

Introduction to seizure semiology Localization related epilepsy

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Outline

- ▶ Introduction
- ▶ Localization and lateralization
 - ▶ Aura
 - ▶ Seizure semiology
 - ▶ Postictal signs

Seizure semiology

- ▶ Study of signs and symptoms of seizure
- ▶ Help to localize symptomatogenic zone → aid in localizing epileptogenic zone
- ▶ Signs used for localization should be
 - ▶ Easy to identify and have a high interrater reliability
 - ▶ First or one of earlier components of seizure

Limitations of using semiology as a localizing and lateralizing tool

- ▶ Subjective: significant inter-rater variability
- ▶ Semiology can reflect only symptomatogenic zone
- ▶ Cannot lateralize a seizure focus with absolute certainty
- ▶ Not always differentiate focal or generalized epilepsies
- ▶ Focal epilepsy may trigger seizures of generalized semiology
- ▶ Generalized epilepsies may have seizures of focal symptomatology

Aura

- ## Aura
- ▶ Subjective ictal phenomenon that may precede an observable seizure
 - ▶ Starting point of symptomatogenic zone

- ## Aura
- | Primary sensory aura | Other |
|----------------------|-------------------|
| ▶ Somatosensory | ▶ Autonomic |
| ▶ Visual | ▶ Abdominal auras |
| ▶ Auditory | ▶ Psychic aura |
| ▶ Olfactory | ▶ Cephalic |
| ▶ Vertiginous | |
| ▶ Gustatory | |

- ## Somatosensory aura
- ▶ Somatosensory: tingling, numbness, electrical shock-like feelings, thermal sensations, pain
 - ▶ More reliable if well localized, in a distal extremity, and associated with sensory march

Somatosensory aura

- ▶ Primary sensory cortex (SI)
 - ▶ Contralateral, distal distribution
- ▶ Second sensory area (SII)
 - ▶ Bilateral or ipsilateral, more wide spread
- ▶ Supplementary sensory motor area (SSMA)
 - ▶ Poorly localized
 - ▶ Contralateral proximal body parts
- ▶ Posterior insula
 - ▶ Vary, focal or wide spread
 - ▶ Most often contralateral

Somatosensory aura

- ▶ Somatosensory illusions
 - ▶ Sensations of swelling, shrinking, movement of body parts
 - ▶ Nondominant inferior parietal lobe or TPO junction

Visual aura

- ▶ Simple visual aura
 - ▶ Static, flashing, or moving lights in different shapes and colors
 - ▶ Primary visual cortex and contiguous visual association areas (BA 17 and 18)
- ▶ Complex visual auras: people, scenes, objects, illusions
 - ▶ Association cortex (parieto-temporal)
 - ▶ Temporo-occipital junction
 - ▶ Basal temporal cortex

Visual aura

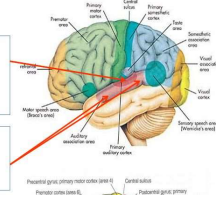
- ▶ Lateralized to one hemifield
 - ▶ Ictal onset in contralateral occipital lobe
- ▶ Restricted to lower or upper quadrant
 - ▶ Localize to contralateral supra- or infracalcarine fissure
- ▶ Prominent movement of object
 - ▶ Localization in contralateral Brodmann areas 18 and 19

Auditory aura: simple, complex

Temporal Lobe

Primary auditory cortex: located in the superior surface of the superior temporal gyrus (Brodmann's area 41, 42)

Auditory association cortex: located immediately around the primary auditory cortex (also includes Wernick's area)



- ▶ Each hemisphere has bilateral innervation for auditory information
- ▶ Contralateral ear is better represented in auditory cortex

Simple auditory aura



- ▶ Hearing ringing, buzz or noise
- ▶ Symptomtogenic zone
 - ▶ Herschel's gyrus in superior temporal gyrus
 - ▶ Area 41,42

Complex auditory phenomena

- ▶ Voices and music
- ▶ Auditory association areas, temporo-occipital cortex

Olfactory aura

- ▶ Unpleasant smells, often associated with gustatory phenomena
- ▶ Localization
 - ▶ Most frequently in mesial temporal lobe epilepsy (amygdala)
 - ▶ Olfactory bulb
 - ▶ Insular cortex

Vertiginous auras

- ▶ Sensations of rotation or movement in all planes
- ▶ Usually associated with visual or auditory symptoms
- ▶ Visual and auditory association areas in temporo-parietal junction

Gustatory aura

- ▶ Unpleasant taste
- ▶ Parietal operculum, basal temporal cortex

Autonomic aura

- ▶ Subjective sensations suggesting possible autonomic alterations
 - ▶ Cardiorespiratory (palpitations and shortness of breath)
 - ▶ Gastrointestinal: nausea, pain, abdominal discomfort
 - ▶ Genitourinary (genital sensations, urinary urge)
 - ▶ Cutaneous (feeling of warmth or cold) sensations, sweating, goose bumps
- ▶ Symptomatogenic zone
 - ▶ Insular cortex, anterior cingulum, amygdala, medial prefrontal

Psychic aura

- ▶ Emotional symptom: fear, anxiety, elation
- ▶ déjà vu and jamais vu
- ▶ Complex hallucinations and/or illusion
- ▶ Localization
 - ▶ Fear: amygdala, hippocampus, mesial frontal region, temporal neocortex
 - ▶ déjà vu and jamais vu: uncus, entorhinal cortex, temporal neocortex
 - ▶ Multisensorial hallucination: mesiobasal temporal, lateral temporal, TPO junction

Cephalic auras

- ▶ Non-vertiginous head sensations
 - ▶ Dizziness, lightheadedness, electrical shock-like feelings, head numbness, and pressure
- ▶ Little lateralizing value
 - ▶ Amygdala, entorhinal cortex, lateral temporal neocortex

Ictal semiology

Ictal seizure semiology

- ▶ Autonomic
- ▶ Dialectic
- ▶ Motor
 - ▶ Simple
 - ▶ Complex
- ▶ Special seizure: atonic, astatic, hypomotor, akinetic, negative myoclonic, aphasic

Autonomic seizure

Autonomic seizures

- ▶ Epileptic seizures → main symptomatology is an autonomic alteration, can be documented objectively e.g. ictal tachycardia documented on ECG
- ▶ Multisystem: cardiac, respiratory, GI, cutaneous, respiratory, urogenital
- ▶ Localization → medial prefrontal cortex, amygdala, insular

Cardiac

Most well recognized autonomic manifestation of focal seizure

- ▶ Ictal tachycardia
 - ▶ HR >100 bpm
 - ▶ Early and significant tachycardia is more common in TLE than extratemporal lobe epilepsy, primarily with right mesial TLE
- ▶ Ictal bradycardia
 - ▶ HR <60 bpm
 - ▶ Much less common
 - ▶ Not been shown to have localizing or lateralizing value
- ▶ Ictal asystole and arrhythmia
 - ▶ Rare
 - ▶ Implicated in pathogenesis of SUDEP

Respiratory

- ▶ Ictal hyperventilation
 - ▶ 10% or greater increase in RR from baseline
 - ▶ Observed in seizures of >50% of children in one series, TLE > FLE
 - ▶ Adult with TLE, mesial TLE > neocortical TLE
- ▶ Ictal apnea → most common in infants and neonates
- ▶ Ictal dyspnea and stridor
 - ▶ Rare and occur primarily during tonic phase of GTCs

GI

- ▶ Epigastric phenomena, ictal vomiting, defecation
- ▶ Ictal vomiting → often nondominant temporal seizure
- ▶ Abdominal epilepsy
 - ▶ Episodic abdominal pain, nausea, vomiting, confusion
 - ▶ Common autonomic manifestation of TLE in children

Cutaneous

- ▶ Ictal piloerection
 - ▶ Goose bumps involving a limb ipsilateral to seizure onset
 - ▶ Most common in TLE
- ▶ Ictal pallor
- ▶ Ictal flushing

Pupillary change

- ▶ Typically bilateral in GTCs
- ▶ May be unilateral in focal epilepsy
 - ▶ Unilateral mydriasis → ipsilateral temporo-occipital region

Urogenital: rare phenomena

- ▶ Incontinence, ictal urinary urge, orgasmic sensations, genital sensations
- ▶ Ictal urinary urge and orgasmic phenomena may suggest seizure origin in non-dominant temporal lobe or frontal lobe

Autonomic seizure: Misc.

- ▶ Postictal nose wiping and cough
 - ▶ Increased parasympathetic activity resulting in increased nasal and pharyngeal secretions
- ▶ Ictal vomiting and ictal retching, mainly in non-dominant TLE
- ▶ Ictal spitting, non-dominant TLE
- ▶ Ictal hypersalivation, more frequently in non-dominant mTLE

Dialeptic seizure

- ## Dialeptic seizure → focal impaired awareness
- ▶ Alteration of consciousness and staring with minimal motor activity
 - ▶ Not localized or lateralized
 - ▶ **Epileptogenic zone tends to be at a distance from primary or supplementary motor areas**
 - ▶ **Duration of seizures has a localizing value**
 - ▶ Mesial temporal seizure → longer duration than frontal lobe seizure

Motor seizure

Frontal lobe anatomy

A

B

Kellinghaus C, Lüders HO. Epileptic disord. 2004;6(4):223-39.

Motor seizure

- ▶ Simple motor seizures
 - ▶ Unnatural but simple movements
 - ▶ Primary and somatosensory motor areas
 - ▶ Several types based on duration of contraction, rhythmicity of movement, muscle groups involved
- ▶ Complex motor seizures
 - ▶ Movements that imitate natural movements
 - ▶ Usually complex involving several articulations in different planes
 - ▶ Tend to be repetitive

Simple motor seizure

- ▶ Myoclonic
- ▶ Tonic
- ▶ Clonic
- ▶ Tonic-clonic
- ▶ Epileptic spasm
- ▶ Versive

Myoclonic seizures

- ▶ Transient (<100 ms), involuntary, single or multiple muscle jerks
- ▶ Usually generalized or bilateral → generalized epilepsy
 - ▶ Prominently affecting shoulders and proximal arms
- ▶ Unilateral myoclonic seizures → contralateral primary motor area or premotor cortex

Tonic seizure

- ▶ Sustained contraction of one or more muscle groups lasting at least 3 sec and leading to posturing of limbs and/or trunk
- ▶ Bilateral proximal muscles affected, asymmetric postures involving primarily contralateral muscles in some cases
- ▶ Preserved consciousness is common at least at the onset
- ▶ If clearly unilateral, tonic seizures strongly support seizure origin in contralateral hemisphere

Tonic seizure

- ▶ FLE
 - ▶ SSMA
 - ▶ Bilateral from onset but may begin in one part of body and move rapidly to other limbs
 - ▶ Fencing position (M2e)
 - ▶ Hemisphere contralateral to raised arm
 - ▶ Asymmetric tonic limb posturing "sign of four"
 - ▶ Hemisphere contralateral to extended arm
 - ▶ Motor cortex
- ▶ TLE: unilateral tonic
- ▶ Part of generalized seizures

Clonic seizure

- ▶ Repetitive, short contractions of agonist and antagonist muscle groups, regular intervals
- ▶ Symptomatogenic zone: primary motor strip
 - ▶ Distal extremity or face usually affected
- ▶ Jacksonian march
 - ▶ Spread of clonic seizures from distal to proximal

Clonic seizure: localization

- ▶ FLE: clonic seizures tend to occur early, consciousness is preserved
- ▶ TLE: face, frontal eye field and hand areas tend to be affected earlier than legs
- ▶ PLE: clonic is preceded by somatosensory disturbances
- ▶ OLE: clonic is preceded by visual auras or versive head/eye movements
- ▶ SSMA seizures: bilateral clonic activity associated with tonic posturing

Clonic seizures: lateralization

- ▶ Unilateral clonic seizures → highly lateralizing value to contralateral hemisphere
- ▶ In secondarily GTCs, clonic activity persist on side ipsilateral to epileptogenic focus
 - ▶ End of seizure paradoxical clonus → highly reliable lateralizing sign

Tonic-clonic seizures

- ▶ Focal or generalized onset
- ▶ Seizures start with tonic posturing of all limbs followed by a "jittery" phase that progressively slows down and eventually transforms in a clonic activity of all four extremities
- ▶ Occur at the onset and relatively symmetrical involvement of all limbs is highly suggestive of generalized epilepsy
- ▶ In focal epilepsies → focal to bilateral tonic-clonic
 - ▶ Almost always are preceded by other seizure types
 - ▶ Tonic phase is asymmetric

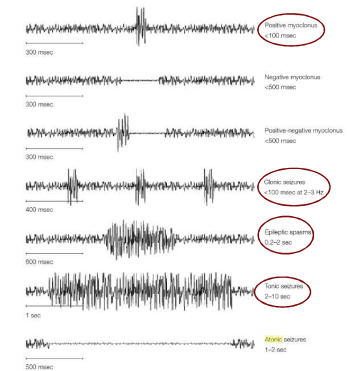
Epileptic spasms

- ▶ Relatively symmetric muscle contractions, either tonic or myoclonic features which affect predominantly proximal axial muscles
- ▶ Flexion of trunk and an extension and abduction of arms in a "salaam position"
- ▶ Usually clusters on awakening
- ▶ Variable duration, typical 1-2 seconds
- ▶ Onset 4-8 month
- ▶ Generalized epilepsies > focal epilepsy (parieto-occipital)

Myoclonic, clonic, spasm, tonic

- ▶ Myoclonic seizure
 - ▶ Single or irregularly recurrent events (<100msec)
- ▶ Clonic seizures
 - ▶ Rapid rhythmically recurrent myoclonic-like events
 - ▶ Rhythmical, regular repetitive myoclonic jerks < 100msec at 2 to 3 Hz
- ▶ Epileptic spasms: sudden and brief bilateral tonic contractions of axial and proximal limb muscles with abrupt onset and termination
 - ▶ Usually last 0.4-0.8 secs (0.2-2 secs)
- ▶ Tonic seizures comprising sustained increase in muscle contraction
 - ▶ Usually last a few secs (>2-10 secs), occasionally last minutes

Myoclonic, tonic, atonic, epileptic spasm: EMG pattern



Panayiotopoulos 2006

Versive seizure

- ▶ Forced and involuntary turning of head and eyes in one direction with neck extension, sustained unnatural position
- ▶ Symptomatogenic zone → frontal eye field
- ▶ Appear earlier in seizures of frontal lobe origin
- ▶ Appear later while consciousness is impaired in TLE
- ▶ Highly lateralizing value to contralateral hemisphere, especially when occur within 10 seconds before secondary generalization

Complex motor seizure

- ▶ Hypermotor seizure
- ▶ Automotor
- ▶ Gelastic seizure

Hypermotor

- ▶ Repetitive complex movements involving proximal limbs and trunk, rapid and violent in nature
- ▶ Motor activity simulates normal movements inappropriate for situation
 - ▶ Thrashing, rocking, jumping, waving, bicycling, kicking
- ▶ Vocalization, laughter, and crying are common
- ▶ Consciousness may be preserved
- ▶ Occur mostly during sleep

Hypermotor

- ▶ Frontal lobe (orbital, mesial frontal) >> temporal lobe, insula, posterior cortex
 - ▶ Ventromedial frontal seizure → more hypermotor features
 - ▶ Dorsolateral frontal seizure → more with head and eye version and complex gestural automatism

Automotor seizure

- ▶ Repetitive, stereotyped, semipurposeful motor behaviors, involving primarily distal limbs, mouth, and tongue
- ▶ Oral automatism: mouth and tongue
 - ▶ Mastication, swallowing, lip smacking, blowing, whistling, kissing
- ▶ Gestural automatism: distal extremities
 - ▶ Fumbling, picking, gesticulating movements

Automotor: localization, lateralization

Temporal

- ▶ Homogeneous perseverative automatisms, complex gestures
- ▶ Upper limb automatisms
- ▶ Prolonged in duration

Frontal

- ▶ More hyperkinetic
- ▶ Irregular in quality
- ▶ Involve proximal segments of limbs
- ▶ Shorter duration

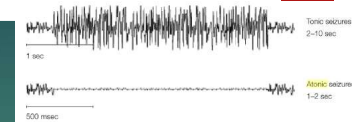
Unilateral automatisms → more frequently ipsilateral epileptogenic zone
Awareness is generally impaired except in nondominant temporal lobe seizure

Gelastic seizure

- ▶ Brief periods of laughter or grimacing with or without subjective feeling of mirth
- ▶ Strongly suggests presence of hypothalamic hamartoma (50%)
- ▶ Extrahypothalamic localizations
 - ▶ Anteromesial frontal, cingulate
 - ▶ Basal temporal regions

Atonic seizure

- ▶ Sudden loss of muscle tone results in a loss of posture
 - ▶ Fragmentary or massive: head drop, falls
- ▶ Interruption of EMG discharges associated with an EEG correlate
- ▶ Generalized or focal origin
 - ▶ Generalized: most frequently in symptomatic generalized epilepsies (LGS)
 - ▶ Focal → FLE, TLE
 - ▶ Slower falls, infrequently result in significant injuries



Astatic seizure, drop attacks

- ▶ Epileptic falls
 - ▶ Atonic seizure
 - ▶ Myoclonic seizure followed by an atonic seizure
 - ▶ Bilateral asymmetric tonic seizure

Hypomotor seizure

- ▶ Main manifestation is decrease or total absence of motor activity
- ▶ Expression is only used in whom consciousness cannot be tested during or after seizure (newborns, infants and children under 3 years, mentally retarded patients)
- ▶ In focal epilepsy, most frequently in temporal and parietal lobe epilepsy

Akinetic seizure

- ▶ Inability to perform voluntary movements
- ▶ Patients are conscious and cooperative, try to perform a movement but are unable to do (apraxia)
- ▶ Activation of negative motor areas in mesial frontal and inferior frontal gyri

Aphasic seizure

- ▶ Aphasic despite preserved awareness and memory
- ▶ Often mixed aphasias and lateralize epilepsy to dominant hemisphere

Dystonic posturing

- ▶ Sustained (>10 sec), forced, unnatural positioning of upper extremity on one side of body with a clear rotational component
- ▶ Reliable lateralizing sign to contralateral hemisphere in TLE > 90%
- ▶ Thought to be related to activation of basal ganglia through spread of epileptiform discharges

Speech and language

- ▶ **Vocalizations, abnormal speech (speech arrest, dysphasia, dysarthria, non-identifiable speech), ictal speech, postictal aphasia**
- ▶ Ictal speech
 - ▶ Defined as presence of clearly intelligible speech when patient already shows unresponsiveness and/or has clear distal automatisms
 - ▶ Lateralize to non-dominant hemisphere in TLE in 83%
- ▶ Postictal aphasia: 12% of patients and always localized to dominant temporal lobe
- ▶ Vocalizations, dysarthria, dysphasia, speech arrest, non-identifiable speech → no lateralizing value

Peri-ictal water drinking

- ▶ Drinking occurring during or within 2 minutes of termination of an automotor seizure
- ▶ Lateralize to non-dominant TLE

Unilateral eye blinking

- ▶ Ipsilateral to EZ in about 80% of cases
- ▶ Amygdala or mesial temporal structures

Ictal nystagmus

- ▶ Predominantly horizontal binocular nystagmus
- ▶ Fast phase of nystagmus was opposite seizure focus
- ▶ Seizures originate from either occipital or temporo-occipital junction and are often associated with ictal vertigo

Lateralizing: ictal

Manifestation	Laterality	Localization
Head version before GTCs	Contralateral	Premotor area
Focal clonus	Contralateral	Perirolandic
Dystonic limb	Contralateral	Temporal
Tonic limb	Contralateral	Frontal
Figure of 4 in GTCs	Contralateral	SSMA
Unilateral eye blink	Ipsilateral	Temporal
Ictal speech	Non-dominant hemisphere	Temporal or frontal
Aphasic	Dominant	Temporal or frontal
Unilateral limb automatism	Ipsilateral	Temporal
Automatism w preserved responsiveness	Non-dominant	Temporal
Eye deviation	Contralateral or ipsilateral	Frontal eye field, occipital

Post ictal

Post ictal semiology

- ▶ Postictal aphasia
- ▶ Postictal todd's paralysis
- ▶ Postictal nose wipe

Postictal aphasia

- ▶ Lateralize to language dominant hemisphere in TLE
- ▶ Recovery of language function after ictal EEG stopped was found to be significantly more delayed in left TLE
- ▶ Less significantly affected in FLE
- ▶ Essential to have a patient who is cooperative postictally (clearly tries to understand language and tries to talk)
- ▶ Should be tested continuously and language should recover slowly (10-20 minutes) but progressively

Todd's paralysis

- ▶ Non-localizing but highly lateralizing sign
- ▶ Always preceded by prominent ipsilateral motor activity of affected limb

Post-ictal nose wipe

- ▶ Wiping or rubbing of nose during or within 60 seconds of seizure termination
- ▶ Most common in seizures of mesial temporal origin (50–85%)
- ▶ Lateralizes epilepsy to ipsilateral hemisphere in 75–90% of cases
 - ▶ Hemisphere contralateral to nose-wipe suffers from post-ictal neglect

Lateralizing: postictal

Manifestation	Laterality	Localization
Postictal aphasia	Dominant	Temporal > frontal
Todd's paralysis	Contralateral	Any focal
Postictal nose-wiping	Ipsilateral	Temporal