

Supplement 236

WAVEFORM PRESENTATION STATE

DICOM WORKING GROUP 32

BEFORE PUBLIC COMMENT

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2024-03-15



Purpose of Waveform Presentation State

A Waveform Presentation State ...

- provides display properties separate from the waveform object
- preserves display settings in order to be able to re-create a specific view
- aligns a display view and the presentation of annotations stored in a separate object
- refers to waveform objects and specific channels within these
- defines color, shading and scaling

Existing Waveform Presentation

- DICOM Waveform Module PS3.3 C.10.9 contains display information
 - Stored within the waveform object (this means: at recording time)
 - Referencing channels in the current object
 - Grouping of channels with same display properties
 - Just defines color, shading and scaling

Existing Waveform Presentation

Attribute Name	Attribute Description
Waveform Data Display Scale	The recommended time-based waveform data display scale in units of mm/s
Waveform Display Background CIELab Value	A color triplet value recommended for rendering the waveform display background on a color display.
Waveform Presentation Group SQ	Sequence of Items, each Item describing a Presentation Group of one or more waveform channels to be displayed together
> Presentation Group Number	A number that identifies the Presentation Group
> Channel Display SQ	Sequence of Items, each Item describing a channel to be displayed in the Presentation Group.
>> Referenced Waveform Channels	Identifier of the displayed channel, specified as a pair of values (Multiplex Group item no. in SQ), Channel item no. in SQ)
>> Channel Offset	The offset in seconds from the beginning of the channel waveform data to the first sample to be used for presentation

Existing Waveform Presentation

Attribute Name	Attribute Description
>> Channel Recommended Display CIELab Value	A color triplet value recommended for rendering the channel on a color display.
>> Channel Position	Position of the Channel within the Presentation Group display area
>> Display Shading Flag	Specifies display area shading between the displayed waveform channel and another line. Enumerated Values: <ul style="list-style-type: none"> • NONE • BASELINE • ABSOLUTE • DIFFERENCE
>> Fractional Channel Display Scale	Fraction of the Presentation Group vertical display dimension assigned to the unit quantity (least significant bit) of the Channel samples
>> Absolute Channel Display Scale	Nominal vertical display height in mm assigned to the unit quantity (least significant bit) of the Channel samples

Use Cases

WHICH INFORMATION SHOULD BE STORED AND EXCHANGED IN
WHICH SITUATION

Use Case: Recording

- A technologist performs an EEG recording. From time to time, the technologist changes the filter settings and viewing montages, in order to check the quality of the recording.
 - The filter settings and viewing montages convey to selected channels
 - These channels may come from more than one instance (e.g. the EEG instance and the ECG instance)
 - Question: could this also affect channels from elder recordings (might be a prior examination or just a short time ago)?
Answer: No, changes to the montage only affect the current recording.

Use Case: Recording cont.

- The EEG technologist may note power line noise on a particular channel and physically manipulate the scalp and EEG electrode of that channel to improve impedance (or if the notch filter is employed incorrectly they may fail to note quality problems on some channel). If abnormalities occur or if external circumstances change that could be of importance for the evaluation of the recording, the technologist adds event annotations at various timepoints in the recording.
- In addition to the annotations, the recording system also saves any changes to the display filter settings and the montage selected for the display throughout the recording.

Use Case: Recording cont.

- Information that shall be preserved and exchanged:
 - Annotations added by the technologist
 - Time, Text, and Originator
 - Changes to Display Filter Settings
 - Changes to Display Montages

Use Case: post-hoc Review

- A physician or technologist acting as a post-hoc reviewer looks through a completed EEG recording and marks potential epileptic patterns. The annotations added by the technologist during the recording are shown.
- The physician has the option of using the settings for display filters and montage stored in the presentation state object generated during recording (so that the reviewer can view the EEG recording in the same manner as it was viewed by the technologist who made the recording).
- If the physician or technologist reviewer adds annotations, these are stored as well.

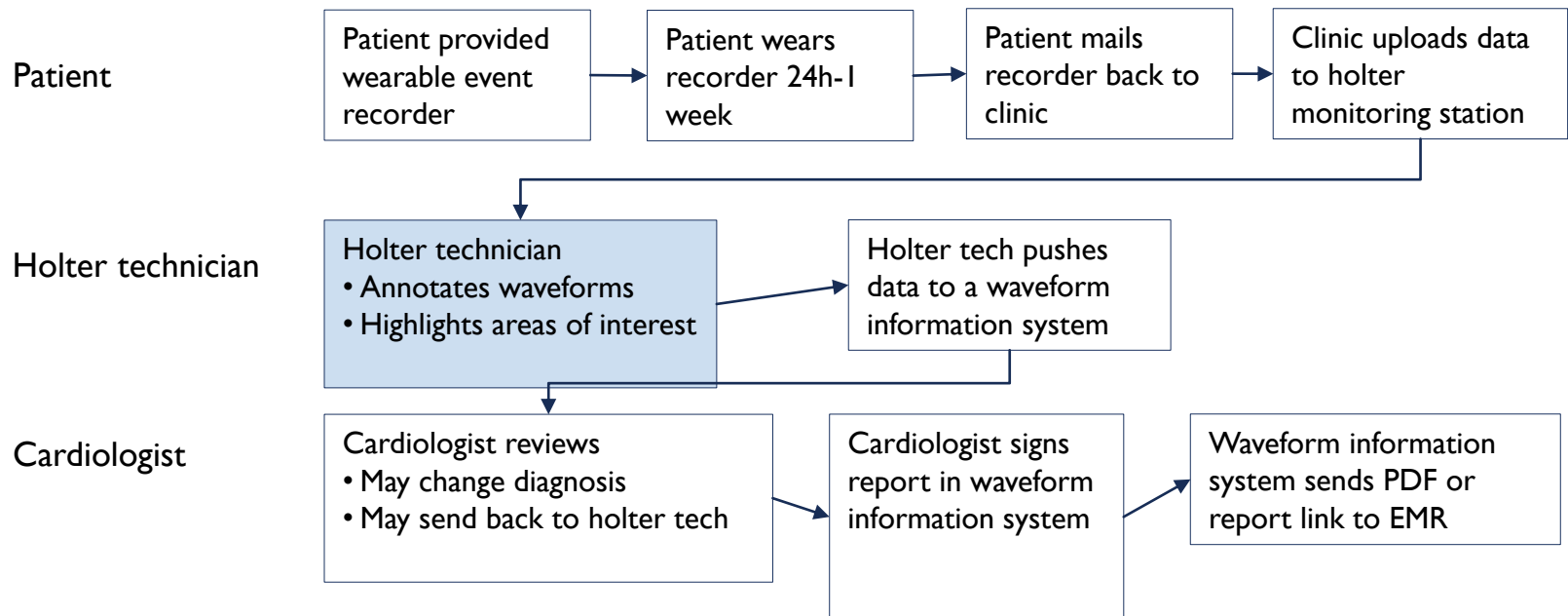
Use Case: post-hoc Review


- Changes to display settings are only stored based on user interaction/request.
- Reviewer annotations are always stored.
 - Reviewer Annotations do not necessarily have a relationship to filters / montages.

Cardio Use Case: Home Performed Holter

- A patient wears a 24 h ECG recorder for 1 week. Afterwards the data are sent/uploaded to a holter monitoring station.
- A holter technician annotates the waveforms and highlights areas of interest. Then these data are sent to some kind of information system.
- A cardiologist reviews the data and may change diagnosis or may send back to technician. Finally she signs the report in the information system and sends it to the EMR (probably as a PDF as well)

Cardio Use Case: Home Performed Holter






Zio® Patch Report for Report #1, Training

Date of Birth **Patient ID** **Gender** **Primary Indication**
 Arrhythmia (unspecified)


Prescribing Clinician **Managing Location** **This report is a compilation of multiple patients' arrhythmias.**
 Dr. E. Physician INCC Lincolnshire

iRhythm Technologies, Inc.
 Tel: (888) 693-2401
 www.zioreports.com

Enrollment Period **Analysis Time**
 13 days 16 hours 13 days 11 hours
 02/22/13, 01:12:2pm to 03/08/13, 05:03:4am (after artifact removed)




Ventricular Tachycardia (4 beats or more)
 ▼ Fastest VT (HR Range 99-182 bpm, Avg 135 bpm) No. of Episodes: **4**



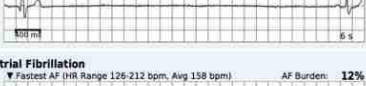
Patient Triggered Event? (≥ 45s)
 YES NO

Supraventricular Tachycardia (4 beats or more)
 ▼ Fastest SVT (HR Range 156-187 bpm, Avg 164 bpm) No. of Episodes: **5871**



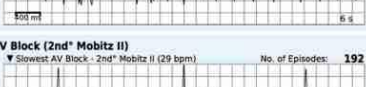
Patient Triggered Event? (≥ 45s)
 YES NO

Pauses (3 secs or longer)
 ▼ Longest Pause (5.4 s, 11 bpm) No. of Episodes: **3**



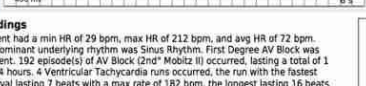
Patient Triggered Event? (≥ 45s)
 YES NO

Atrial Fibrillation
 ▼ Fastest AF (HR Range 126-212 bpm, Avg 158 bpm) AF Burden: **12%**



Patient Triggered Event? (≥ 45s)
 YES NO

AV Block (2nd* Mobitz II)
 ▼ Slowest AV Block - 2nd* Mobitz II (29 bpm) No. of Episodes: **192**



Patient Triggered Event? (≥ 45s)
 YES NO

Heart Rate

Maximum HR **212 bpm** (at 07:52pm on 03/04)
 Minimum HR **29 bpm** (at 03:46pm on 02/25)
 Average HR **72 bpm**

Patient Events

Number of Triggered Events: 3
Findings within ± 45 sec of Triggers:
 AV Block, Supraventricular Tachycardia, Sinus Rhythm, Ventricular Ectopic beat(s), Supraventricular Ectopic beats)

Number of Diary Entries: 3
Findings within ± 45 sec of Entries:
 Atrial Fibrillation, AV Block, Pause(s), Sinus Rhythm, Supraventricular Ectopic beat(s)

Ectopics

Rare: 0 to <-1.0%
 Occasional: 1.0% to <-5.0%
 Frequent: 5.0%+

Supraventricular Ectopy (SVE/PACs)

Isolated	Frequent	5.4%	76752
Couplet	Occasional	3.7%	26323
Triplet	Occasional	1.7%	7781

Ventricular Ectopy (VE/PVCs)

Isolated	Rare	<1.0%	5154
Couplet	Rare	<1.0%	19
Triplet	Rare	<1.0%	1

Longest Ventricular Bigeminy Episode: 4.8 s
 Longest Ventricular Trigeminy Episode: 7.7 s

Findings
 Patient had a min HR of 29 bpm, max HR of 212 bpm, and avg HR of 72 bpm. Predominant underlying rhythm was Sinus Rhythm. First Degree AV Block was present. 192 episode(s) of AV Block (2nd* Mobitz II) occurred, lasting a total of 1 day 4 hours. 4 Ventricular Tachycardia runs occurred, the run with the fastest interval lasting 7 beats with a max rate of 182 bpm, the longest lasting 16 beats with an avg rate of 133 bpm. 5871 Supraventricular Tachycardia (SVT) runs occurred, the run with the fastest interval lasting 12 beats with a max rate of 187 bpm, the longest lasting 35.3 secs with an avg rate of 133 bpm. Atrial Fibrillation occurred (12% burden), ranging from 45-212 bpm (avg of 84 bpm). 3 Pause(s) occurred, the longest lasting 5.4 secs (11 bpm). Supraventricular Tachycardia, Pauses, AV Block, and Atrial Fibrillation were detected within ±45 seconds of patient triggered diary event. Isolated SVEs were frequent (5.4%, 76752), SVE Couplets were occasional (3.7%, 26323), and SVE Triplets were occasional (1.7%, 7781). Isolated VEs were rare (0 to <1.0%, 5154), VE Couplets were rare (0 to <1.0%, 19), and VE Triplets were rare (0 to <1.0%, 1). Ventricular Bigeminy and Trigeminy were present. MD notification criteria for Rapid Atrial Fibrillation and AV Block met - notified RN on 03/15/2013 at 12:00 pm CST.

Final Interpretation
 1- Sinus rhythm with first degree AV block. 2- Episodes of second degree 2:1 AV Block. 3- Sinus pauses with longest being 5.4 seconds. 4- Frequent isolated PACs with occasional atrial couplets and triplets. 5- Many runs of SVT many of which appear to be ectopic atrial tachycardia (5871) with longest being 35 sec. 6- Rare isolated PVCs, ventricular couplets and triplets. 7- 4 Runs of VT up to 16 beats rate range of 135-182/min. 8- Atrial fibrillation with a burden of 12% with rates of 45-212 min. 9- Symptoms appear to correlate with SVT, sinus pauses, AV Block and atrial fibrillation.

Signed by Dr. Example Physician on 03/17/13 at 03:41 PM (CT)

Presentation state

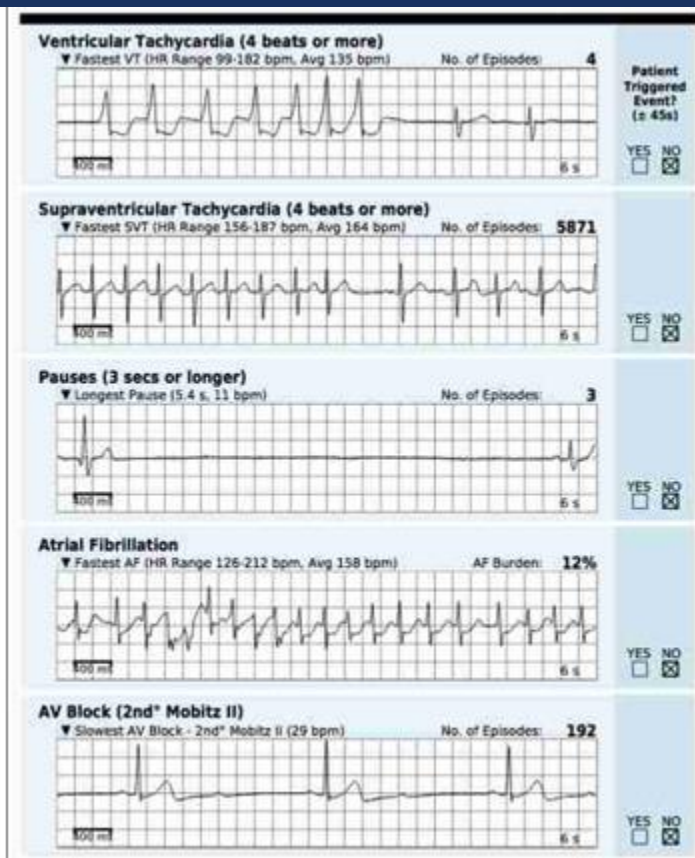
SR context

SR tables

SR narrative

https://www.researchgate.net/figure/iRhythm-Technologies-Inc-sample-Zio-Patch-report-format_fig1_259503800

Cardio Use Case



- Annotations:
 - If determined in real-time on the recording device: **Annotation Module in the Waveform Object**
 - If determined afterwards (after creation of the ECG Waveform): probably
 - **Presentations State** (anchored to a point on the strip) or
 - **Structured Report**
- Segment („6s“): Presentation State („Segment of Interest“ - with defined color)

HOLTER MONITOR REPORT SUMMARY

K. C. RAMESH MD																													
Phone: _____ Fax: _____																													
Recording Start Date: 2/28/2002	HOLTER ECG REPORT SUMMARY	Recording Start Time: 12:00																											
Patient Name: <u>Holter Test</u> ID# _____ Address: _____ Age: _____ DOB: _____ Sex: _____ Pacemaker: <u>None</u> Weight: _____ Height: _____ Supervising Physician: <u>Doctor A</u> Referring Physician: <u>Doctor B</u> Indications: _____ Medications: _____																													
<table border="1"> <thead> <tr> <th>HEART RATE</th> <th>VENTRICULAR ECTOPY</th> <th>HEART RATE VARIABILITY</th> </tr> </thead> <tbody> <tr> <td>Minimum HR-4 Minute: 47 bpm at 12:51</td> <td>VE Total: 1421</td> <td>SDNN 24 Hour: 162</td> </tr> <tr> <td>Minimum HR-4 Hour: 107 bpm at 13:20</td> <td>V-Pair Total: 12</td> <td>SDANN: 152</td> </tr> <tr> <td>Average HR-24 Hour: 65 bpm</td> <td>V-Pair Index: 20</td> <td>SDNN Index: 59</td> </tr> <tr> <td>Minimum HR-Hourly: 56 bpm at 12:00</td> <td>Longest V-Run: 9 beats at 13:53</td> <td>SDSD: 48</td> </tr> <tr> <td>Maximum HR-Hourly: 74 bpm at 13:00</td> <td>Maximum HR-V-Run: 123 bpm at 13:27</td> <td>SDHRV: 24</td> </tr> <tr> <td>Analysis Date: 7/6/03</td> <td>Maximum HR-V-Run: 102 bpm at 12:13</td> <td>Spectral Power-24 Hour: 3695.0</td> </tr> <tr> <td>Analysis Minutes: 117</td> <td>V-Run per 1000-pair Hour: 17/6716</td> <td>Delta Spectral Power Hour: 3695.0</td> </tr> <tr> <td></td> <td>Ventricular E on T: N/A</td> <td>Delta Spectral Power Hour: 3695.0</td> </tr> </tbody> </table>			HEART RATE	VENTRICULAR ECTOPY	HEART RATE VARIABILITY	Minimum HR-4 Minute: 47 bpm at 12:51	VE Total: 1421	SDNN 24 Hour: 162	Minimum HR-4 Hour: 107 bpm at 13:20	V-Pair Total: 12	SDANN: 152	Average HR-24 Hour: 65 bpm	V-Pair Index: 20	SDNN Index: 59	Minimum HR-Hourly: 56 bpm at 12:00	Longest V-Run: 9 beats at 13:53	SDSD: 48	Maximum HR-Hourly: 74 bpm at 13:00	Maximum HR-V-Run: 123 bpm at 13:27	SDHRV: 24	Analysis Date: 7/6/03	Maximum HR-V-Run: 102 bpm at 12:13	Spectral Power-24 Hour: 3695.0	Analysis Minutes: 117	V-Run per 1000-pair Hour: 17/6716	Delta Spectral Power Hour: 3695.0		Ventricular E on T: N/A	Delta Spectral Power Hour: 3695.0
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<p>CONCLUSIONS</p> <p>The average heart rate was 65. The minimum heart rate was 47 at 12:51. The maximum heart rate was 107 at 13:20. Pauses greater than 2.5 seconds were 2. Ventricular ectopy was 1421, with 20 V-Runs and 62 V-Pairs. Ventricular Bigeminy events were 1 and Ventricular Trigeminy events were 62. Supraventricular ectopy was 21, with 1 SVE-Run. Supraventricular Bigeminy events were 0 and Supraventricular Trigeminy events were 0. Total A-Fib(Fu) minutes were 0. ST episode minutes totaled 0. The maximum Delta ST change was -3.3 and occurred at 13:24.</p>																													

SR context

SR table

Presentation state

SR narrative

<https://nurseslabs.com/wp-content/uploads/2019/02/HOLTER-MONITOR-REPORT-SUMMARY-Holter.jpg>

Use Case: Electronic Health Record

- A patient receives care in a new hospital system from a new neurologist which uses neurophysiology review workstations built by a OEM which is different from the OEM which made the equipment which recorded the patient's previous video-EEG recordings.
- The new neurologist receives the DICOM data from the patient's previous video-EEG recordings made with the equipment of one OEM and is able to view this data using the review station made by a different OEM. The neurologist is able to view the:
 - video-EEG data using the montages used by the technologist who made the recordings
 - video-EEG data using his or own personal montages.
 - Annotations made by the technologist during the video-EEG recording
 - Annotations made by the neurologist who created the clinical report during the review process.
- This involves review of data encoded with existing waveform IODs (EEG IOD, ECG IOD, video IOD) and also the Annotations IOD and the Presentation State IOD

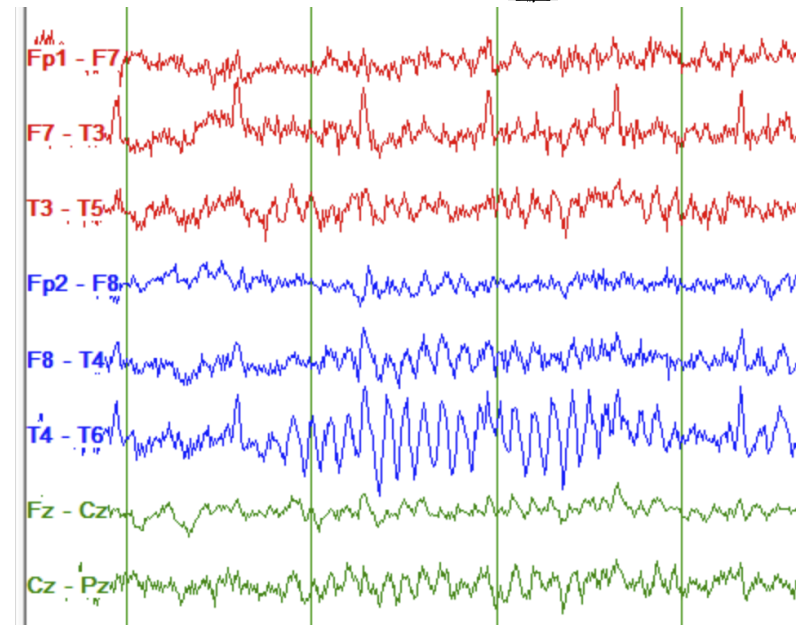
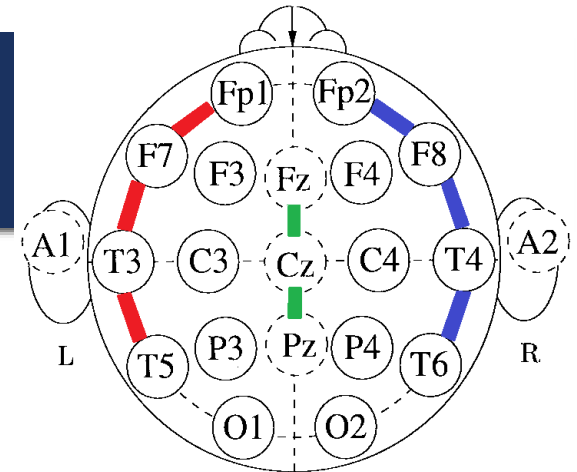
Definition of “Montage” in Neurophysiology



- Each channel of EEG records the potential difference between multiple electrodes and a single common digital reference electrode.
- Technically, “montage” defines a list of original channel sources and the method for their mathematical (linear) recombination to create a new “remontaged” list of channels for visualization of the data.
- In clinical practice, the term “montage” includes the above in addition to other attributes of each “remontaged” channel including visualization filters, color, inter-channel vertical spacing, channel group number, and channel polarity

Montages

Display	Recorded
Channel 1	Fp1, F7
Channel 2	F7, T3
Channel 3	T3, T5
Channel 4	Fp2, F8
Channel 5	F8, T4
Channel 6	T4, T6
Channel 7	Fz, Cz
Channel 8	Cz, Pz



File Edit View Trace Montage Notes Analysis Audio Window Help

Type EEG LFF 1 Hz HFF 70 Hz Notch 60 Hz Sensitivity 7 uV/mm Timebase 30 mm/sec

Speed 1.0 [Navigation icons]

AWAKE SAVE ENTIRE SEGMENT SAVE FOR REC DROWSY ASLEEP EEG SZ ONSET (Ctrl+F2) EEG SZ END (Ctrl+F3) CLINICAL EVENT ONSET (F4) CLINICAL END (F5) ??? (F2) IED (F9) USE FOR REC Custom...

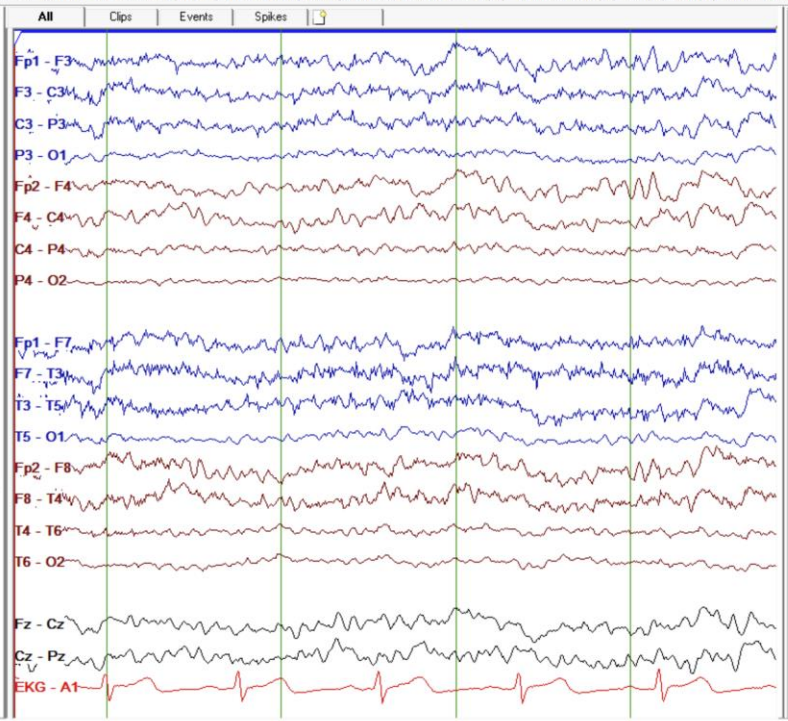
Time / Title

- d1 14:18:43 Beginning of Recording
- d1 14:18:43 Start Recording
- d1 14:18:43 Analyzer info - Persyst
- d1 14:18:43 Started Analyzer - Persyst
- d1 14:18:43 Started Analyzer - XLSpike
- d1 14:18:43 Started Analyzer - XLEvent / ECG
- d1 14:18:43 Started Analyzer - DSA
- d1 14:18:55 Analyzer Montage Changed - DSA
- d1 14:18:57 Video Recording ON
- d1 14:20:03 Analyzer Montage Changed - DSA
- d1 14:20:30 Impedance at 10 kOhm
- d1 14:20:42 eo/ec on routine
- d1 14:20:44 HA monitoring
- d1 14:21:01 tap test on routine
- d1 14:21:08 event button test on routine
- d1 14:21:24 echo with pt
- d1 14:21:41 LD signing out
- d1 14:22:21 generalized slowing
- d1 14:24:54 no event
- d1 14:29:15 periods of discontinuity

All Events

- Information Notes
- Comments
- Calibration
- Channels On/Off
- Clips
- Gain/Filter Change
- Review Gain/Filter Change
- Impedance Check
- Montage
- Review Montage

All Filtered EEG SZ ONSET



Comprehensive MUSC - <-> 2.0 hr + Add Baseline A

P14 Trends, A

Artifact Intensity

Secure Probability (P14): 0-1

Secure Detections (P14): 0-1

Spike Detections, all for (count per sec): 0-3

Spikes => 3 per ten seconds (blue=left, red=right, yellow=L&R, green=generalized): 0-1

Power Spectrogram Left Hemisphere: 0-20 Hz

Power Spectrogram Right Hemisphere: 0-20 Hz

Rhythmogram Spectrogram Left Hemisphere: 1-20 Hz

Rhythmogram Spectrogram Right Hemisphere: 1-20 Hz

Asymmetry Relative Spectrogram Asym Hemi: 0-20 Hz

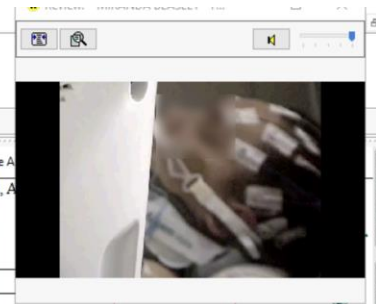
Asymmetry Absolute Index (EAS): 0-20 Hz Asym Hemi -50-50% Asymmetry Relative Index (REAS): 0-20 Hz Asym Hemi -50-50%

ASD: Left Hemisphere and Right Hemisphere

Peak Envelope: 2-20 Hz Left Hemisphere and Right Hemisphere: 0-100 uV

Heart Rate: 30-150 bpm

Timeline: 01:14:20, 01:14:40:22, 01:15:00:22, 01:15:20:22, 01:15:40:22, 01:16:00:22



Numeric Values
Comments
Electrode Signal Quality

Changes in Supplement since last meeting

- Additional Module in the Waveform PR:
 - Waveform Activation Module
(required for the recording use case)
- Edits in definition of Temporal Range Macro
- Cleaned up the document, esp. open / closed issues