NIH Stroke Scale
And
Brain Localization

David M Henzler, MD
Sanford Bismarck
Stroke Program Medical Director
Disclosures

• None
Lecture Goals

• Review brain and cervical/intracranial artery anatomy
• NIHSS history and limitations
• NIHSS deficits and anatomical localization
Number of cerebral cortex brain lobes?
Brain Anatomy
Cerebral Cortex Lobes

Parts of the Human Brain

- frontal lobe
- parietal lobe
- occipital lobe
- temporal lobe
- cerebellum
- spinal cord
Brain Anatomy
Major Functional Areas
## Brain Anatomy

### Cerebral Hemisphere Function

<table>
<thead>
<tr>
<th>Lobe</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal Lobe</td>
<td>Primary motor cortex: precentral gyrus</td>
</tr>
<tr>
<td></td>
<td>Broca’s area: inferior left frontal lobe</td>
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<tr>
<td></td>
<td>Executive function</td>
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<tr>
<td>Parietal Lobe</td>
<td>Primary sensory cortex: postcentral gyrus</td>
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<tr>
<td></td>
<td>Association areas</td>
</tr>
<tr>
<td>Occipital Lobe</td>
<td>Primary visual cortex</td>
</tr>
<tr>
<td>Temporal Lobe</td>
<td>Hippocampus: new memory</td>
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<tr>
<td></td>
<td>Amygdala: emotions</td>
</tr>
<tr>
<td></td>
<td>Wernicke’s area: posterior superior left temporal gyrus</td>
</tr>
<tr>
<td></td>
<td>Primary auditory cortex</td>
</tr>
</tbody>
</table>

Disclaimer: In about 5 percent of right-handed people, the key language-processing centers are on the right sides of the brain, and in 30 percent of left-handed people, these centers are on the right side of the brains. Plus, in most people, both hemispheres take part in some aspect of speaking.
Brain Anatomy
More Detailed Functional Areas

Anatomy and Functional Areas of the Brain

Functional Areas of the Cerebral Cortex
1. Visual Area: Sight, image recognition, image construction
2. Association Area: Short-term memory, equilibrium, hearing, vision
3. Motor Function Area: Initiation of voluntary movements
4. Broca’s Area: Muscles of speech
5. Auditory Area: Hearing
6. Emotional Area: Pain, hunger, “fight or flight” response
7. Sensory Association Area
8. Olfactory Area: Smell
9. Sensory Area: Sensation from muscles and skin
10. Somatosensory Association Area: Evaluation of weight, touch, temperature, etc., for object recognition
11. Wernicke’s Area: Written and spoken language comprehension
12. Motor Function Area: Eye movement and organization
13. Higher Mental Functions: Concentration, planning, judgment, emotional expression, response inhibition
14. Functional Areas of the Cerebellum: Motor functions, coordination of movement, balance, and equilibrium
• First described in 1909.
• Neuronal cytoarchitecture organization.
Brain Anatomy
Homunculus

Motor Homunculus
(frontal section left side)

Sensory Homunculus
(frontal section right side)

brain
circle view

upper motorneuron
axon tract

sensory
axon tracts

Joshua Heafield
Brain Anatomy
Homunculus Figurine

Inside the cortex

We know that different areas of the cortex control different parts of the body. Scientists can say how much of the cortex relates to each part of the body, as this exhibit shows.

'Cortex man' (representational models)
This is what a man would look like if each part of his body grew in relation to the area of the cortex that controls it.
Brain Arterial Supply
Brain Arterial Supply, Simplified
Cerebral Artery Territories

Key
- Blue: Anterior cerebral artery
- Yellow: Middle cerebral artery
- Pink: Posterior cerebral artery
Vertebral Basilar Artery Territory
When was the NIHSS first reported?

1967
1989
1996
2003
NIHSS History

• NIHSS published in 1989 as a 15-item neurological examination stroke scale for use in acute stroke therapy trials, after used in naloxone treatment trial for acute stroke published in 1988. ¹, ²

• Seminal paper describing NIHSS referenced by >8000 research papers. (Harold P Adams personal communication, 8/2/2019)

• Originally included pupillary response and plantar reflex (Babinski sign), subsequently dropped from exam.
  • Pupil response: idiosyncratic abnormalities, poor congruence with the total score

Which of the following is a benefit of the NIHSS?

- Brief neuro exam used in screening acute stroke patients
- Accurately localizes stroke anatomic impairment
- Excellent at differentiating between right and left hemisphere impairments
- Sensitive to posterior circulation strokes
NIHSS Localization

• Coarse relatively brief examination; subset of comprehensive neuro exam
• Heavily weight to left cerebral hemisphere and language function
• Underrepresents posterior circulation and right cerebral hemisphere deficits
• Not sensitive for minor but important functional impairments
  • Fine finger function
  • Cognitive deficits: Calculation, problem solving, executive function
1 A Level Of Consciousness; Scale Definition

- 0: Alert; keenly responsive
- 1: Not alert; arousable by minor stimulation to obey, answer, or respond
- 2: Not alert; requires stimulation to attend, or is obtunded and requires strong or painful stimulation to make movements (not stereotyped)
- 3: Responds only with reflex motor or autonomic effects, or totally unresponsive, flaccid
1 A Level Of Consciousness, Localization

• 0: no significant impairment of bilateral cerebral hemispheres or upper brainstem
• 1 and 2: Probable mild diffuse bilateral cerebral hemisphere dysfunction, unlikely to affect upper brainstem but possible
• 3: Severe bilateral cerebral hemisphere dysfunction or significant bilateral upper brainstem dysfunction
The consciousness system is a diffuse yet organized neuronal system located in the brainstem, diencephalon, and cerebral hemispheres with diffuse reciprocal connections. Although it is complex and still much to be explored, it can be divided into few groups of structures for current understanding. This includes:

1) Nuclei of the brainstem reticular formation, hypothalamus, basal forebrain, and thalamus
2) The ascending projection pathways
3) Widespread areas of the cerebral cortex

General organization of the brainstem reticular formation.
Cholinergic nuclear groups of the consciousness system.
(A), the dopamine-synthesizing neurons are located in the substantia nigra pars compacta. (B), the norepinephrine-synthesizing neurons located at the locus ceruleus project extensively.
(A), The serotonin-synthesizing neurons are located in the raphe nuclei. The rostral raphe nuclei, located in the upper pons and midbrain. (B), is the histamine-synthesizing neurons of the tuberomammillary nucleus.
Image shows the effects toward consciousness resulting from different level of interruption.
1b/c Level of Consciousness Questions/Commands

- Assuming has adequate level of consciousness to respond.
- Receptive languages areas, expressive language areas, and interconnections must be intact or minimal impairment for normal score.
1b/c Level of Consciousness Questions/Commands

- Language processing involves many regions of the brain (blue regions in the frontal cortex and the cerebellum in these images, for example)
- Not just the classic areas localized by Broca and Wernicke to the perisylvian cortex of the dominant (left) hemisphere

PET scan of the brain during different components of language processing. Areas in red/yellow are the most active; areas in purple/blue are the least active.
Lateral gaze impairment only occurs from brainstem stroke?

True

False
Visual field impairment can be from either anterior or posterior circulation stroke?

True

False
3. Visual

- Lacunar infarct in supraorbital frontal white matter
- Thalamic lacunar infarct (Basilar or PCA perforating arteries)
- Lacunar infarct in temporal white matter
- Lacunar infarct in parietal white matter
- MCA-PCA watershed infarct
- PCA infarct
- ICA occlusion or embolus
4. Facial

- Minor or partial paralysis: Cerebral weakness sparing forehead muscles.
4. Facial

- Complete unilateral or bilateral paralysis is brainstem.
5 and 6. Motor Arm and Leg

- Impairment anywhere from primary motor cortical surface to spinal cord along corticospinal track.
7. Limb Ataxia

• Usually lesion in cerebellum (2% of all strokes).
• Sensory
• Vestibular; also prominent vertigo, nausea, and vomiting
7. Limb Ataxia (Cerebellum)

- **PICA infarct:**
  - Vertigo, nausea, truncal ataxia
  - 30% with lateral medulla infarcts (Wallenberg).

- **SCA infarct:**
  - Ataxia, dysarthria, nystagmus; sometimes Horner’s syndrome and contralateral sensory impairment

- **AICA infarct:**
  - ~1% of ischemic cerebellar strokes
  - Vertigo; also facial weakness, hypoacusis, facial sensory loss, crossed sensory loss, gait ataxia, limb ataxia and Horner’s syndrome
7. Limb Ataxia (Sensory)
7. Limb Ataxia (Vestibular)
8. Sensory
9. Best Language

General Language Pathway:

- Language input from visual or auditory cortex (1) goes first to Wernicke's area (posterior temporal lobe) (2), which performs the final stages of language comprehension.
- Wernicke's area connects to Broca's area (posterior inferior frontal lobe) via the arcuate fasciculus.
- Broca's area (3) is responsible for production of meaningful language.
- Output from Broca's area goes to motor cortex (4) for control of the voluntary muscles required to speak or write words.
Second, parallel route for language production in addition to the general language pathway

The inferior parietal lobule is located at the junction of, and is connected to the auditory, visual, and somatosensory cortices.

Cells in this region are multimodal (i.e., they respond to many different kinds of stimuli).

This lobule may help classify and label things, which is a prerequisite for forming concepts and thinking abstractly.

Inferior parietal lobule is one of the last structures to mature, which may explain why children typically do not begin to read and write until they are 5 or 6 years old.
10. Dysarthria

- **Flaccid**—associated with disorders of the lower motor neuron system and/or muscle
- **Spastic**—associated with bilateral disorders of the upper motor neuron system
- **Ataxic**—associated with disorders of the cerebellar control circuit
- **Hypokinetic**—associated with disorders of the basal ganglia control circuit
- **Hyperkinetic**—associated with disorders of the basal ganglia control circuit
- **Unilateral upper motor neuron**—associated with unilateral disorders of the upper motor neuron system
- **Mixed**—various combinations of dysarthria types (e.g., spastic-ataxic; flaccid-spastic)
- **Undetermined**—perceptual features are consistent with a dysarthria but do not clearly fit into any of the identified dysarthria types

American Speech-Language-Hearing Association:
10. Dysarthria
11. Extinction and Inattention (formerly Neglect)

• Heterogenous locations
  • Cortical surface
  • Subcortical nuclei
  • Subcortical white matter tracts

• Up to 2/3 right hemisphere stroke with hemispatial neglect
  • Specialized for spatial perception

• Left hemisphere stroke with hemispatial neglect is rare
  • Specialized for language
  • Redundant processing of the right visual fields by both hemispheres
11. Extinction and Inattention (formerly Neglect)
Cortical Surface Areas

The anatomy of hemispatial neglect. A variety of cortical lesions can lead to the syndrome of hemispatial neglect, tending to center around the temporo-parietal junction (TPJ), angular gyrus (ang), inferior frontal gyrus (IFG), inferior parietal lobe (IFL), intraparietal sulcus (ips), middle frontal gyrus (MGF), supramarginal gyrus (smg), superior temporal gyrus (STG).
11. Extinction and Inattention (formerly Neglect)
Subcortical Nuclei

• Putamen and pulvinar (nucleus of thalamus) > caudate nucleus
11. Extinction and Inattention (formerly Neglect) 
Subcortical Nuclei: Pulvinar of Thalamus
11. Extinction and Inattention (formerly Neglect)
Subcortical White Matter Tracts

- splenium of the corpus callosum (interhemispheric disconnection)
- white matter fronto-parietal pathways (intrahemispheric disconnection).
NIH Stroke Scale and Brain Localization Summary

• NIHSS first described in 1989 for rapid neurological assessment of acute stroke patient
• Basis for most subsequent stroke treatment medical intervention trials
• Excellent for evaluating anterior circulation infarcts but not posterior circulation infarcts except posterior PCA.
• Lesions in different parts of the brain can lead to similar neurological findings
NIH Stroke Scale and Brain Localization

• Questions?