

## Neonatal seizures, semiology and monitoring



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## Neonatal seizures - a clinical diagnosis?

- 20 video clips of 11 seizures and 9 other events
- Evaluated by 137 health professionals (US, Ire, UK)
  - 91 doctors (consultants, fellows, residents)
  - 46 NICU nurses / midwives
- Asked to identify seizures vs non-seizures

Malone et al 2008

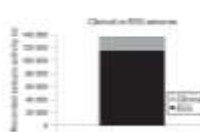
## Neonatal seizures - not a clinical diagnosis!

- Correctly identified events: 10/20 in average
  - Conic seizures most frequently identified
  - Others poorly
- Poor agreement with correct diagnosis (0.09/-0.02)
- Poor inter-observer agreement (0.21/0.29)

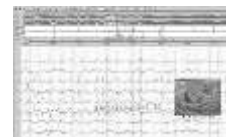
Malone et al 2008

## Seizure manifestations in neonates

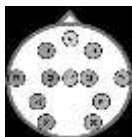
- Non-seizure behaviour with similar semiology
- Seizures in neonatal period are subclinical /electrographic only in ~ 60% (Mizrahi & Kellaway 1989; Murray 2009)
- In clinical ITU setting high risk of under diagnosis (~90%) and over diagnosis (~70%)
- Poor concordance between clinical and electrical evidence



Murray et al 2009



## Neonatal EEG: Gold standard



- EEG with 10-21 electrodes
  - Full montage
  - Reduced montage
- ECG
- Respiration
- EMG (bilateral deltoid)
- Video
- Duration
  - 60 min (incl wakefulness & sleep)
  - Monitoring 24-72 hr

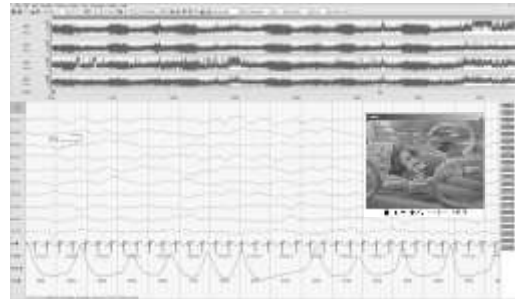
Tekgul et al 2005, De Weerd et al., 1999, Shellhaas et al 2011, McCoy & Hahn 2013

## Maturation milestones

|  |                                                                                                                                                                      |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <b>23-28 weeks</b> <ul style="list-style-type: none"> <li>• Discontinuous, interburst interval 10-60 sec</li> <li>• No sleep wake cycling</li> </ul>                 |
|  | <b>29-32 weeks</b> <ul style="list-style-type: none"> <li>• Discontinuous, interburst interval 5-40 sec</li> <li>• Sleep wake cycling appearing</li> </ul>           |
|  | <b>33-36 weeks</b> <ul style="list-style-type: none"> <li>• Continuous in W &amp; AS, discontinuous in QS</li> <li>• Clear sleep wake cycling, reactive</li> </ul>   |
|  | <b>37-42 weeks</b> <ul style="list-style-type: none"> <li>• Continuous in W &amp; AS, tracé alternant in QS</li> <li>• Clear sleep wake cycling, reactive</li> </ul> |

## Normal neonatal graphoelements

|                                                                                   |                             |          |
|-----------------------------------------------------------------------------------|-----------------------------|----------|
|  | Monorhythmic delta activity | GA 24-34 |
|  | Premature temporal theta    | GA 26-38 |
|  | Delta bushes                | GA 26-40 |
|  | Multifocal sharp waves      | GA 30-44 |
|  | Encoche frontale            | GA 35-44 |
|  | Anterior slow dysrhythmia   | GA 35-44 |



Neonatal polygraphy: 10 EEG channels, ECG, blood pressure, respiration, oxygen saturation. At the top 4 channels displayed as aEEG

## EEG features of neonatal seizures

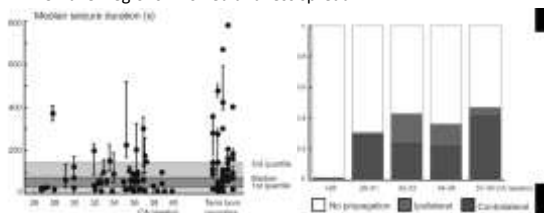
- Any rhythmic activity is suspicious
- Sudden and distinct beginning & end
- Focal origin with spread
- Evolution of amplitude & morphology
- Minimum duration  $\geq 10$  sec
- Status: >50% seizure activity in 30 min EEG

## BIRDs (brief ictal rhythmic discharges)



## Preterm vs term infants

- More likely to be subclinical
- Shorter duration (mean 60 sec vs 90 sec)
- Smaller regions involved and less spread



Janáková et al 2016

## Guidelines and glossaries

- **European Guidelines, 1999**  
De Weerd AW, Despland PA, Plouin P. Neonatal EEG. The International Federation of Clinical Neurophysiology. *Electroencephalogr Clin Neurophysiol Suppl.* 1999;52:149-57.
- **French Glossary, 2010**  
André M, Lamblin MD, d'Allest AM, et al. Electroencephalography in premature and full-term infants. *Neurophysiol Clin.* 2010 May;40(2):59-124.
- **American Guidelines, 2011**  
Shellhaas RA, Chang T, Tsuchida TN et al 2011 ACNS's Guideline on Continuous EEG Monitoring in Neonates. *J Clin Neurophysiol* 28: 611–617.
- **American glossary, 2013**  
Tsuchida TN, Wusthoff CJ, Shellhaas RA, et al 2013 ACNS's Terminology and Categorization for the Description of Continuous EEG Monitoring in Neonates. *J Clin Neurophysiol* 30: 161–173.

## Recommendations for monitoring clinically ill neonatal seizures

- **WHO guidelines (2011)**
  - If EEG available, treat all electrical seizures (strong, context)
  - If available, confirm all clinical seizures by EEG (strong, context specific)
- **ACNS EEG monitoring recommended (Shellhaas 2011):**
  - After abnormal paroxysmal event
  - Neonates at high risk of electrographic seizures
  - When AED are withdrawn
  - Monitoring of burst suppression pattern

## Neonatal seizures

- Incidence of seizures:
  - 0.5-3 per 1,000 term live births
  - 10-130 per 1,000 preterm live births
- Nearly all acute symptomatic seizures
- Onset mostly in first 7 days
- Several classifications used
  - Volpe (1989)
  - Mizrahi and Kellaway (1989)
  - ILAE (1989, 2010)



Ronen et al 1999; Lanska et al 1995; Watkins et al 1988;  
Special edition of Seminars Fetal & Neonatal med 2013

## Classification of neonatal seizures

Volpe (1970, 1989, 2000)

| Class        | Frequency | Characteristics |
|--------------|-----------|-----------------|
| Subtle       | 4+        |                 |
| Clonic       | 2         |                 |
| Tonic        | 2         |                 |
| Myoclonic    | 2         |                 |
| Spasms       | 2         |                 |
| Autonomic    | 2         |                 |
| Behavioral   | 2         |                 |
| Unclassified | 2         |                 |

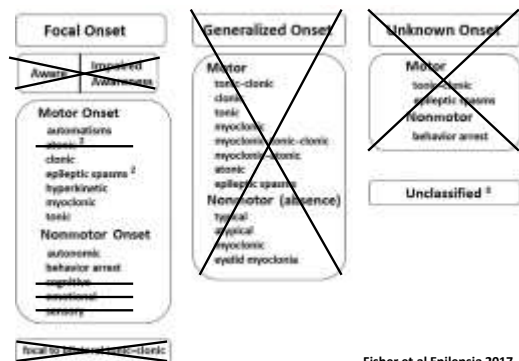
Mizrahi (1987, 1998)

1. Subtle
2. Clonic
3. Tonic
4. Myoclonic
5. Spasms
6. Autonomic
7. Behavioral
8. Unclassified

### ILAE classification

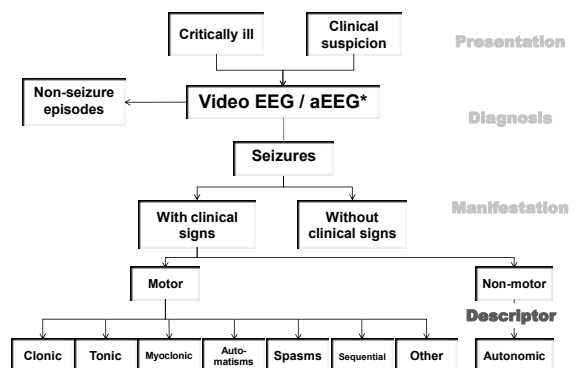
- 1981/1989 not included neonatal seizures
- Berg et al 2010 includes neonatal seizures but no specific considerations
- New ILAE position paper (Fisher et al 2017)

## ILAE 2017 seizure classification



Fisher et al Epilepsia 2017

## ILAE neonatal seizure task force





## Conclusion



- Clinical diagnosis not possible due to discreet or no clinical manifestation (electrographic only)
- EEG for diagnosis & monitoring of neonatal seizures
- Classification of phenotype to aid
  - Clinical communication between specialities
  - Aid diagnosis, management and treatment
- New diagnostic framework to describe neonatal seizures

## Acknowledgements

### Neonatal Task force

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wellcome trust

