Functional Organization of Motor Movements
in Epileptic Seizures
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Disclosures

None related to this presentation
Learning Objectives

1. Understand which brain areas are involved in physiological motor movements
2. Explore how seizure manifestations result from involvement of specific brain areas by the ictal discharge
Outline

1. Review the brain regions which control motor function
2. Review the semiological features of various types of motor seizures (atonic, hypermotor, myoclonic, epilepsia partialis continua)
3. Examine the contribution of subcortical structures to seizures
Architectonic Subdivisions of the Cerebral Cortex

CONNECTIONS BETWEEN THE PRE AND POST-CENTRAL GYRI

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PERI-ROLANDIC SEIZURES

• Characterized by early motor / sensory involvement
• Clonic or focal Myoclonic
• Tonic
• Jacksonian march may be seen
• May remain focal or become secondarily generalized
• May exhibit Todd’s Paralysis
SENSORY AURAS

- Indicate involvement of the post-central gyrus
- Seizures may begin there or occur due to spread from elsewhere
- Patients with peri-rolandic seizures describe tingling, numbness or feeling of tightening in the limbs and/or trunk
- Possible to elicit motor movements with stimulation of postcentral gyrus
TUMOR EXCISED FROM POST-CENTRAL GYRUS

Somatosensory aura (left cheek) -> left face and arm clonic seizure
Pathology: Dysembryoplastic Neuroepithelial tumor
Outcome: completely seizure free and off AEDs
VERSIVE SEIZURES

• Main feature of seizure is Version
• Version defined as unnatural, extreme and sustained deviation of the eyes and/or head to one side often with neck extension
• Indicate involvement of frontal eye fields
• Version occurs earlier in extratemporal seizures compared to seizures from mesial temporal origin
• Reliably lateralize to contralateral hemisphere
• Ipsilateral head deviation in FLE may precede version
• Lateralizing value uncertain if the seizure does not evolve to GTC seizure
EPILEPSIA PARTIALIS CONTINUA

- Focal clonic status affecting limited portion of the Peri-Rolandic cortex
- No loss of consciousness
- May occur very frequently or chronic
- Result of lesions such as dysplasia, infarcts, neoplasm and Rasmussen Syndrome
- EEG findings often subtle
- Difficult to treat medically
EPILEPSIA PARTIALIS CONTINUA VIDEO
SUPPLEMENTARY MOTOR AREA (SMA) SEIZURES

• Typically occur at night, often multiple times
• Sudden onset
• Bilateral symmetrical or asymmetrical tonic stiffening, proximal > distal;
• Dystonic posturing may occur but differs from that seen in TLE
• May evolve to clonic jerking and proximal body movements
• Similar symptomatology occurs as a result of spread to SMA from other brain regions
• EEG: midline spikes and seizure patterns; if not seen, could be mistaken for psychogenic seizures
COMPLEX MOTOR SEIZURES

• Semi-puposeful movements of trunk and extremity (trying to sit up or get out of bed, reaching or grabbing)
• Differ from Automotor Seizures which manifest discrete, distal, stereotyped repetitive movements (hand fumbling, lip-smacking)
• Lacking the frenetic, marked agitation and violent body movements characteristic of Hypermotor Seizures
COMPLEX MOTOR SEIZURE VIDEO
TEMPORAL SEQUENCE OF CLINICAL MANIFESTATIONS IN FRONTAL LOBE COMPLEX PARTIAL SEIZURES

Complete LOC
Complex Motor Activity

Hypermotor Activity

Vocalizations

Oroalimentary Automatisms

Unilateral Dystonia

Partial LOC

Complete LOC
Behavioral Arrest/Staring

Repetitive Gross Arm Movements

HYPERMOTOR SEIZURE TYPE I VIDEO
TYPES OF HYPERMOTOR SEIZURES

Type I

Type II

BODY TURNING AROUND HORIZONTAL AXIS SEEN IN MESIAL FRONTAL LOBE EPILEPSY

HYPERMOTOR SEIZURE TYPE II VIDEO
### CHARACTERISTICS OF HYPERMOTOR SEIZURES

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>TYPE I</th>
<th>TYPE II</th>
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<tbody>
<tr>
<td>Agitation</td>
<td>Marked</td>
<td>Mild</td>
</tr>
<tr>
<td>Hypermotor</td>
<td>Sitting up</td>
<td>Rotation</td>
</tr>
<tr>
<td></td>
<td>Laying down</td>
<td>of trunk</td>
</tr>
<tr>
<td></td>
<td>Kicking/boxing</td>
<td>horizontally</td>
</tr>
<tr>
<td>Head deviation</td>
<td>Ipsilateral</td>
<td>+/- contra</td>
</tr>
<tr>
<td>Expression</td>
<td>Fear, anger</td>
<td>-</td>
</tr>
<tr>
<td>LOC</td>
<td>Yes</td>
<td>Variable</td>
</tr>
<tr>
<td>Amnesia</td>
<td>Yes</td>
<td>Variable</td>
</tr>
<tr>
<td>Vegetative</td>
<td>urine incontinence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>facial flushing</td>
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</table>

ICTAL ONSET OF TYPE I HYPERMOTOR SEIZURES

Rostral ant cingulate
Mesial premotor frontal cortex

<table>
<thead>
<tr>
<th>HMSI</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
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<tr>
<td>Patient #1</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
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<tr>
<td>Patient #2</td>
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<tr>
<td>Patient #6</td>
<td><img src="image9" alt="Image" /></td>
<td><img src="image10" alt="Image" /></td>
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</table>

Type I

TYPE II HYPERMOTOR SEIZURES
ICTAL ONSET ZONES

Dorsal ant cingulate
Mesial premotor cortex

Mesial premotor frontal cortex

NEGATIVE MOTOR SEIZURES

• Symptomatology: inability to move a body part
• Difficult to detect unless looked for by asking patient to elevate the extremity
• Onset from anterior SMA region, where cortical stimulation produces similar effects – inhibition of voluntary motor movements
Negative Motor Seizures arising from the Negative Motor Area

Vague aura
Repetitive vocalization
Inability to speak or move
Followed by Left hand clonic
-> GTC seizure

Ikeda A et al. Epilepsia 2009;50:2072-84
TYPES OF ASYMMETRIC LIMB POSTURING SEEN DURING SEIZURES

• Tonic Fencer posture results from involvement of the SMA. Extended arm is generally contralateral

• M2e posturing follows Version but just before secondary generalization – contralateral arm is elevated and abducted at shoulder

• Figure 4 sign (asymmetric tonic limb posturing) follows M2e. Contralateral arm extends before the ipsilateral arm during the GTC seizure
FIGURE 4 POSTURING DURING SECONDARILY GTC SEIZURES

FIGURE 4 VIDEO

Annual Meeting
## VALUE OF LATERALIZING SIGNS

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<thead>
<tr>
<th>SIGN</th>
<th>FREQUENCY</th>
<th>PREDICTIVE VALUE</th>
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<tbody>
<tr>
<td>Focal clonic movements</td>
<td>11%</td>
<td>100% (p=0.05)</td>
</tr>
<tr>
<td><strong>Version</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ≤ 10sec before gen</td>
<td>27%</td>
<td>100% (p&lt;0.01)</td>
</tr>
<tr>
<td>• at any time during sz</td>
<td>45%</td>
<td>60% (NS)</td>
</tr>
<tr>
<td>Ipsilateral head tilt</td>
<td>9%</td>
<td>60% (NS)</td>
</tr>
<tr>
<td><strong>Unilateral dystonia</strong></td>
<td>18%</td>
<td>90% (p=0.05)</td>
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<tr>
<td>Unilateral tonic post.</td>
<td>13%</td>
<td>86% (NS)</td>
</tr>
<tr>
<td>Ipsilateral automatisms</td>
<td>9%</td>
<td>80% (NS)</td>
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<tr>
<td>Eye deviation</td>
<td>27%</td>
<td>57% (NS)</td>
</tr>
<tr>
<td>Face deviation</td>
<td>2%</td>
<td>100% (NS)</td>
</tr>
<tr>
<td>Postictal hemiparesis</td>
<td>2%</td>
<td>100% (NS)</td>
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# INTER-OBSERVER AGREEMENT & PPV

<table>
<thead>
<tr>
<th>SIGN</th>
<th>TLE</th>
<th>XTLE</th>
<th>p value</th>
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<tbody>
<tr>
<td></td>
<td>n=34</td>
<td>n=20</td>
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<tr>
<td><strong>Dystonic Posturing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>35%</td>
<td>20%</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Kappa</td>
<td>0.78</td>
<td>0.31</td>
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</tr>
<tr>
<td>PPV</td>
<td>92%</td>
<td>100%</td>
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</tr>
<tr>
<td><strong>Tonic Posturing</strong></td>
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<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>17.7%</td>
<td>15%</td>
<td>0.032</td>
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<tr>
<td>Kappa</td>
<td>0.23</td>
<td>0.08</td>
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</tr>
<tr>
<td>PPV</td>
<td>100%</td>
<td>-</td>
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<tr>
<td><strong>Immobile Limb</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Frequency</td>
<td>12%</td>
<td>-</td>
<td>0.030</td>
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<tr>
<td>Kappa</td>
<td>0.23</td>
<td>0.06</td>
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<tr>
<td>PPV</td>
<td>100</td>
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## Lateralizing Value of Figure 4 Sign During Secondarily Generalized Seizures

<table>
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<tr>
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<tbody>
<tr>
<td><strong>Figure 4 sign</strong></td>
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</tr>
<tr>
<td>Frequency</td>
<td>78.6%</td>
<td>87.5%</td>
</tr>
<tr>
<td>Predictive value</td>
<td>90.9%</td>
<td>87.5%</td>
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<tr>
<td>Kappa index</td>
<td>0.711</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Version</strong></td>
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</tr>
<tr>
<td>Frequency</td>
<td>64.3%</td>
<td>40%</td>
</tr>
<tr>
<td>Predictive value</td>
<td>100%</td>
<td>100%</td>
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<tr>
<td>Kappa index</td>
<td>0.725</td>
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</tbody>
</table>

Kappa is a measure of inter-observer agreement

Bleasel AF et al. Epilepsia 1997;38:168–174*
ICTAL MANIFESTATIONS OF BASAL GANGLIA SPREAD

LT ARM DYSTONIA

RIGHT ARM DYSTONIA

HYPOMETABOLISM IN RIGHT TEMPORAL AND IPSILATERAL BASAL GANGLIA

SEIZURES FROM SUBCORTICAL STRUCTURES

Seizures improved but still persist after Anatomical Hemispherectomy for Hemimegalencephaly

Hypothalamic Hamartoma
LEFT HEMIFACIAL SEIZURES ARISING FROM CEREBELLAR GANGLIOGLIOMA

Chae JH et al. Epilepsia 2001;42:1204-7
Seizure Semiology may be as good as EEG, MRI
For Lateralizing & Localizing Seizures

Elwan S, Alexopolous A, Silveria D, Kotagal P. AES 2010 Abstract 1.177 (in preparation)
Impact on Clinical Care and Practice

• Reviewed how motor functions are organized in the cortex
• Seen how various seizure symptoms result from ictal involvement of different brain regions
• Improved seizure diagnosis based on history, examination and review of seizure semiology
• Seizure semiology is an important component of evaluation for epilepsy surgery