• Seizure:
  – Caused by abnormal brain electrical activity
  – Brain’s electrical system malfunctions:
    • Uncontrolled electrical discharges
    • Brain cells keep firing causing abnormal surge of energy
• Seizure physical characteristics depend upon what part of the brain is involved
The Brain
Seizures and Epilepsy

- Seizure:
  - Most common paroxysmal disorder of infancy and childhood
- 25,000-40,000 children diagnosed with seizures yearly
Seizures and Epilepsy

• Epilepsy: two or more *afebrile* seizures

• Status Epilepticus:
  – > 30 minutes of continuous seizing
  – Sequential seizures without recovery
  – Can be life threatening or permanently disabling
  – Represents 1/3 of initial epilepsy presentations
  – 20% of epilepsy patients experience status epilepticus within the first 5 years of diagnosis

©Julie Sprague-McRae, 2014
Old Terminology: Simple Partial Seizures

- Sometimes accompanied by an aura
- No alteration of consciousness
- Motor movements are unilateral
- Somatosensory symptoms: unilateral
- Autonomic changes:
  - Sweating, tastes, blood pressure, heart and breathing rates, body temperature, digestion
Old Terminology: Complex Partial Seizures

- Alteration of Consciousness
- Involves one side of the body
- Unilateral motor movements
- Can spread to opposite side of the brain = Secondarily generalize
  - motor movements are bilateral
- Simple → Complex → Secondarily Generalized
Old Classification Terminology: Generalized Seizures

- Absence: Very brief pauses
- Myoclonic: Jerking
- Tonic: Stiffening
- Atonic: Drop attacks
- Clonic: Rhythmic jerking or twitching
- Tonic-Clonic: Stiffening & jerking
Old Terminology: Etiology of Seizures

• **Provoked:** A result of an acute condition
  – head trauma, central nervous system infection, tumor, hypoxia (lack of oxygen), metabolic imbalance

• **Unprovoked**
  – Symptomatic
    • Pre-existing brain problem: (malformation, prior injury or insult, etc.)
    – Cryptogenic (no known cause)
    – Idiopathic (genetic)
  – Healthy developmentally normal children, normal brains, inherited trait

©Julie Sprague-McRae, 2014
New Terminology  (ILAE, 2010)

• Mode of Seizure Onset
• Classification of Seizures
• Syndrome or Non-Syndrome
• Underlying Cause (Etiology)

ILAE Report & outline of changes:


http://www.ilae.org/Visitors/Centre/ctf/documents/ILAEHandoutV10_000.pdf
New Terminology: Mode of Onset

New
- Focal seizure
- Generalized seizure
- Unknown if focal or generalized seizure

Old
- Partial or localization related
- Same
- No previous category
New Terminology: Focal Seizure Classifications

• Based upon describing characteristics:
  – Aura +/-
  – Motor movements unilateral
  – Autonomic features

• Unaltered or altered consciousness

• May evolve to bilateral brain involvement → with bilateral motor movement
New Terminology: Generalized Seizure Classification

- Tonic
- Clonic
- Tonic-Clonic
- Absence
  - Typical
  - Atypical
  - Special features:
    - Myoclonic Absence
    - Eyelid Myoclonia

- Myoclonic
  - Myoclonic
  - Myoclonic atonic
  - Myoclonic tonic
- Atonic
- Epileptic Spasms

©Julie Sprague-McRae, 2014
New Classifications  

Source: [www.epilepsy.org.au](http://www.epilepsy.org.au), revised ILAE, 2010

Seizure Classification

- **Partial** (seizure activity originates in one part of the brain)
  - **Simple** w/o alteration of consciousness
    - Absence (typical, atypical, special features)
    - Myoclonic (myoclonic, atonic, tonic)
  - **Complex** w/alteration of consciousness
    - Tonic clonic
    - Tonic
    - Atonic

- **Generalised** (seizure activity involved entire brain)
  - Epileptic Spasms
New Terminology: Underlying Cause (Etiology)

<table>
<thead>
<tr>
<th>Old Term</th>
<th>New Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Idiopathic</td>
<td>• Genetic or presumed</td>
</tr>
<tr>
<td>• Symptomatic</td>
<td>• Structural/Metabolic</td>
</tr>
<tr>
<td>• Cryptogenic</td>
<td>• Epilepsy of unknown cause</td>
</tr>
<tr>
<td></td>
<td>• Infectious</td>
</tr>
<tr>
<td></td>
<td>• Immune</td>
</tr>
</tbody>
</table>
Description of Symptoms and History of the Seizure

• Possible seizure triggers:
  – Illness (URI, fever or other)
  – Sleep deprivation
  – Travel
  – Compliance issues with medication doses
  – Hormonal changes (puberty)
  – Weight gain (outgrew dosage)
  – Other
Treatment Goals

• Prevent seizures or keep them short
• Prevent injury
• Improve learning by reducing time spent having & recovering from seizures
• Increase time spent in school
• Improve quality of life
Treatment Options

• Anti-Epileptic Medications (AED’s)
• Epilepsy Surgery (focal resection)
• Implantation of Vagus Nerve Stimulator (VNS)
• Ketogenic Diet Therapy
• Alternative treatments: None proven
Medication and Treatments

• Anti-Epileptic medications (AED’s)
  – Maintenance:
    • Monotherapy is ideal
    • Polytherapy is often the reality
  – Rescue:
    • Oral Benzodiazepines
      – Diazepam (Valium®), Lorazepam (Ativan®), Clonazepam (Klonopin®)
    • Rectal Diazepam (Valium®)
    • Nasal Midazolam (Versed®)
Old generation Anti-Epileptic Drugs

- Phenytoin (Dilantin®)
- Phenobarbital
- Carbamazepine (Tegretol®)
- Valproic Acid (Depakote®)
- Ethosuximide (Zarontin®)
Old generation Anti-Epileptic Drugs

- Multi-system effects of old AED’s:
  - Liver, bone marrow, pancreas
  - Follow drug levels, CBC, ALT, AST, lipase
- Many interact with other AED’s and affect efficacy or cause toxicity
  - Valproic Acid (Depakote®) increases other drugs
  - Some AED’s decrease other drug levels
Newer Generation Anti-Epileptic Drugs

- Lamotrigine (Lamictal®)
- Topiramate (Topamax®)
- Levitiracetam (Keppra®)
- Zonisamide (Zonegran®)
- Oxcarbazepine (Trileptal®)
- Rufinamide (Banzel®)
- Lacosamide (Vimpat®)
- Clobazam (Onfi®)

©Julie Sprague-McRae, 2014
Advantages of Newer Generation Anti-Epileptic Drugs

• Typically, less routine blood work
  – Optional drug levels
  – Carbon Dioxide
    • Topiramate (Topamax®)
    • Zonisamide (Zonegran®)
  – No significant drug interactions
    • Except Lamotrigine (Lamictal®)

©Julie Sprague-McRae, 2014
What Guides Choice of AED?

• Seizure Type
  – Focal onset
  – Generalized onset

• Syndrome

• EEG pattern
  – Focal onset
  – Generalized onset

• Co-morbidities
  – Psychiatric: Labile mood
  – Weight: Overweight vs. underweight
  – Other medical problems

©Julie Sprague-McRae, 2014
Narrow Spectrum AEDs

Focal Epilepsy
- Oxcarbazepine (Trileptal®)
- Carbamazepine (Tegretol®)
- Phenytoin (Dilantin®)
- Gabapentin (Neurontin®)
- Lacosamide (Vimpat®)

Generalized Epilepsy
- Ethosuximide (Zarontin®) absence only
- Rufinamide (Banzel®) Lennox-Gastaut

©Julie Sprague-McRae, 2014
Broad Spectrum AED for Generalized and Focal Epilepsy

- Lamotrigine (Lamictal®)
- Zonisamide (Zonegran®)
- Topiramate (Topamax®)
- Levetiracetam (Keppra®)
- Valproic Acid (Depakote® and siblings)
- Clobazam (Onfi®)
Anti-Epileptic Drug Side Effects

• Temporary and are dose dependent
• Sedation, grogginess
• Difficulty thinking – cognitive slowing
• Off balance, “dizzy,” ataxic
• Behavior changes (good or bad)
• Stomach irritation
• Folic Acid deficiency
Anti-Epileptic Drug Unique Side Effects

- **Weight gain:**
  - Valproic Acid (Depakote®)
  - Oxcarbazepine (Trileptal®), maybe
- **Weight loss:**
  - Zonisamide (Zonegran®)
  - Topiramate (Topamax®)
- **Weight neutral:** Most other AEDs

©Julie Sprague-McRae, 2014
Anti-Epileptic Drug Unique Side Effects

- **Tremor:**
  - Valproic Acid (Depakote®)
  - Lamotrigine (Lamictal®)

- **Osteoporosis:**
  - Phenytoin (Dilantin®)
  - Phenobarbital

- **Acidosis:**
  - Zonisamide (Zonegran®)
  - Topiramate (Topamax®)
Anti-Epileptic Drug Unique Side Effects

• Rash:
  • Any AED
  • Steven Johnson Syndrome
    – Lamotrigine (Lamictal®)
    – Clobazam (Onfi®)

• Hypohydrosis, hyperthermia and kidney stones:
  – Zonisamide (Zonegran®)
  – Topiramate (Topamax®)
Oxcarbazepine (Trileptal®)

- Used for focal seizures
- Chemically similar to Carbamazepine (Tegretol®)
  - Fewer side effects: blood and liver issues
  - Less sedation, dizziness, or balance problems
  - Can be used in infants (2 wks. of age) -> elderly
  - No routine labs needed
  - Oxcarbazepine metabolite level is checked
  - Rare hyponatremia seen in infants

*FDA approval adjunct: >2 yr.; monotherapy: > 4 yrs.*
Genetic testing: HLA-B*1502 variant (Asian decent)

©Julie Sprague-McRae, 2014
Carbamazepine (Tegretol®)

- Used for focal seizures
- TID dosing vs. longer acting
  - Tegretol, Tegretol XR, Carbatrol
- Monitor CBC, LFT’s (ALT/AST), blood levels
- Can cause hyponatremia
- Drug interaction:
  - Erythromycin and other antibiotics
  - INH
  - Grapefruit

FDA approval Pediatric
Genetic testing: HLA-B*1502 variant (Asian decent)

©Julie Sprague-McRae, 2014
Levetiracetam (Keppra®)

- Effective for focal and generalized epilepsy
- Can be used in all ages: Infants -> elderly
- Behavioral side effects:
  - Aggression, labile mood, can rarely lead to psychotic behavior
  - Higher risk: History of behavior problems or intellectual disability
  - Lower risk: Developmentally normal

*FDA approval adjunct: tonic-clonic, primary generalized ≥ 6 yr. oral; ≥ 16 yr. IV; myoclonic ≥ 12 yr. oral; ≥ 16 yr. IV; focal ≥ 1 month oral; ≥ 16 yr. IV, ER*
Levetiracetam (Keppra®)

• Good choice for children:
  – On multiple medications
  – With multi-organ failure
    • No medication interactions
    • Not metabolized or excreted by kidneys
• No routine labs or drug levels needed
• Now available as an IV preparation
Zonisamide (Zonegran®)

FDA approval adjunct: focal > 16 yr.

- Used from neonatal period -> elderly
- Broad spectrum with once a day dosing
- Weight loss +
- Some behavior problems
- Risk of kidney stones, hyperthermia and hypohydrosis
- Used with caution with sulfa drug allergies
- Drug levels optional

©Julie Sprague-McRae, 2014
Phenytoin (Dilantin®)

FDA approval adjunct: generalized tonic clonic, focal; pediatric

- Focal, secondarily generalized, generalized tonic-clonic, and status epilepticus
- QD or BID dosing
- Monitor CBC, LFT’s (ALT/AST), AED levels
- Concentration can vary, so shake
- Side Effects:
  - Hirsutism, gum hyperplasia

©Julie Sprague-McRae, 2014
Gabapentin (Neurontin®)

FDA approval adjunct: focal 3-12 yr.

- Focal seizures
- Few drug interactions
- Renal metabolism
- Easy to titrate and wean
- Many other uses
  - Psychiatry, neuropathic pain, migraine
  - Drug levels not tested
Lamotrigine (Lamictal®)

FDA approval adjunct: oral IR Lennox-Gastaut Syndrome, ≥ 2 yr.; adjunct or monotherapy: focal ≥ 2 yr.; oral ER ≥ 13 yr.; adjunct: tonic-clonic, primary generalized, ≥ 2 yr.; oral ER ≥ 13 yr.

• Broad spectrum & best side effect profile:
  – Least sedating and cognitive slowing
  – Good mood stabilizer

• Blood levels optional

• Negative:
  – “Black Box Warning”
  – Rash → Steven Johnson's Syndrome (titrated too fast, used with Valproic Acid (Depakote®), children < 2 yrs.)
Topiramate (Topamax®)

FDA approval adjunct: Lennox-Gastaut Syndrome, focal, tonic-clonic, primary generalized ≥ 2 yr. XR ≥ 6 yr.; monotherapy: focal, tonic-clonic, primary generalized ≥ 2 yr. XR ≥ 10 yr.

- Used neonatal period - elderly
- May cause weight loss
- Used for migraine headache prophylaxis
- Can cause cognitive slowing
- No routine labs
- Can be associated with kidney stones, hypohydrosis, hyperthermia and paresthesia

©Julie Sprague-McRae, 2014
Valproic Acid (Depakote®)

FDA approval: absence, focal, >10 yr.

• Positive:
  – Effective when other anti-epileptic drugs fail
  – Good mood stabilizer (psychiatric uses)
  – Good for migraine headache prophylaxis
Valproic Acid (Depakote®)

- **Negative:**
  - Significant side effect profile:
    - Liver, pancreas, and bone marrow
    - Weight gain, polycystic ovaries, hair loss, and tremor
    - *Fulminate liver failure in children < 2 yrs.*
  - Interacts with other drugs, and increases levels
- Monitor CBC, LFT’s (ALT/AST), blood levels

©Julie Sprague-McRae, 2014
Ethosuximide (Zarontin®)

FDA Approval absence ≥ 3 yr.

- Narrow spectrum old generation drug
- Used for primary generalized epilepsy with absence seizures
- Monitor drug levels, CBC and LFT’s (ALT/AST)
- Take with food to avoid GI upset
Newer Anti-Epileptic Drugs

• Lacosamide (Vimpat®) FDA approval: no pediatric; adult focal
  – Baseline and interval ECG
    • Known conduction problems
    • PR interval increasing drugs
    • Cardiac disease

• Rufinamide (Banzel®) FDA approval adjunct: Lennox-Gastaut Syndrome ≥ 4 yr.
  – Baseline and interval ECG
    • Can shorten QT interval

©Julie Sprague-McRae, 2014
Other Anti-Epileptic Drugs

- Phenobarbital *FDA approval pediatric*
- Primidone + Phenobarbital = *(Mysoline®)* *FDA approval*
  
  *adjunct or monotherapy: epilepsy pediatric*
  
  – Focal, secondarily generalized, generalized
tonic clonic, status epilepticus
  
  – First choice for infants
  
  – QD or BID dosing
  
  – Monitor CBC, LFT’s (ALT/AST), blood levels
  
  – Possible effect on development
Other Anti-Epileptic Drugs: Benzodiazepines

- **Clobazam (Onif®)**  
  - FDA approval Lennox-Gastaut Syndrome ≥ 2 yr.  
  - Adjunct therapy  
  - Associated with Steven Johnson Syndrome

- **Clonazepam (Klonopin®)**  
  - Adjunct therapy  
  - Rescue medication  
  - Can habituate which alters efficacy over time  
  - Increases oral secretions

©Julie Sprague-McRae, 2014
Rarely used Anti-Epileptic Drugs

• **Felbamate (Felbatol®)** *FDA approval adjunct: Lennox-Gastaut Syndrome, focal and generalized 2-14 yr.*
  – Focal seizures, Lennox Gastaut Syndrome
  – Released 1993, FDA warning 1994
  – Associated with aplastic anemia, liver toxicity

• **Vigabatrin (Sabril®)** *FDA approval adjunct: focal ≥10 yrs.*
  – Available in US under special program
  – Infantile spasms, partial seizures
  – Significant side effect profile: risk of blindness

©Julie Sprague-McRae, 2014
Management: Rescue Anti-Epileptic Drugs (AEDs)

- **Indications:**
  - Prolonged seizures
  - Seizure flurries
  - Emergency medical services (EMS) unavailable
    - Travel
    - Rural areas

- **Delivery:**
  - Oral
  - Rectal
  - Nasal

©Julie Sprague-McRae, 2014
Management: Rescue Anti-Epileptic Drugs (AEDs)

- **Oral Benzodiazepines**
  - **Diazepam (Valium®)**
    - FDA approved
    - Oral > 6 months
    - Injectable > 30 days
  - **Lorazepam (Ativan®) buccal, sublingual, injectable**
    - Injectable only FDA approved adults status epilepticus
  - **Clonazepam (Klonopin®)** FDA approved seizures pediatric
Management: Rescue Anti-Epileptic Drugs (AEDs)

- Rectal Benzodiazepine: Diazepam
  - Diastat®, AcuDial®
  - FDA approved 2 years and older
Management: Rescue Anti-Epileptic Drugs (AEDs)

Nasal Midazolam (Versed®)

No FDA approval for treating status epilepticus or seizures adults or children

Retrieved from: http://www.intranasal.net/Home/default.htm
Other Treatment Options

- Epilepsy surgery (resection if focal)
- Ketogenic diet therapy
- Vagus nerve stimulator

- Classic Ketogenic Diet
  - High fat, low CHO, low protein
  - Ketotic state enhances seizure control
  - Requires family commitment

- Modified Atkins Diet
  - Restricted CHO (10-15 gm)
  - Unrestricted fat & protein
Vagus Nerve Stimulator

Vagus Nerve Stimulation (VNS)

- Vagus nerve (in the neck) is stimulated with short bursts of electrical current
- Stimulation travels through the vagus nerve to the brain

• Implanted Device

©Julie Sprague-McRae, 2014
Interval History: Description of Symptoms

• **Identify:**
  – Epilepsy classification
  – Date of last seizure
  – Typical seizure presentation:
    • Onset, and associated factors
    • Frequency, timing, and duration
    • Level of consciousness
    • Body parts involved (unilateral or bilateral)
    • Recovery (post-ictal period)
Interval History: Medication and Treatments

- Anti-epileptic and PRN rescue drugs:
  - Formulation (*changes, brand-generic*), dosage (adjustments), schedule (access)
  - Duration of Treatment and **compliance**
- Other medications/supplements
- Side effects, toxicity, drug interactions
- Tolerance and efficacy of other treatments (VNS, ketogenic diet therapy)
Interval History:
Medical Update: Illness & Issues

- Age & weight
- Acute: Signs & symptoms of illness
- Chronic: Status of other medical or physical co-morbid problems or disabilities and environmental risk
- Recent laboratory or procedural testing
  - AED levels
  - LFTs, CBC, CO2
  - EEG, Imaging

©Julie Sprague-McRae, 2014
• Educate family:
  – Seizure etiology
  – Factors that can exacerbate seizures
    • Sleep deprivation
    • Illness
    • Missed medication doses (compliance)
    • Travel
    • Hormonal influences
  – Med side effects, and rescue meds
Action: Signs & Symptoms Medical Update

• Educate the family:
  – Safety
  – Seizure first aid
  – Guidelines for activating EMS (911)
  – Guidelines for follow-up:
    • Seizures worsening in frequency, intensity or duration
    • Worsening co-morbid medical problems or disabilities
Action: Seizure First Aid

- Most seizures < 2 minutes
- Goal: Protect the child
  - Keep calm and time the seizure
  - Turn gently to side
  - Do not hold down or restrict movement
  - Clear the area
  - Do not put anything in mouth or force it open
  - Reassure as awareness returns
General Seizure Safety Tips

• **Water Safety:**
  – **NEVER** leave alone in a bathtub, hot tub or swimming pool
  – Encourage showers
  – Keep bathroom door unlocked

• Avoid pillows, blankets, or toys in bed

• Avoid heights and high risk sports activities
General Health and Psycho-Social Issues

• Sleep:
  – Poor sleep patterns common
  – Sleep deprivation can worsen seizures

• Nutrition:
  – AED can increase or decrease appetite
  – AED can cause weight gain or loss

• Psychiatric co-morbidities are common
  – ADD/ADHD, anxiety, OCD, other
Behavior
  – Temperament
  – New or worsening behaviors, and provoking factors
  – Emotional labiality

Effect of anti-epileptic drugs on behavior
  – Some AED’s modulate behavior
  – Some AED’s make behavior worse
General Health and Psycho-Social Issues

• Communication
  – Language
  – Speech
  – Eye Contact

• Social Skills

• Relationships
  – Peers (teasing or bullying)
  – Family and sibling relationships
Family Dynamics and Coping

- Identify and Describe:
  - Change in family dynamics or structure
  - Financial or health insurance issues
  - Parent/patient level of concern and understanding about epilepsy/seizures
  - Family support systems
• Encourage family to follow-up for:
  – Medication side effects or interactions
  – Exacerbation of seizures
  – Behavioral or psychiatric issues
  – Changes in status of co-morbidities
  – Concurrent illness

• Update or consult child neurology provider as indicated
Early Intervention, School and Therapy Programs

• Identify:
  – Grade level & classroom setting
  – Academic performance
  – Educational or ADD/ADHD testing
  – Learning disabilities
  – Services/Therapies (OT/PT, speech, adaptive PE)
  – Educational Interventions (504 Plan, IEP, Resource, tutoring)
• Identify:
  – Focusing/Attention issues
  – Cognitive skills
  – Language skills
  – Classroom behavior
  – Other identified co-morbidities
  – Social skills
  – Response to medication (ADHD, AED, other)
Obtain/verify consent for exchange of information

Contact the school nurse to help facilitate:

– School seizure safety plan
  • Avoid water sports/PE unless full supervision
  • Rescue Medications:
    – Usually not necessary unless history of prolonged seizures or no access to EMS
    – CA Senate Bill 161: Controversial to have non-licensed personnel to administer

– Educating school staff: seizure safety
• Facilitate appropriate evaluations:
  – Educational or ADD/ADHD
  – Speech, OT, PT or adaptive PE
• Provide input school management:
  – IEP (individualized educational plan)
  – 504 plan
  – Behavior plan
• Refer family to school liaison, advocacy sources, counseling as needed
Epilepsy Resources

• Epilepsy Foundation of America: [www.efa.org](http://www.efa.org)
  - Books, Kits, Pamphlets and Videos
  - School:
    • Seizure Action Plan
    • Seizure Observation Record
    • Parent Questionnaire

• Association of Child Neurology Nurses:
  - Child Neurology Encounter Guides: [www.acnn.org/books](http://www.acnn.org/books)

• American Academy of Neurology: [www.aan.com](http://www.aan.com)

• American Epilepsy Society: [www.aesnet.org](http://www.aesnet.org)

• CDC Epilepsy website: [http://www.cdc.gov/Epilepsy/](http://www.cdc.gov/Epilepsy/)

©Julie Sprague-McRae, 2014