“It’s All in Your Head”
Using Neuroanatomy to Maximize Clinical Outcomes for MCA Strokes

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CSM 2019
Washington, DC
Course Objectives

1. Relate the clinical presentations of small branch and large stem MCA stroke syndromes with the underlying neuroanatomical involvement.

2. Identify the expected Neurologic Exam positives and negatives associated with each stroke syndrome to promote differential diagnosis for movement dysfunction.

3. Plan a focused neurologic examination and evaluation based on knowledge of neuroanatomical involvement.

4. Predict functional outcomes for individuals with MCA stroke by utilizing most current evidence regarding prognosis.

5. Integrate knowledge of neuroanatomy and movement analysis to prioritize a patient’s problem list to develop an effective plan of care that will maximize clinical outcomes.
Why Neuroanatomy?
Ahhaa Moment

• Initial Impression
  • Min A with RW and functional
  • 4/5 LE strength
  • Flat affect
  • Low complexity
  • Recommendation: 1 week IP rehab stay

• 2nd Impression
  • Couldn’t clap hands or perform step up
  • Pegs
  • Able to initiate automatic movements
  • Couldn’t perform tasks on command that weren’t automatic
  • Frustration/Depression
  • Recommendation: 3 weeks
Course Timeline

3:00 – 3:30  Introduction
• Foundational Neuroanatomy review
• Pathology and prognosis of stroke

3:30 – 4:10  Middle Cerebral Artery (MCA)
• Clinical Significance
• The Neurologic Exam
• Prognosis

4:10 – 4:30  Case Examples
• Left MCA
• Right MCA

4:30 – 4:50  Guided case study

4:50 – 5:00  Wrap up and questions
Disclosures

• We have no conflicts of interest or other disclosures.
Basic Neuroanatomy Review

Organization of the CNS
Blood Supply to the Cortex
Stroke Pathology and Prognosis
Organization of the Central Nervous System

CNS

Brain

Spinal Cord

Cerebral Cortex

Frontal

Parietal

Temporal

Occipital

Sub-cortex

Cerebellum

Brain Stem
Organization of the Central Nervous System: Sensorimotor Homunculus\textsuperscript{1}
Blood Supply to the Cortex: Circle of Willis

1
Blood Supply to the Cortex: Circle of Willis

Anterior circulation
Internal Carotid Artery
- ACA
- MCA

Posterior circulation
Vertebrobasilar Artery
- PCA
- SCA
- AICA
- PICA
Stroke Pathology

Cerebrovascular accident (CVA)
Sudden death of brain cells due to disruption of blood flow

Ischemic
Narrowing or blockage of cerebral artery causes brain tissue infarction

Hemorrhagic
Blood from ruptured or leaking cerebral artery is toxic and causes excess pressure
Stroke Pathology: Potential Complications

- Mass effect
- Midline shift
- Hemorrhagic conversion
Stroke Prognosis: Long Term Recovery

10% - recover almost completely
25% - minor impairments
40% - moderate/severe impairments, require special care
10% - nursing home or other long-term facility
# Stroke Prognosis: Prognostic Indicators

<table>
<thead>
<tr>
<th></th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual-related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stroke-related</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Stroke Prognosis: Prognostic Indicators

<table>
<thead>
<tr>
<th>Individual-related</th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Older age(^{4,5})</td>
<td>• Inpatient Rehab(^{6,7,8})</td>
</tr>
<tr>
<td></td>
<td>• Multiple co-morbidities(^4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Premorbid disability(^4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lack of social support(^4)</td>
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</tbody>
</table>
## Stroke Prognosis: Prognostic Indicators

<table>
<thead>
<tr>
<th>Stroke-related</th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Severity: imaging, NIHSS score[^4;^5;^9]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Type: ischemic[^10]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Location: cortical, MCA[^10]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Associated symptoms[^4]:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lower FIM score</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dense, flaccid paralysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Bowel and bladder incontinence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Trunk instability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Aphasia[^10], neglect[^11]</td>
<td></td>
</tr>
</tbody>
</table>
Stroke Prognosis: Emerging Research

• Brain-derived Neurotropic factor (BDNF)\(^9\)
  • Maintains existing neurons
  • Promotes growth of new neurons
  • Independent predictor of functional outcomes

• Potential stroke biomarkers\(^{12,13}\)
  • GABA:Creatine ratio, infarct volume, white matter tract injury, cortical activation
The Middle Cerebral Artery

Clinical Significance, Clinical Presentation, Prognosis, Case Examples
Clinical Significance

- Most commonly affected and largest vascular territory $^1$
  - Bulk of lateral surface of hemisphere
- With large MCA infarcts, substantial edema and mass effect may develop after first 3-4 days$^{14}$
- Multiple branches$^{14}$:
  - *Superior division*: inferolateral frontal lobe
  - *Inferior division*: lateral temporal lobe
  - *Deep territory*: basal ganglia and internal capsule
Clinical Significance: Vascular Territories
Clinical Significance: Divisions

1
Clinical Significance: Divisions
Clinical Significance: Lateralization

**Left**
- Language
- Detailed analytical and sequential skills
- Complex motor planning

**Right**
- Attention: general and spatial
- Insight and awareness
- Complex visual-spatial abilities
Neurologic Exam

**Mental Status**
- Level of alertness, attention, and cooperation
- Orientation
- Memory
- Language
- Calculations, right-left confusion, finger agnosia, agraphia
- Apraxia
- Neglect and constructions
- Sequencing tasks and frontal release signs
- Logic and abstraction
- Delusions and hallucinations
- Mood

**Cranial Nerves**
- Olfaction (I)
- Vision (II)
- Pupillary Responses (II/III)
- Extraocular Movements (III, IV, VI)
- Facial sensation and muscles of mastication (V)
- Muscles of facial expression and taste (VII)
- Hearing and vestibular sense (VIII)
- Palate elevation and gag reflex (IX, X)
- Muscles of articulation (V, VII, IX, X, XII)
- Sternocleidomastoid and trapezius muscles (XI)
- Tongue muscles (XII)

**Motor Exam**
- Observation, Inspection, Palpation
- Muscle Tone
- Functional Testing
- Strength of individual muscle groups

**Sensory Exam**
- Primary Sensation
- Cortical Sensation
- Extinction

**Reflexes**
- Deep Tendon Reflexes
- Plantar Response
- Abnormal Reflexes

**Coordination and Gait**
- Appendicular Coordination
- Romberg Test
- Gait
Neuro Exam

Mental Status
- Aphasia (left)
- Apraxia (left)
- Neglect (right)

Cranial Nerves
- Contralateral visual loss
- Contralateral face weakness

Motor Exam
- Contralateral hemiparesis (UE>LE)

Sensory Exam
- Contralateral hemisensory loss (UE>LE)

Coordination
- Normal
Clinical Presentation

Mental Status

- **Aphasia (left)**
- Apraxia (left)
- Neglect (right)
Clinical Presentation$^{11,15}$

Mental Status

- Aphasia (left)
- **Apraxia (left)**
- Neglect (right)
Clinical Presentation\textsuperscript{11,15}

Mental Status

- Aphasia (left)
- Apraxia (left)
- \textbf{Neglect (right)}
Clinical Presentation

Mental Status
- Aphasia (left)
- Apraxia (left)
- Neglect (right)

Cranial Nerves
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Coordination
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Clinical Presentation

Cranial Nerves
- Contralateral visual loss
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Sensory Exam
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Clinical Presentation

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Coordination
- Normal
Clinical Presentation

Mental Status
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- Apraxia (left)
- Neglect (right)

Cranial Nerves
- Contralateral visual loss
- Contralateral face weakness

Motor Exam
- Contralateral hemiparesis (UE>LE)

Sensory Exam
- Contralateral hemisensory loss (UE>LE)

Coordination
- Normal
Divisions

Superior
- Contralateral face, arm weakness
- Broca's aphasia

Inferior
- Contralateral face, arm sensory loss
- Wernicke’s aphasia
- Contralateral visual field deficit

Deep
- Contralateral pure motor hemiparesis
# MCA Prognosis

<table>
<thead>
<tr>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stroke-related</strong></td>
<td></td>
</tr>
<tr>
<td>• ACA involvement is predictive of mortality in MCA strokes(^{18})</td>
<td>• Spontaneous recanalization</td>
</tr>
<tr>
<td>• Proximal occlusions → significant cerebral edema, increased ICP, loss of consciousness, fatality(^{18})</td>
<td>• More likely with hypertension compared to atrial fibrillation(^{16})</td>
</tr>
<tr>
<td>• Lowest admit and discharge FIMs compared to all other cortical and subcortical strokes(^{10})</td>
<td>• Distal occlusions → milder deficits(^{17})</td>
</tr>
<tr>
<td>• More than one branch affected: outcomes significantly worse compared to one branch or cortical strokes in general(^{19})</td>
<td></td>
</tr>
<tr>
<td>• Hemianopsia, reduced consciousness, complete MCA occlusion → severe disability(^{19})</td>
<td></td>
</tr>
<tr>
<td>• Right sided strokes: higher morbidity rate than left(^{20})</td>
<td></td>
</tr>
<tr>
<td>• Impaired attention may decrease neuroplasticity(^{21})</td>
<td></td>
</tr>
</tbody>
</table>
Case Example: Right MCA stem

IMPRESSION

1. **Nonhemorrhagic cortical based** focal acute right MCA vascular insult which involves the insula, inferior, middle frontal, precentral and postcentral gyri. **Regional mass effect** results in partial effacement of the right lateral ventricle.

2. **Subtle** hyperdense appearance of the **M1 segment** of the right MCA a punctate hyperdense focus in the right sylvian fissure indicate the insult is in part **embolic**.
Case Example: Right MCA stem

IMPRESSION

1. Status post interval right frontal cranietomy.

2. A 5.6 x 10 x 3.5 cm extra-axial air and fluid collection overlies the right frontotemporal convexity with associated mild local mass effect.

3. Decreased subfalcine shift from right to left, now measuring approximately 3 mm. Decreased compression of the right lateral ventricle and right cerebral parenchyma.
Case Example: Right MCA stem

IMPRESSION

1. No acute abnormalities.

2. Resolved right frontoparietal scalp hematoma and brain swelling when compared to 10/18/12

3. Previous right hemispheric MCA vascular insult has evolved into an extensive area of encephalomalacia. Previous duraplasty as in folded medially compressing the underlying encephalomalacic hemisphere.
Case Example: Right MCA stem
Based on the involved neuroanatomy, what are some expected impairments for this patient?

Example
(separate texts)

“cool”

“super-fun”
## Case Example: Right MCA stem

<table>
<thead>
<tr>
<th>Neuro Exam</th>
<th>Expected</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Status</td>
<td>Aphasia (left)</td>
<td>Oriented x4</td>
</tr>
<tr>
<td></td>
<td>Apraxia (left)</td>
<td>Bilingual in Spanish and English</td>
</tr>
<tr>
<td></td>
<td>Neglect (right)</td>
<td>Easily distracted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L neglect</td>
</tr>
<tr>
<td>Cranial Nerves</td>
<td>Contralateral visual loss</td>
<td>L homonymous hemianopsia</td>
</tr>
<tr>
<td></td>
<td>Contralateral face weakness</td>
<td>L facial droop</td>
</tr>
<tr>
<td>Motor</td>
<td>Contralateral hemiparesis (UE&gt;LE)</td>
<td>L hemiparesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- UE: no active movement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- LE: MMT 2- to 2+</td>
</tr>
<tr>
<td>Sensory</td>
<td>Contralateral hemisensory loss</td>
<td>Diminished light touch on L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+ve tactile, visual, and auditory extinction</td>
</tr>
<tr>
<td>Coordination</td>
<td>Normal</td>
<td>Testing limited by weakness but no observed deficits</td>
</tr>
</tbody>
</table>
Case Example: Right MCA stem

Cognition
What are some positive and negative prognostic indicators for this patient?

Example
(2 separate texts)

“+ nice, tall”

“- blue shirt”
Case Example: Right MCA stem

Prognostic indicators

<table>
<thead>
<tr>
<th></th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual-related</strong></td>
<td>Orthostatic hypotension, visuospatial disorder</td>
<td>Family support, minimal co-morbidities, full time employment at time of infarct</td>
</tr>
<tr>
<td><strong>Stroke-related</strong></td>
<td>Right side, hemorrhagic conversion, midline shift, partial lobectomy</td>
<td></td>
</tr>
</tbody>
</table>

Long term outcomes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sit&lt;&gt;stand</td>
<td>Total A</td>
<td>Max A</td>
<td>Min A</td>
<td>Min A</td>
<td>Min A</td>
</tr>
<tr>
<td>6MWT</td>
<td></td>
<td></td>
<td></td>
<td>85’</td>
<td>165’</td>
</tr>
</tbody>
</table>
Case Example: Right MCA stem

Long Term Outcomes
Case Example: Left MCA stem

IMPRESSION:

*Occlusion* of the *left proximal M1 segment* and left proximal pericallosal arteries
Based on the involved neuroanatomy, what are some expected impairments for this patient?

Example
(separate texts)

“cool”

“super-fun”
## Case Example: Left MCA stem

<table>
<thead>
<tr>
<th>Neuro Exam</th>
<th>Expected</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Status</td>
<td>Aphasia</td>
<td>Profound global aphasia Ideomotor apraxia</td>
</tr>
<tr>
<td></td>
<td>Apraxia</td>
<td></td>
</tr>
<tr>
<td>Cranial Nerves</td>
<td>Contralateral visual loss</td>
<td>Unable to assess vision</td>
</tr>
<tr>
<td></td>
<td>Contralateral face weakness</td>
<td>R facial droop</td>
</tr>
<tr>
<td>Motor</td>
<td>Contralateral hemiparesis (UE&gt;LE)</td>
<td>R hemiparesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- UE: no active movement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- LE: quad and glut max activation in standing, no movement with MMT</td>
</tr>
<tr>
<td>Sensory</td>
<td>Contralateral hemisensory loss</td>
<td>Unable to assess sensation</td>
</tr>
<tr>
<td>Coordination</td>
<td>Normal</td>
<td>Testing limited by weakness/cognition but no observed deficits</td>
</tr>
</tbody>
</table>
Case Example: Left MCA stem

Mental status
What’s your name?
   *(Sounds, no words)*
Is your name Juan?
   *Three, forty, sixty*
Is your name Diomedes?
   *Three, (sounds)*
Yes or no?
   *(Sounds)*
Case Example: Left MCA stem

Strength testing
What are some positive and negative prognostic indicators for this patient?

Example
(2 separate texts)

“+ nice, tall”

“- blue shirt”
Case Example: Left MCA stem

Prognostic indicators

<table>
<thead>
<tr>
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<th>Negative</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual-related</strong></td>
<td>Stem involvement, ischemic Aphasia, apraxia Chronicity</td>
<td>Good family support Trunk control Minimal comorbidities</td>
</tr>
<tr>
<td><strong>Stroke-related</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Long term outcomes (over 3 months)

- PASS: 22/36 → 31/36 ($MDC = 3.2$ pts)
- Standing: max A → mod I
- Gait: non-ambulatory → min A
Case Example: Left MCA stem

Long term outcomes
MCA Clinical Pearls

• Know more than just “MCA”
  • Divisions
  • Lateralization

• Prognosis
  • MCA poorer than other territories
  • R MCA poorer than L
  • More branches affected → worse prognosis

• Figure out cognition sooner rather than later

• Day 1 priorities:
  • Cognition screening and assess safety
  • Gross, functional strength
Case Study

Your patient is a 56 year old African American male referred to outpatient PT for “history of stroke,” his chief complaint is shoulder pain and weakness.

This is what you observe as you bring him into the clinic.
Case Study

Subjective interview
Based on the information you have so far, what do you think are this patient's primary impairments?

Example
(separate texts)

“cool”

“super-fun”
What impairments do you think you can rule out?

Example
(separate texts)

“cool”

“super-fun”
Case Study
As part of your evaluation, you have him ascend and descend stairs.

What do you predict as his MMT scores for knee extensors?

<table>
<thead>
<tr>
<th>Score</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2+</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>3-</td>
<td>0</td>
</tr>
<tr>
<td>3+</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

0 1 2 3 4 5
0 1 2 3 4 5

3 3
Case Study

What do you predict as his MMT score for plantarflexors?

- 2+: 3
- 3: 2
- 2: 0
- 2-: 0
- 1: 0
- 0: 0

0 1 2 3

Start the presentation to see live content. Still no live content? Install the app or go to help at Periea.com/app
## Case Study

<table>
<thead>
<tr>
<th>Muscle</th>
<th>MMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deltoids</td>
<td></td>
</tr>
<tr>
<td>Biceps</td>
<td></td>
</tr>
<tr>
<td>Triceps</td>
<td></td>
</tr>
<tr>
<td>Wrist flex/ext</td>
<td></td>
</tr>
<tr>
<td>Psoas</td>
<td></td>
</tr>
<tr>
<td>Glut max</td>
<td></td>
</tr>
<tr>
<td>Glut med</td>
<td></td>
</tr>
<tr>
<td>Quads</td>
<td></td>
</tr>
<tr>
<td>Hamstrings</td>
<td></td>
</tr>
<tr>
<td>Gastroc</td>
<td></td>
</tr>
</tbody>
</table>
What impairment should you further assess?
Case Study

You perform the following test
What is this patient's primary impairment?

- Quad weakness (A)
- Gastroc weakness (B)
- Impaired cognition (C)
- Impaired proprioception (D)
Thank you!

• Laurie Bramlett
• Laura Wiggs
• Anne Miller
• Harris Health System Neurologic Residency faculty and Residents
• Fabulous Neuro Team at Quentin Mease Hospital

Don't worry. I saw this done on Grey's Anatomy once.
References


References


