior root, plexus, peripheral nerve) produces “lower motor neuron” weakness.

<table>
<thead>
<tr>
<th>Features of “Upper” vs. “Lower” Motor Neuron Deficits</th>
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<tbody>
<tr>
<td><strong>Upper Motor Neuron</strong></td>
</tr>
<tr>
<td>Increased tone (spasticity)</td>
</tr>
<tr>
<td>Increased reflexes</td>
</tr>
<tr>
<td>Babinski sign</td>
</tr>
<tr>
<td>No atrophy</td>
</tr>
<tr>
<td>No fasciculations</td>
</tr>
<tr>
<td><strong>Lower Motor Neuron</strong></td>
</tr>
<tr>
<td>Decreased tone</td>
</tr>
<tr>
<td>Decreased reflexes</td>
</tr>
<tr>
<td>no Babinski sign</td>
</tr>
<tr>
<td>atrophy</td>
</tr>
<tr>
<td>fasciculations</td>
</tr>
</tbody>
</table>

ii. **Central v. Peripheral Facial Weakness**

Facial weakness is a common neurologic finding that must be interpreted correctly. The part of the 7th cranial nerve that innervates the lower face receives upper motor input from the opposite cerebral hemisphere, as is true for the limbs. The part of the 7th nerve nucleus that innervates the forehead receives bi-hemispheric innervation. Consequently, the contralateral lower face is weak when a cerebral lesion interrupts corticobulbar fibers, but the forehead is spared because it is still innervated by the opposite hemisphere (i.e., a “central” or “supranuclear” facial palsy spares the forehead).

With lesions of the nucleus itself or the peripheral 7th nerve, the forehead and lower face are weak ipsilateral to the lesion (a “peripheral” or “nuclear” facial palsy includes the forehead). Like the facial nerve nucleus, the 12th cranial nerve nucleus is also preferentially contralaterally innervated, so the contralateral hypoglossus is weak with cerebral lesions that interrupt the corticobulbar fibers.

iii. **Central Patterns of Weakness Depend on Location**

<table>
<thead>
<tr>
<th>Lesion Site</th>
<th>Distribution of Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebral cortex</td>
<td>contralateral monoparesis</td>
</tr>
</tbody>
</table>

*
Corona radiata contralateral hemiparesis *
Internal capsule contralateral hemiplegia *
*Note: Contralateral face in a “central” pattern, (see above) and tongue weakness are usually present as well.

Brainstem Quadriplegia with bilateral cranial nerve deficits or contralateral hemiparesis with ipsilateral cranial nerve deficits

Cord Quadriplegia or paraplegia – lower motor neuron at site of lesion, upper motor neuron weakness below

b. The central sensory system

i. While all modalities of tactile sensation travel together in the peripheral nerve, there is separation of modalities in the cord. Position and vibration sensation are carried ipsilaterally in the posterior column. Pain, non-discriminating touch, and temperature are carried in fibers that cross in the cord, over several segments, to ascend in the contralateral spinothalamic tract. This arrangement is responsible for the “dissociated” sensory deficits seen in some spinal cord lesions (see Brown-Sequard, syrinx below).

ii. The central sensory nucleus of the 5th cranial nerve extends within the ipsilateral brainstem from the pons almost to the cervical cord. Central lesions over this long interval characteristically produce ipsilateral facial numbness.

iii. Patterns of Sensory Deficits with Various CNS Lesions

<table>
<thead>
<tr>
<th>Lesion Site</th>
<th>Characteristic Distribution of Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse Myelopathy</td>
<td>bilateral loss of all modalities below the lesion (produces a symmetric sensory “level”)</td>
</tr>
<tr>
<td>Hemicord (Brown-Sequard)</td>
<td>ipsilateral vibration/position loss; contralateral pain/temp loss below lesion</td>
</tr>
<tr>
<td>Central cord (syrinx)</td>
<td>loss of pain/temp in band over segments occupied by the lesion</td>
</tr>
<tr>
<td>Brainstem</td>
<td>loss of ipsilateral face sensation, contralateral limb sensation</td>
</tr>
<tr>
<td>Thalamus</td>
<td>loss of all contralateral modalities usually spares trunk</td>
</tr>
<tr>
<td>Parietal lobe</td>
<td>loss of contralateral “parietal” modalities (e.g. stereognosis), usually spares trunk</td>
</tr>
</tbody>
</table>

c. The visual system

i. Interruption of visual pathways, from the retina to the occipital cortex, results in loss of vision in predictable patterns. The pattern is defined by the particular “field” of vision that is lost – individuals who lose vision to their right are said to have
“right visual field cuts”. If perception in the entire right visual field is lost, there is said to be a “hemianopia”. Fields of vision are subserved by both eyes, and the field loss can either be identical in each eye (“homonymous”) or slightly different in the 2 eyes (“heteronymous”).

ii. Patterns of Visual Deficits with Various CNS Lesions

<table>
<thead>
<tr>
<th>Site of Lesion</th>
<th>Description of Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prechiasmal</td>
<td>Monocular, often affecting acuity</td>
</tr>
<tr>
<td>Chiasmal</td>
<td>Monocular and heteronymous deficits; bitemporal with sagittal lesion</td>
</tr>
<tr>
<td>Postchiasmal</td>
<td>Contralateral heteronymous or homonymous, sparing acuity</td>
</tr>
</tbody>
</table>

Post-Lateral Geniculate Contralateral homonymous Occipital Cortex

d. The cerebellum

Cerebellar tracts caudal to the cerebellum are uncrossed, hence lesions of a cerebellar hemisphere, or of tracts leading to it, cause ipsilateral limb ataxia. Cerebellar truncal ataxia, manifested by a broad-based gait or by titubation (a weaving, bobbing unsteadiness), is associated with involvement of the vermis.

3. Localization in some important regions

a. The brainstem

i. Longitudinal anatomy-brainstem Rostral-to-Caudal segments with cranial nerves
   a) diencephalon (RAS*)
   b) midbrain (RAS, 3, 4)
   c) pons (RAS - rostral 1/3 of pons, 5, 6, 7, 8)
   d) medulla (8, 9, 10, 11, 12)

*Note: RAS = reticular activating system

ii. Transverse anatomy
   a) cranial nerves dorsal
   b) RAS central (rostral 1/3 of pons and cephalad)
   c) Motor tracts ventral

iii. Localization patterns
   a) cranial nerve symptoms/signs characteristic of segment plus...
   b) contralateral limb motor deficits (crossed hemiparesis) or quadriparesis plus
   c) ipsilateral or bilateral limb ataxia plus
   d) impairment of consciousness if RAS involved (more rostral brainstem segments)
b. The cord
   i. Important systems
      a) motor
      b) sensory
      c) autonomic function, especially bladder control, sexual function
   ii. Focal cord lesions produce deficits of long tract nature caudally and “segmental” findings at the level of the lesion.

   iii. The cord – lesions (continued)

<table>
<thead>
<tr>
<th>System</th>
<th>Long Tract Deficits</th>
<th>Segmental Deficits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor</td>
<td>Quadriplegia with Upper Motor Neuron findings</td>
<td>segmental Lower Motor Neuron findings</td>
</tr>
<tr>
<td>Sensory</td>
<td>Symmetric loss of sensation Caudal to Lesion; “level”</td>
<td>Dermatomal sensory loss or radicular pain</td>
</tr>
<tr>
<td>Autonomic</td>
<td>Sweat level (loss of sweat caudal to lesion)</td>
<td>Horner’s syndrome</td>
</tr>
<tr>
<td></td>
<td>Loss of sexual function Spastic bladder</td>
<td>Loss of sexual function Flaccid bladder</td>
</tr>
</tbody>
</table>

IV. Cases

1. A 26-year-old, right-handed woman was involved in an auto accident. There was minor head trauma but no loss of consciousness. The patient did report neck pain.

   Initial examination finds normal mental status, normal cranial nerves, left hemiparesis, left Babinski, reduced position sense in left arm and leg, reduced pin prick sense in right arm and leg.

   Where is the lesion?

2. A 28-year-old, right-handed man presents with a visual field disturbance and right-sided limb clumsiness. Symptoms developed over the past 2 months. Medical history is remarkable for positive HIV serology.

   Examination finds inattentiveness, right homonymous hemianopia, right “central” facial weakness, right hemiparesis with hyperreflexia and Babinski, right-sided numbness to all modalities.

   Where is the lesion?

   What is the clinical profile?

   What is a likely etiology?
3. A 60-year-old, right-handed man presents with whirling dizziness, choking, hoarseness, and difficulty using his left arm. Symptoms began abruptly this morning. Past history is remarkable for hypertension, peripheral vascular disease.

Examination finds normal mental status. There is numbness of the left face, including the corneal reflex. Speech is dysphonic, slurred. Gag reflex is absent on the left. Palate is weak on the left. Limb strength is normal, as are reflexes. There is loss of sensation over the right-sided extremities. Left extremities are ataxic.

Where is the lesion?
What is the clinical profile?
What is the likely etiology?

VI. SAMPLE EXAM QUESTIONS

A previously healthy 45-year-old woman developed a right upper extremity focal seizure and was brought to the ER. The seizure was quickly controlled, but she was left with new sensory disturbance and weakness in the right upper extremity and face, in addition to loss of language function, which persisted during a 2-week hospitalization.

1. The localization of the lesion, the upper extremity weakness would be expected to most prominently involve which of the following movements?
   a. Shoulder adduction
   b. Elbow flexion
   c. Forearm pronation
   d. Finger grip
   e. Finger extension and abduction

2. Which of the following statements is true regarding the likely pattern of weakness in her face?
   a. The forehead muscles would be spared because that portion of each 7th nerve is innervated by projections from both cerebral hemispheres.
   b. The entire right face would be weak
   c. The forehead would be spared because each 7th nerve projects to both frontalis muscles.
   d. The mouth would be spared because each 7th nerve projects to the entire orbicularis oris muscle bilaterally.
   e. The perioral muscles would be spared because that portion of each 7th nerve nucleus is innervated by projections from both cerebral hemispheres.

3. Where is the lesion that is responsible for her neurological deficits?
   a. Left frontal and parietal lobes
   b. Left internal capsule, anterior limb
   c. Left internal capsule, posterior limb
   d. Left ventral posterior lateral thalamus
   e. Left caudate nucleus