# Normal EEG in children

## EEG workshop

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## **Electrode placement**

- International 10-20 system
  - Minimum 21 electrodes
  - Odd-numbered electrodes are placed on the left side of the head, and even-numbered electrodes are placed on the right side of the head
  - Specific letters designate the anatomical area; for example "F" means frontal

### International 10-20 system





#### The difference in voltage between two electrodes

#### • Bipolar:

Each channel represents difference between 2 adjacent electrodes

- AP bipolar
- Coronal / transverse bipolar

#### • Referential:

Each channel represents the difference between a certain electrode and the designated reference position

- ipsilateral ear
- average
- midline, etc.

# AP bipolar montage (double banana): for localization



# Referential montage: for amplitude measurement



## **EEG** activity

- Waveform
- Frequency
- Amplitude
- Polarity
- Timing

## Wave form

- Spike
  - Sharply contoured, duration 20-70 msec
- Sharp wave
  - Sharply contoured, duration 70-200 msec
- Sharp transient
  - Sharply contoured waveform
- Other morphology
  - spindles, arciform, saw-tooth

## Wave form

- · Monophasic wave
  - Single deflection: up or down
- · Diphasic wave
  - 2 components on opposite sides
- ₩,

- · Polyphasic wave
  - 2 or more components of different direction

### Frequency

- Delta wave < 4 Hz
- Theta wave 4-7 Hz
- Alpha wave 8-13 Hz
- Beta wave > 13 Hz

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HyperV	
Photic	
ECG 50 μ√/mm	

## Amplitude

#### Total vertical distance of wave

- Low < 20 μV
- Medium 20-50  $\mu$ V
- High > 50 μV

Affected by barriers



## Distribution

- Generalized / diffuse
- Lateralized
- Focal / localized

## Polarity

#### Bipolar (input 1 – Input 2)

- Upward pen deflection
  - when input 1 is more negative than input 2
  - when input 2 is more positive than input 1
- Downward deflection
  - when input 1 is more positive than input 2
  - when input 2 is more negative than input 1

Referencial (Input 1 - Ref)

- negative is up and positive is down



## Timing

- Synchronous
- Bilaterally synchronous
- Asynchronous
- Independent

## Pediatric EEG

## EEG in newborn

- Post conceptional age
- Duration at least 60 minutes
- Awake / Active sleep / Quiet sleep
- Continuity / Synchrony
- Symmetry / Reactivity
- Normal specific EEG pattern

## Awake

- Posterior dominant rhythm (PDR)
- Posterior slow wave of youth (PSWY)
- Mu rhythm
- Beta activity
- Lambda wave
- Eye movement
- Artifact

## PDR

- · Alert, eye-closed, in rest state
- First seen at 3 months of age
- Maximum posterior head region
- Reactivity
  - Attenuation with eye opening, <u>+</u> anxiety

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<mark>ECG</mark> 100 µV/mm	hand	all	j-M_M

## PDR

- Higher amplitude over right hemisphere (< 50% difference)</li>
  - due to asymmetric skull thickness
- Amplitude ~ 50-100 uV
- Decreasing amplitude with increasing age due to increased bone density of the skull

## PDR

Frequency in Children

3-4 months:	4 Hz
12 months:	5-6 Hz
2 years:	7 Hz
3 years:	8 Hz
9 years:	9 Hz
15 years:	10 Hz

## PSWY

- Slow activity intermixed with PDR
- Moderate voltage (<120% of normal alpha rhythm voltage )
- May be asymmetry
- Best seen in 8-14 years
- · Block with eye opening
- Disappear with the alpha rhythm during drowsiness and light sleep

#### PSWY

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Photic	

### Mu

- central arch-like rhythm of alpha frequency (usually 8-10 Hz)
- May be related to the functions of the sensorimotor cortex at rest
- Best seen between 8-16 years
- Asymmetrical
- Blocked unilaterally with movement of the contralateral extremity
- Not blocked by eye opening

#### Mu rhythm



#### Beta

- Frequencies more than 13 Hz
- Amplitude < 20 uV, usually < 10 uV
- Three band

18-25 Hz band (common)

14-16 Hz band (less common)

35-40 Hz band (rare)

- · Increased by
  - Drugs eg. barbiturate, benzodiazepine, chloral hydrate (18-25 Hz > 14-16 Hz)



## Lambda wave

- Surface positive, check mark-like wave
- Occipital region
- During eye opening
- Visually scanning at complex picture (ceiling, TV etc.) with saccadic eye movement
- Best seen in 2-15 years
- May be asymmetrical

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## Eye movement (EM)

Vertical EM

(Fp1, Fp2)

(F7, F8)

- Eye opening
- Eye closure
- Eye blinking

Horizontal EM

- To the left
- To the right

## Eye movement (EM)

- Cornea  $\rightarrow$  positivity
- Retina  $\rightarrow$  negativity
- Nearest electrode of the direction of EM will pick up positivity, the opposite electrode will pick up negativity

## Vertical EM

- Eye closure (relatively eyes go up)
  → Fp1 and Fp2 pick up positivity
  → downward deflection at Fp1-F7, Fp2-F8
- Eye opening (relatively eyes go down)
  - $\rightarrow$  Fp1 and Fp2 pick up negativity
  - → upward deflection at Fp1-F7, Fp2-F8



## Horizontal EM

- Eye turn to the left
  - $\rightarrow$  F7 pick up positivity, F8 pick up negativity
  - $\rightarrow$  positive phase reversal at F7 (Hole)
  - $\rightarrow$  negative phase reversal at F8
- Eye turn to the right
  - $\rightarrow$  F8 pick up positivity, F7 pick up negativity
  - $\rightarrow$  positive phase reversal at F8 (Hole)
  - $\rightarrow$  negative phase reversal at F7





## Sleep

Non-REM sleep

- Stage 1 (drowsiness)
- Stage 2
- Stage 3 & 4

**REM** sleep

# Stage 1

- Alpha drop out
- Hypnagogic hypersynchrony
- POSTs
- Beta activity
- Vertex wave

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## Hypnagogic hypersynchrony

- Burst of generalized high voltage 3-5 Hz
- Maximum fronto-central
- Awake  $\rightarrow$  sleep
- Begin 6 months
- Best seen 1-5 years
- Rare after 11-12 years
- Hypnapompic: sleep  $\rightarrow$  awake



# POSTs

- · Positive occipital sharp transients of sleep
- 4-5 Hz, checkmark-like, isolated or in trains
- Esp. daytime nap, arousal  $\rightarrow$  return to sleep
- Commonly asymmetry
- Age 4-50 years
- Best seen 15-35 years

#### POSTs

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#### Vertex wave

- Sharp transient maximum Cz (vertex)
- Begin 8 weeks post term
- Age 1-4 years; spiky and high amplitude
- Runs of vertex



Stage 2

- Sleep spindles
- K-complex
- Delta wave
- (Vertex, POSTs)

## **Sleep spindles**

- 11-14 Hz
- Maximum central, frontal (Cz, C3C4, F3F4)
- 2-5 seconds duration, may be spiky
- Lack of fusiform shape as in adult
- Begin 6-8 weeks post term; asynchronous but symmetrical
- Age 2 years; synchronous



## K-complex

- 1. Vertex + spindles
- 2. Biphasic high amplitude slow wave > 0.5 seconds duration
- Maximum Cz (vertex)
- Begin 5 months

### K-complex: transverse montage



### Stage 3 & 4

Delta activity
 20-50% → stage III
 > 50% → stage IV

• (Sleep spindles)



## REM

- Sleep onset in newborn until 2.5 months, then NREM onset
- Rapid eye movement
- Relatively absent EMG
- Intermixed delta/theta, saw tooth appearance
- Rarely seen in routine pediatric EEG

## Arousal

- Brief arousal period from sleep
- Abrupt change of the background
- Biphasic slow wave: begin 3 mo
- 4-5 Hz: begin 7 mo
- 8-10 Hz: adolescent
- Usually 4-5 seconds or longer

## Photic stimulation

Done in dimly lit room, 30 cm away from eyes Frequency 1-30 Hz

- Visual evoked response
- Photo myogenic response
- Photic driving response

## Photic driving response

- Usually > 3 Hz
- Posterior head region
- Related to stimulus frequency
- Asymmetry is not associated with structural brain disease in the absence of other abnormalities



## Hyperventilation test

- Duration 3 minutes; adequate
- Normal response: build up of diffuse, synchronous high voltage delta activity
- More prominent posteriorly in age < 8 yrs</li>
- Change usually resolve within 60 seconds

