Tying Stroke Syndromes to Vascular Anatomy

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Disclosures

• Consultant - Integra
Why is the anatomy important

- Know the normal structures
- Visualize the vascular distribution
- Recognize symptoms of pathology
- Where is the problem
- What is the problem
  - Helps to plan management
  - Anticipate complications
  - Educate the family
Ischemic Stroke
Hemorrhagic Stroke
Lacunar Strokes

• May be a small vessel with vital structures
  - Choroidal artery
  - Artery of Heubner
Meninges

- Coverings of the brain and spinal cord
- Dural Arterial Supply
  - Supply from middle meningeal artery in a groove of the temporal bone
Meninges

• Dural Venous drainage
  - Occurs through the bridging veins
  - Superior Sagittal
  - Inferior Longitudinal
  - Straight
  - Cavernous
  - Internal Jugular Vein
Clinical Considerations

- Venous drainage
  - Monitoring catheters in the jugular vein
  - Head position
  - Pathologic occlusion
Clinical Considerations

- Hemorrhages within the meningeal layers
  - Epidural
  - Subdural
  - Subarachnoid
Subarachnoid Hemorrhage
Anterior Cerebral Delivery

- **Carotid Arteries**
  - Common carotid artery leads to the internal carotid
  - 15-20% of cardiac output
  - External carotid artery supplies face and scalp
  - Internal carotids branch to become anterior cerebral circulation
Internal Carotid Artery
Carotid Cavernous Fistula

High pressure ICA & low pressure cavernous sinus

- Headache, pain, tinnitus
- Unilateral massive proptosis
- Pulsating exophthalmos
- Eyelid/orbital congestion
- Visual loss
- Optic neuropathy, disc edema
- Cranial nerve palsies
- Epistaxis
- Retinal hemorrhages, venous congestion
- Loud ocular/cranial bruit
Clinical Considerations

Carotid Arteries

• Atherosclerotic disease
  - Contralateral motor & sensory loss

• Traumatic Dissection/Aneurysm

  Internal carotid artery
  - Blurred Vision
  - Amaurosis fugax
  - Visual hallucinations
  - Contralateral hemiplegia
Sympathetic Pathway to Eye

Fight or Flight

Horner’s Syndrome
Miosis
Ptosis
Anhydrosis
Carotid Artery Dissection

- Hallmark sign - sharp or throbbing pain, ipsilateral in head, neck or scalp
- Ischemia - TIA, transient blindness
  - Retinal artery occlusion
- Disruption of sympathetic fibers along ICA
  - Partial Horner's syndrome
  - Miosis and Ptosis (sweating is preserved)
- Cranial Nerve Deficit
  - IX, X, XI, XII
- Audible bruit
Posterior Cerebral Delivery

Vertebral Arteries

- Branch from the subclavian artery
- Join to form the basilar artery

Basilar Artery travels anterior to the pons in the anterior sulcus and has pontine perforators

- Superior Cerebellar Artery
- PICA
- AICA
Clinical Considerations

- Vertebral Arteries
  - Tightening of the pathway thru C-spine
  - Traumatic aneurysm
  - Vertebral artery syndrome
  - Wallenburg’s syndrome
  - PICA Aneurysm
Tentorium

- **Supratentorial**
  - Cerebral Lobes
  - Diencephalon
  - Basal Ganglia

- **Infratentorial**
  - Cerebellum
  - Brain Stem
Circle of Willis

- **Middle Cerebral Arteries**
  - Lenticulostriate vessels
- **Anterior Cerebral Arteries**
  - Proximal and Distal
- **Anterior Communicating**
- **Posterior Communicating**
- **Posterior Cerebral**
Cerebral Cortex

- Frontal Lobes
- Parietal Lobes
- Temporal Lobes
- Occipital Lobes
Frontal Lobe

- Initiates motor function
- Broca’s speech center
- Bowel and bladder
- Judgement
- Personality
- Reasoning
- Long term memory
Frontal Lobe

- **Dominant**
  - Speech
  - Calculation
  - Motor dominance

- **Non-Dominant**
  - Organization of speech
  - Spatial relations
  - Perception
  - Artistry
Recurrent Artery of Heubner

Medial Striate Artery - ACA1 or ACA2

- Unilateral occlusion
  - weakness contralateral arm
  - weakness contralateral face
  - dysarthria
  - hemichorea
- Bilateral occlusion
  - akinetic mutism
Parietal Lobe

Sensory interpretation and discrimination

• Primary
  - Pain and temperature

• Association areas
  - Deep structures perception
  - Defines shape, size, weight
  - Consistency
  - Coordinate intentional & purposeful movement
  - Orientation in space
Left Frontal & Parietal Stroke

- **Left Carotid and Left MCA**
  - Aphasia, dysphasia
  - R sensory/motor loss
  - R visual field loss
  - Contralateral motor loss in lower face
  - Difficulty reading, writing, calculations
  - NERVOUS, ANXIOUS
Right Frontal & Parietal Stroke

- **Right Carotid and Right MCA**
  - L side spatial neglect
  - L upper extremity motor/sensory loss
  - Constructional apraxia and dressing
  - Impaired proprioception
  - Stereognosia - unable to detect item when placed in hand (i.e. buttons, coins, scissors)
  - Agraphia—unable to detect numbers written on skin
  - Left visual field loss and conjugate gaze defect
  - AGITATED, CAN’T BE TRUSTED
Frontal & Parietal Anterior Stroke

- **R/L Anterior Cerebral and AcoA**
  - Incontinence of bowel and/or bladder
  - Weakness & sensory changes in contralateral lower extremity
  - Abulia - slowed reactions
  - Flat affect, lack of initiative
  - Confusion, personality changes, perseveration
  - Impulsive behavior
Anterior Choroidal Stroke

Corticospinal tract - Hemiparesis (opposite)
Posterior columns - Hemianesthesia
Optic tracts and - Homonymous
Lateral Genic. nuc. - hemianopia
Temporal Lobe

- Short term memory
- Hearing and discrimination of auditory input
- Primary
  - Detects specific tones
  - Loudness of sounds
- Secondary
  - Interprets meaning
  - Words and music
- Wernicke’s Area
  - Only in one hemisphere
  - Integration of sensory input
MCA and ACA

Branches
Orbitofrontal (1)
Pre-rolandic (2)
Rolandic branches (3)
Anterior and posterior parietal branches (4)
Anterior temporal (5)
Posterior temporal (7)
Angular artery
Lenticulostriate arteries (central arteries)

Branches
The medial striate (recurrent artery of Heubner)
Orbital branches (1)
Frontopolar artery (2)
Callosomarginal artery (3)
Pericallosal artery (4)
Occipital Lobe

- Visual interpretation and discrimination
  - **Primary**
    - Calcarine fissure
    - Terminus for direct visual signals
  - **Secondary**
    - Surrounds primary
    - Interpretation of vision
    - Meaning of written word
Primary visual cortex

- Calcarine fissure

Primary Visual Cortex
Where to Parietal Lobe (location, motion)
What to Temporal Lobe (color, form)
Visual Cortex

• Primary visual cortex
  - Calcarine fissure/sulcus
  - Stripe of Gennari (LGN myelinated fibers)
  - Representation on the map is opposite and upper visual field is below

• Prestriate cortex
  - Subdivided areas that project to temporal lobe and ask “what am I looking at”

• Medial temporal area
  - Projects to the parietal area and asks “where is the object”
Using visual information

V1 - Primary
Ventral goes to temporal lobe
Dorsal goes to parietal
Pathway Pathology

Dorsal pathway to parietal lobe

- Optic Ataxia - patient can’t guide hand to touch object
- Neglect - incomplete drawings, unaware of left side
- Akinetopsia - don’t perceive movement
- Apraxia - unable to produce voluntary movement
  although there is no motor weakness

Ventral pathway to temporal lobe

- Hypothesis is that this pathway is the working memory
- Attention to detail and relevance of objects
Partial visual deficits

1. Total blindness of right eye due to complete lesion of right optic nerve
2. Bipolar hemianopia due to midline chiasmal lesion
3. Right nasal hemianopia due to lesion involving right perichiasmal area
4. Left homonymous hemianopia due to lesion or pressure on right optic tract
5. Left homonymous inferior quadrantanopia due to involvement of lower right optic radiations
6. Left homonymous superior quadrantanopia due to involvement of upper right optic radiations
7. Left homonymous hemianopia due to lesion of right occipital lobe
L/R Temporal & Occipital Stroke

- **Temporal**
  - Seizures
  - Hearing and discrimination
  - Memory loss

- **Occipital**
  - Visual field cuts
  - Visual impairment
Posterior Communicating Deficit

- **Posterior Communicating**
  - Oculomotor palsy
  - Collateral flow when occluded
Posterior Cerebral Artery Stroke

Depends on area of vessel

- Sensory loss
- Pain syndromes
- Tremor
- Memory loss
- Cranial nerve dysfunction
- Visual field loss - ipsilateral
Basal Ganglia

- Caudate Nucleus
- Putamen
- Globus Pallidus
  - Masses of sub-cortical nuclei
  - Close to thalamus & midbrain
  - Controls gross body movement
  - Fine motor of hands and feet
Basal Ganglia Stroke

- **MCA**
- **Lenticulostriate vessels**
  - Most common site for hypertensive hemorrhages
  - Weakness and sensory changes on contralateral side
  - Hemiballismus
  - Large flailing (usually) single sided movements
  - Damage to contralateral subthalamic nuclei
  - Usually deep infarctions
- **Recurrent artery of Huebner**
Thalamus

- Rests directly on midbrain
- Either side of third ventricle

Functions
- Relay station and control center for the body
- Somatosensory receptors
- Visual
- Auditory
- Muscle control
Location of CVI
Thalamus

- Posterior Cerebral Arteries
- Posterior Choroidal
- Posterior Communicating
  - Sensory integration problems
  - Pain syndromes
  - Tremor
  - Memory loss
  - Cranial dysfunction
  - Visual field loss
Internal Capsule

- Pathways between:
  - Cerebral cortex
  - Spinal cord
  - Brainstem
  - Subcortical structures

- Anterior limb
- Genu
- Posterior limb
Internal Capsule

Anterior Limb
- Thalamocortical Tract
  - Thalamus to frontal lobe
- Frontopontine Tract
  - Frontal to pons

Genu
- Corticobulbar
  - Frontal to brain stem - CNs
- Ventral anterior and lateral
  - Motor initiation of movement

Posterior Limb
- Corticospinal
  - Frontal to anterior spinal cord
- Dorsal column
  - Position sense, vibration
- Spinothalamic
  - Sensory
Internal Capsule

- Corticobulbar
- Corticospinal
- Optic Radiation
Internal Capsule Blood Supply

**BLOOD SUPPLY OF INTERNAL CAPSULE**

**ANTERIOR LIMB**
Upper part: lenticulo-striate branches of middle cerebral artery
Lower part: recurrent branch (Heubner artery) of anterior cerebral artery

**GENU**
Upper part: lenticulo-striate branches of middle cerebral artery
Lower part: direct branches of internal carotid and recurrent branch (Heubner) of anterior cerebral arteries

**POSTERIOR LIMB**
Upper part: lenticulo-striate branches of middle cerebral artery
Lower part: anterior choroidal artery (branch of internal carotid artery)
## Lacunar Stroke Syndromes

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Pathology</th>
<th>Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure motor hemiparesis</td>
<td>Lacunar infarct – posterior limb of internal capsule</td>
<td>Unilateral motor deficit (face, arm, and less for leg) Mild dysarthria, NO sensory visual or higher dysfunction</td>
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<tr>
<td>Pure sensory stroke</td>
<td>Ventroposterolateral nucleus of thalamus</td>
<td>Unilateral numbness, parasthesias, hemisensory deficit involving face, arm, trunk, and leg</td>
</tr>
<tr>
<td>Ataxic hemiparesis</td>
<td>Lacunar infarct – posterior limb of internal capsule</td>
<td>Weakness that is more pronounced in lower extremity with ipsilateral arm and leg incoordination</td>
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<tr>
<td>Dysarthria - clumsy hand</td>
<td>Lacunar infarct at the basis pontis</td>
<td>Hand weakness, mild motor aphasia, NO sensory abnormalities</td>
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</tbody>
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Internal Capsule Stroke

Left lenticulostriate and genu

Posterior limb lesion
Brain Stem

- Midbrain
- Pons
- Medulla Oblongata
Midbrain

- Tegmentum
  - Sensory & motor control
  - Pain
  - Eye movement
- Tectum
- Cerebellar peduncles
- CN III & IV nuclei
  - Movement of the eyes
  - Reaction of the pupil
  - Elevation of eyelid
- Reticular formation
  - Stimulates wakefulness
Arteries: Circle of Willis
- Anterior cerebral
- Anterior communicating
- Middle cerebral
- Internal carotid
- Posterior communicating
- Posterior cerebral

Cranial Nerves
- I - Olfactory
- II - Optic
- III - Oculomotor
- IV - Trochlear
- V - Trigeminal
- VI - Abducens
- VII - Facial
- VIII - Vestibulocochlear
- IX - Glossopharyngeal
- X - Vagus
- XI - Accessory
- XII - Hypoglossal
Location of Stroke
Posterior Circulation

• Posterior Cerebral
  - Contralateral sensory loss and pain syndromes
  - Contralateral motor loss in lower face and arm>leg
  - May have quadriparesis
  - Tremor
  - Memory loss
  - Cranial dysfunction -
    dysarthria, dysphagia, diplopia
  - Ipsilateral visual field loss
  - Cortical blindness
Clinical Correlation

- Posterior cerebral artery
- Weber’s Syndrome
  - Injury in right crus cerebri and right oculomotor nerve
  - Loss of ipsilateral oculomotor and contralateral hemiplegia
Clinical Correlation

Shear Injury or Stroke

Axon Shear (Post Concussion Syndrome)

Normal Axon

Shearing of the Axon

Post-trauma Condition

A. Trauma causes the axon to twist and tear
B. The result is permanent death of the brain cell
Clinical Correlation

- Bilateral lesions - Stroke or Shear Injury

Locked in Syndrome - Basal Pons
- Interrupts corticobulbar
- Interferes with speech, facial movements & activation of motor tracts
- Damage to RAS
- Patient is awake and aware
- Eye movement preserved
Vertebrobasilar Insufficiency

• Visual – diplopia, illusions, hallucinations, blindness, visual field defects
• Drop attacks
• Incoordination
• Weakness
• Less frequently
  - hearing loss, tinnitus
  - headache, dysarthria,
  - numbness
Pons

- Divided into anterior and posterior
  - Anterior
    - Corticospinal tracts
    - Pontine nuclei
    - Transverse fibers
Where is the lesion...

Suprabulbar (Pseudobulbar Palsy)

• Bilateral lesions above the brain stem - strokes that may have occurred at different times
• Dysphagia
  - Trouble chewing, swallowing, food falls out of mouth, pocketing food and silent aspiration
• Dysarthria
  - Speech lacks resonance and tone variation - may be high pitched and strained, weak
• Jaw jerk, snout and sucking reflexes present
• Tongue can’t protrude beyond the teeth more than 1”
• Defective emotional control
• Some signs of bilateral paralysis are present in limbs
Where is the lesion...

Above mid pons

- Contralateral face, arm and leg weakness
- Relatively normal upper face movement
- Watch the speed and strength when patient smiles
- Altho face, leg and arm may be permanent, the tongue weakness is usually transient.
- Upper extremity will lose flexion and abduction of fingers before loss of adduction - “squeeze my fingers” will be a later finding
- Rapid alternating movements would be a better test
- Lower extremity will lose flexors of thigh and dorsiflexion of foot - tripping on a curb, stair riser, etc.
Pons

- **Posterior**
  - Tegmentum *(Continues from Midbrain)*
  - Reticular formation
  - Portions of respiratory and vasomotor centers

- **Cranial nerves**
  - CN V Trigeminal
  - CN VI Abducens
  - CN VII Facial
  - CN VIII Acoustic
Medulla Oblongata

- Cone shaped with wider top
  - Decussation of pyramids
    - Corticospinal tracts cross over
  - Cranial Nerves
    - CN IX  Glossopharyngeal
    - CN X  Vagus
    - CN XI  Spinal accessory
    - CN XII  Hypoglossal
  - Remember bulbar functions
    - Swallowing, gag, phonation
Cerebellum

- Coordinates voluntary movement
- Controls equilibrium
- Provides for delay in signal
- Tone and posture
Location of Stroke
Cerebellum

- **Superior cerebellar artery**
  - Undersurface of the cerebellum
- **AICA,**
  - Anterior surface and underside,
  - Lateral pons
- **PICA**
  - Posterior cerebellum
Location of Stroke Vertebrobasilar

- Posterior Occipital and Cerebellum
  - Superior cerebellar arteries
  - Basilar artery
  - Anterior inferior cerebellar artery
Clinical Correlation

• Posterior Occipital
• Cerebellar
  - Mild to severe visual and memory deficits
  - Dysarthrias
  - Akinetic mutism
  - Locked-in syndrome
  - Limb weakness
  - Dizziness, diplopia, hemianopia/blindness
  - Drop attacks, ataxia
  - Cranial nerve deficits
Clinical Correlation

- **PICA – Wallenburg’s Syndrome**
  - Inferior cerebellar peduncle
    - Cerebellar ataxia
  - Spinal tract of CN V
    - Loss of pain and temperature on face
    - Loss of corneal reflex
  - Descending sympathetic pathway
    - Ipsilateral Horner’s (ptosis, miosis, anhydrosis)
  - Vagus nerve
    - Ipsilateral paralysis of larynx, soft palate, dysphagia, dysphonia
  - Lateral Spinothalamic tract
    - Loss of contralateral pain/temp of arm and leg
Pathology

- **Uncoordinated**
  - Unilateral: Ipsilateral cerebellar syndrome
    Demyelination, vascular disease
  - Bilateral: Bilateral cerebellar syndrome
    Same as above + alcohol, drugs (AEDS)

- **Truncal Ataxia**
  - Midline cerebellar syndrome
    Lesion of the cerebellar vermis

Think of cerebellum as a feedback/feedforward system
Pathology

• Unilateral
  - Ipsilateral loss of arm swing
  - Timing and coordination problems
  - Disorganization of one side with movement

• Bilateral:
  - Arms oscillate before coming to rest with outstrecking
  - Develop a tremor when approaching target for pointing
  - Intention tremor

• Truncal Ataxia
  - Abnormal gait, coordination preserved
  - Inability to sit from lying without falling to one side

• Anterior Lobe
  - Postural problems
Gait - ties all three together

- Look for symmetry
- Normal pace and posture
- Look for the whole movement
  - Feet distance, knees, hips/pelvis, shoulders
- Pain or deformities
- Movement of individual limbs
- Vestibular disease
Pearls

- Deviation of eyes
- Motor strength in all extremities
- Facial droop - smile
- Speech deficits
  - Receptive
  - Expressive
- Cognition and judgment
  - Impulsive vs Fearful
Questions…

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