Electro-Cerebral Shutdown: Does postictal EEG suppression play a role in SUDEP?

June 23, 2012

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Partners Against Mortality in Epilepsy Conference - June 21-24, 2012
Disclosure

UCB, Brussels (Belgium)    Consultancy agreement

Eisai Ltd. (Germany)       Speaker fees
Learning Objectives

• Understand the concept of “electro-cerebral shutdown”

• Describe the features of Postictal generalized EEG suppression (PGES)

• and its clinical correlates (effects on breathing, heart function?)
Concept of “electro-cerebral shutdown”
Pathophysiology

Ventilatory pump

$\text{PO}_2$ ($\text{PCO}_2$)

$\text{O}_2$ content

Hemoglobin

O$_2$ Supply

Chemo-receptors

Baro-receptors

Blood pressure

Blood flow
47 year old man with pharmacoresistant focal epilepsy of unknown etiology

• Intracranial video-EEG telemetry

• Died during 5th seizure (gen. convulsive seizure)
“Electro-cerebral shutdown”

- Right amygdala (depths)
- Right hippocampus (depths)
- Right ant temp (surface)
- Right post temp (surface)
- Left amygdala (depths)
- Left hippocampus (depths)
- Left ant temp (surface)
- Left post temp (surface)

- 2 seconds after seizure onset
- 20 seconds after seizure onset
- 60 seconds after seizure onset
- 120 seconds after seizure onset
- 180 seconds after seizure onset
Primary "electro-cerebral shutdown"

- Ventilatory pump
  - $\text{PO}_2$ ($\text{PCO}_2$)
  - O$_2$ content
  - Hemoglobin
- Circulatory pump
  - Blood pressure
  - Blood flow
- Chemo-receptors
- Baro-receptors
- O$_2$ Supply
Does EEG suppression predict SUDEP? (part 1)

- Case control study of Lhatoo and co-workers
- 10 SUDEP patients, 30 matched controls (all refractory focal epilepsy)
- 30 seizures in SUDEP, 92 seizures in control group

Def.: Postictal generalized EEG suppression (PGES) = Amplitude < 10 µV in bipolar montage (scalp EEG)
Examples of scalp EEG

PGES

Diffuse slowing

Lhatoo et al. AoN 2010
Does EEG suppression predict SUDEP? (part 1)

- **Case control study of Lhatoo and co-workers**

- **Major findings**

  - PGES > 50 seconds: OR of SUDEP 5.22
  - PGES > 80 seconds: OR 23.46
Postictal EEG suppression (PGES):

- Characteristics
- Origin
Characteristics of PGES

• Definition: Amplitude < 10 µV in bipolar montage (scalp EEG)

• Occurrence / frequency:
  • 40-66% of generalized convulsive seizures
  • 1-2% of non-generalized seizures

• Duration: 16–92 seconds (averaged duration)

• Onset and duration independent of duration of precedent seizure / convulsive phase
Origin of PGES

- **Unknown**

- Sign of cerebral exhaustion (e.g. depletion of neurotransmitters)?

- Active mechanism, because of sudden onset and independence of seizure duration?
Limitations of studying PGES

No information about neuronal activity e.g. in thalamus, insula and brain stem
Clinical correlates of PGES
PGES and respiratory function

Seizure

Convulsions

Apnea

60 seconds

Oxygen desatur.

Convulsions

PGES

Apnea

Oxygen desaturation

Adapted from Seyal et al., Epilepsia 2012
PGES and clinical situation

Generalized tonic-clonic seizures during telemetry:
• Electroclinical features
• Immediate clinical management

<table>
<thead>
<tr>
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<th>PGES (-): 12 pat.</th>
<th>PGES (+): 13 pat.</th>
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<tr>
<td>Spontan. movement at seizure termination</td>
<td>9/12 (75%)</td>
<td>1/13 (8%)</td>
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<tr>
<td>Measures taken by staff</td>
<td>5/36 (14%)</td>
<td>18/44 (41%)</td>
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Measures taken by staff (simple interventions):
Suction, oxygen administration, recovery position, vital signs

Semmelroch et al., Epilepsia 2012
PGES and autonomic function


Amplitude of "sympathetic skin response" (µS)

Max. change of parasympathetic activity (%)
(high-frequency power of HRV)
PGES and cardiac function

No apparent association with cardiac arrhythmia or asystole

Lhatoo et al. AoN 2010; Surges et al., Epilepsy & Behav 2011
Does EEG suppression predict SUDEP? (part 2)

- Case control study of our working group
- 17 SUDEP patients, 17 matched controls (all refractory focal epilepsy)
- 42 seizures in SUDEP, 38 seizures in control group

No association of PGES presence/duration with SUDEP

Surges et al., Epilepsy & Behav 2011
Does EEG suppression predict SUDEP? (part 3)

- A good predictor should be reliable and consistent

**Fig 2:** Consistency of PGES presence in 35 people with 2GTCS

**Fig 3:** Consistency of PGES presence in 24 people with ≥3 GTCS

Collaboration with R. Lambs, R. Thijs, L. Sander (Unpublished)
PGES is...

- Frequently associated with generalized convulsive seizures
- Of unknown origin (active mechanism?)
- **Linked to severity of ictal hypoxemia**
  (intrinsic pulmonary dysfunction)
PGES is associated with...

- Suppression of parasympathetic activity
- Increase in sympathetic activity
- **No apparent secondary cardio-respiratory dysfunction**
Impact on Clinical Care and Practice

1. PGES is probably **no reliable predictor** of future SUDEP (marker of severity of ictal hypoxemia?)

2. Concept of primary “electro-cerebral shutdown” not supported by recordings **unrelated** to (near-)SUDEP

Maybe good news, because simple interventions could help to prevent death!?