

EEG

Understanding, interpretation and clinical implications

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Limitations

- Somatics Thymatron IV is used in Norway
 - No experience with MECTA
- EEG-recording basically similar, quality parameters calculated by Thymatron and MECTA vary.
- Thymatron provides a number of parameters, such as ASEI, PSI, MSP and COH, we have chosen to focus mainly on PSI in our ECT-suites.
- While interpreting the EEG during the course, we do not observe the patient (seizure, cough, blinking)

What is the EEG?

- The EEG records cortical electrical activity between two electrodes on the scalp.
- Thymatron (and MECTA) offers a *simplified* EEG
- To obtain a satisfactory EEG recording we
 - Make sure that all recording electrodes are properly attached to skin
 - Measure BASELINE – EEG prior to treatment
 - This ensures that a proper ictal line is recorded which is a prerequisite for the device's interpretation of the seizure

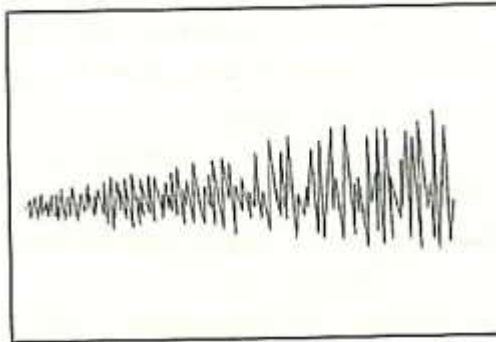
Why record EEG?

- Because
 - Subconvulsive stimulation is identified
 - Unilateral seizures (not generalized) are identified
 - Confirms that seizure has ended
- It is a question of time!
 - EEG duration appr 10% longer than the motor seizure
 - Short seizures are ineffective
 - Very long seizures won't give an additional therapeutic benefit
 - Prolonged seizures may indicate partial status epileptic
- The morphology of the EEG may assist us in dosing strategies and electrode placement

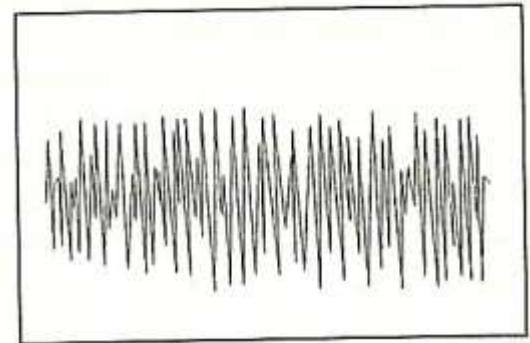
EEG patterns

EEG-
appearance
vary. Look for
rhythmic
discharges
alternating
between sharp
spikes and
round waves

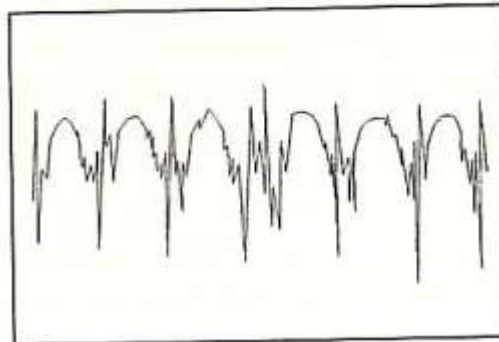
EEG Seizure Phase 1
Buildup (Recruitment)



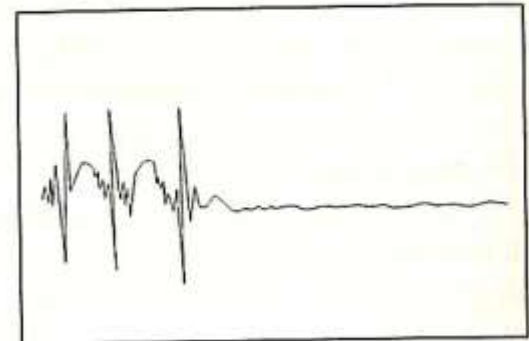
EEG Seizure Phase 2
Hypersynchronous Polyspikes (Tonus)



EEG Seizure Phase 3
Polyspike-and-Slow Wave (Clonus)



EEG Seizure Phase 4
Suppression (Electrical Silence)



From Abrams, R. Electroconvulsive therapy, 2002

How to interpret EEG

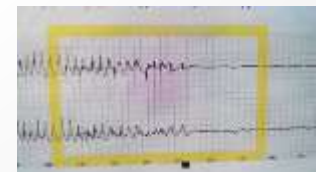
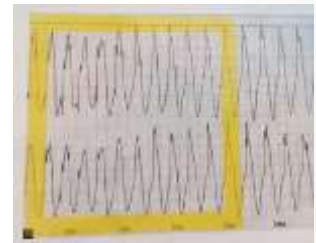
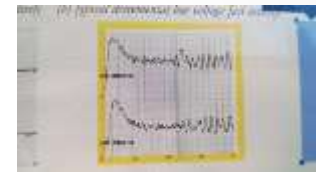
- Abrams 2002
 - Emphasizes three important EEG criteria that indicates good seizure quality
- Semple 2016
 - Describes the typical five phases of the EEG
- Bergsholm/Kessler 2010
 - Quantifies three core phases of the EEG
- Five steps to interpret EEG
- Rule of thumb: Get the whole picture, not the details!

Abrams 2002

- Mid-ictal spike-and-wave activity (3-5 Hz)
- Satisfactory postictal suppression
- Symmetry over the hemispheres

Semple 2016

- Phase 1: Pre-polyspike electrodecremental phase
- Phase 2: Polyspike
- Phase 3: Teta and delta wave activity
 - Includes polyspike and wave
- Phase 4: Seizure termination
- Phase 5: Postictal suppression



Quantifying the EEG (Kessler/Bergsholm 2010)

- Scoring from 1-3, sum 3-9, lowest is best

1. Delta waves:

1. Rythmic, coherent, large amplitude (> 1 cm)
2. Medium quality
3. Arythmic, incoherent, small amplitude

2. Seizure termination:

1. Marked termination
2. Gradual transition, although definite termination
3. Termination unclear

3. Postictal suppression

1. Almost complete, flat line (electrical «silence»)
2. Clearly more suppressed than before termination
3. No evident suppression

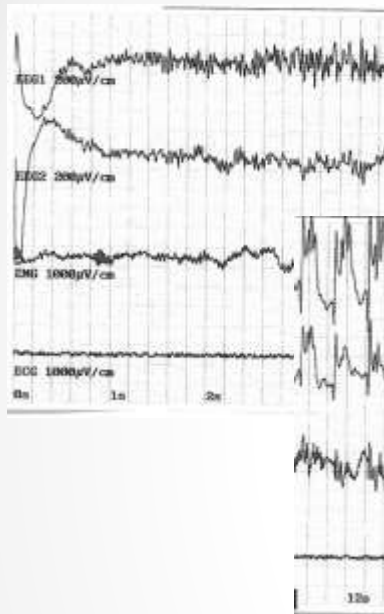
Five steps to EEG interpretation

1. Apparent spike and wave activation?
 1. Recruitment
 2. Mid-ictal spike-and-wave phase
 3. Satisfactory amplitude
2. Bilateral, symmetric activation?
 1. Frequency 3-5 Hz
3. Is duration satisfactory
 1. EEG before termination > 25 seconds
4. Is seizure terminated?
 1. Make sure seizure is terminated before removing electrodes
 2. Consider possibility for partial epileptic status
5. Is PSI satisfactory?
 1. Should be more than 70%

RCPsych 2013

- EEG is essential, but there are no specific features (...) which can establish whether a seizure actually has produced benefit for the patient
- The ECT team treats the patient, not the EEG
- Thus, interpreting the EEG may only give us a hint of whether treatment was successful or not

Print-out

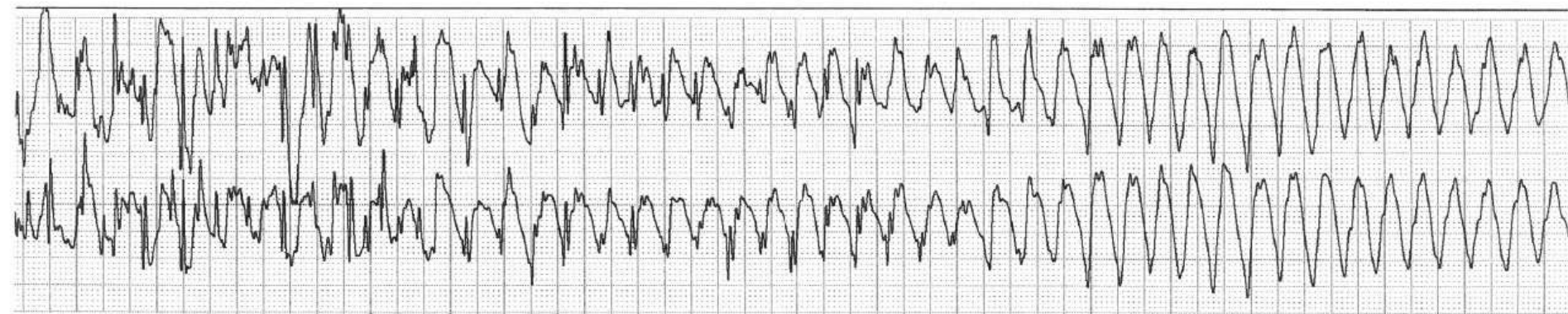
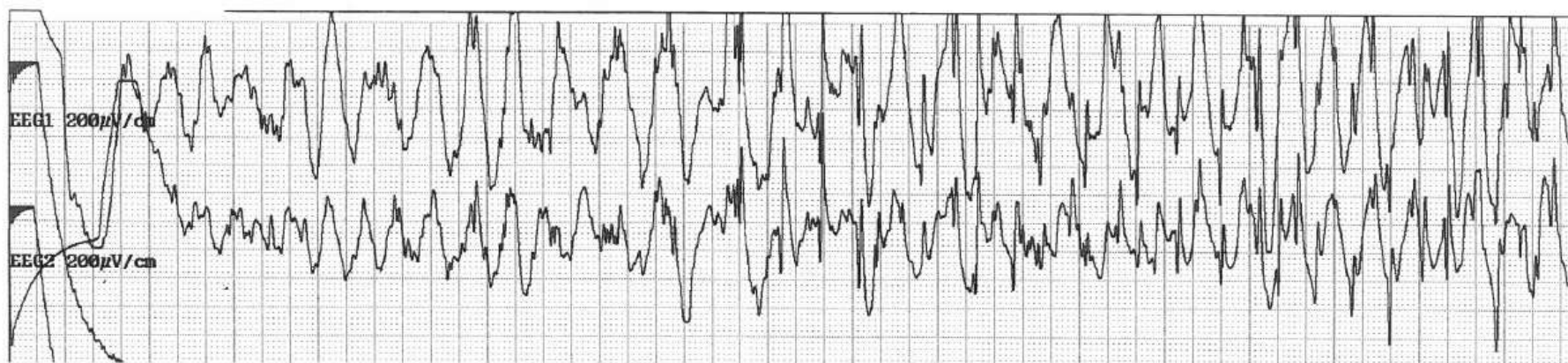


Thymatron System IV S/N: 41717
 22/09/10 08:48:47
 % Energy Set..... 45 %
 Charge Delivered..... 226.5 mC
 Current..... 0.90 A
 Stimulus Duration..... 2.5 Sec
 Frequency..... 50 Hz
 Pulse Width..... 1.00 mSec
 Static Impedance..... 1610 Ohm
 Dynamic Impedance..... 270 Ohm
 EEG Endpoint..... 31 Sec
 EMG Endpoint..... 23 Sec
 Base Heart Rate..... N/A
 Peak Heart Rate..... N/A
 Average Seizure Energy Index.. 7603.7 μV^2
 Postictal Suppression Index... 78.5 %
 Maximum Sustained Power..... 14386.5 μV
 Time to Peak Power..... 15 Sec
 Maximum Sustained Coherence... 89.7 %
 Time to Peak Coherence..... 22 Sec

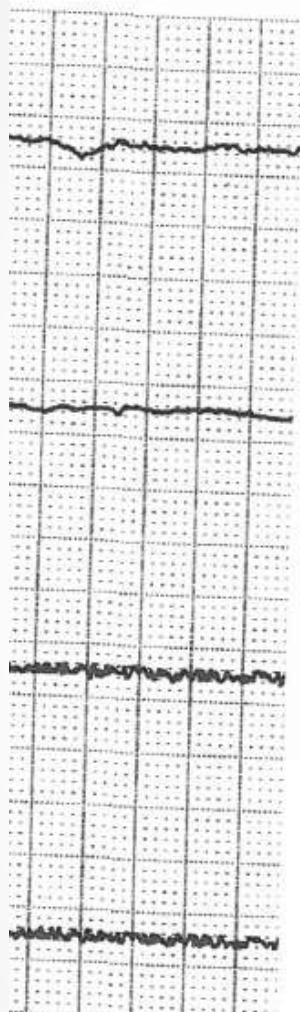


Program Selected: DGX

1. Spike and wave? 2. Bilateral activation? 3. Duration OK? 4. Seizure terminated? 5. PSI OK?



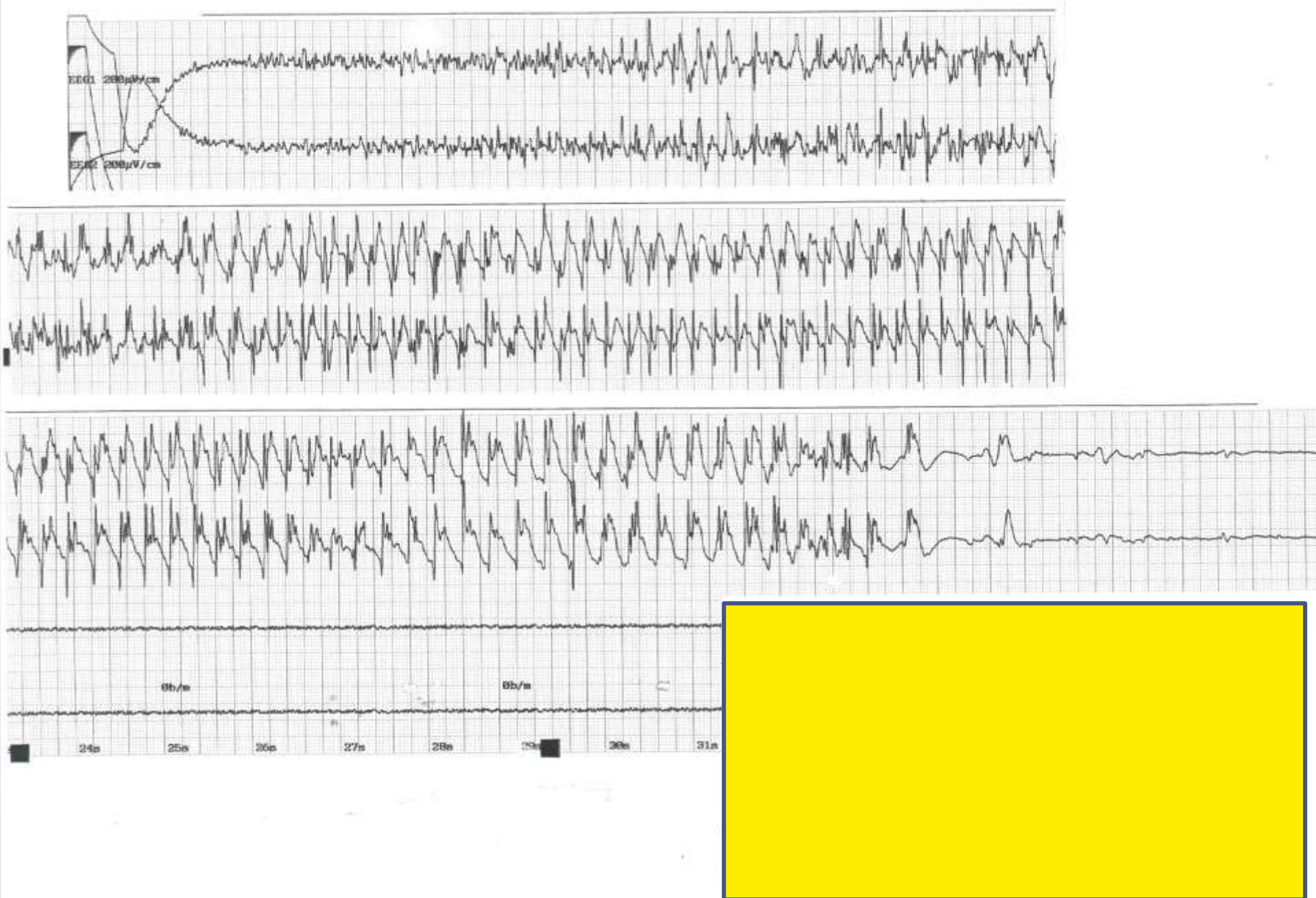
1. Spike and wave? 2. Bilateral activation? 3. Duration OK? 4. Seizure terminated? 5. PSI OK?



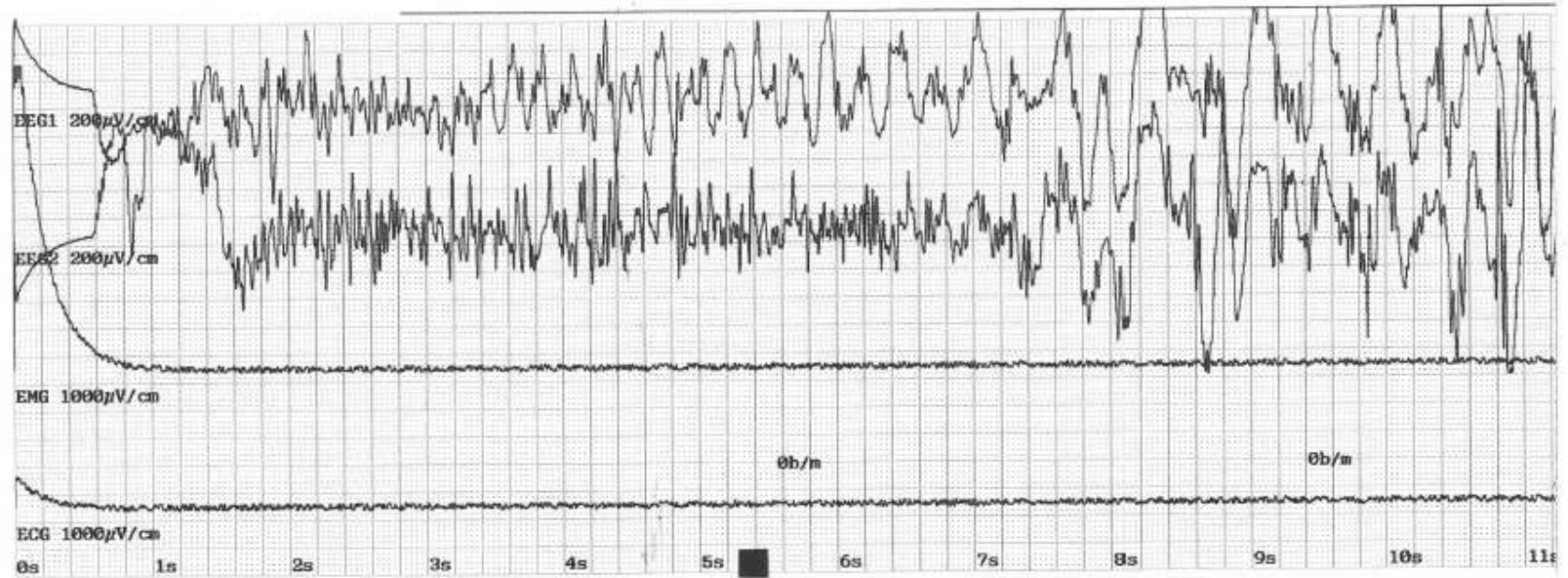
Sykehuset Innlandet HF - Sanderud
30/09/15 08:12:22

% Energy Set.....	50 %
Charge Delivered.....	254.5 mC
Current.....	0.91 A
Stimulus Duration.....	2.8 Sec
Frequency.....	50 Hz
Pulse Width.....	1.00 mSec
Static Impedance.....	1380 Ohm
Dynamic Impedance.....	260 Ohm
EEG Endpoint.....	29 Sec
EMG Endpoint.....	N/A
Base Heart Rate.....	N/A
Peak Heart Rate.....	N/A
Average Seizure Energy Index..	19003.2 μ V2
Postictal Suppression Index...	88.5 %
Maximum Sustained Power.....	27430.3 μ V2
Time to Peak Power.....	9 Sec
Maximum Sustained Coherence...	94.2 %
Time to Peak Coherence.....	24 Sec

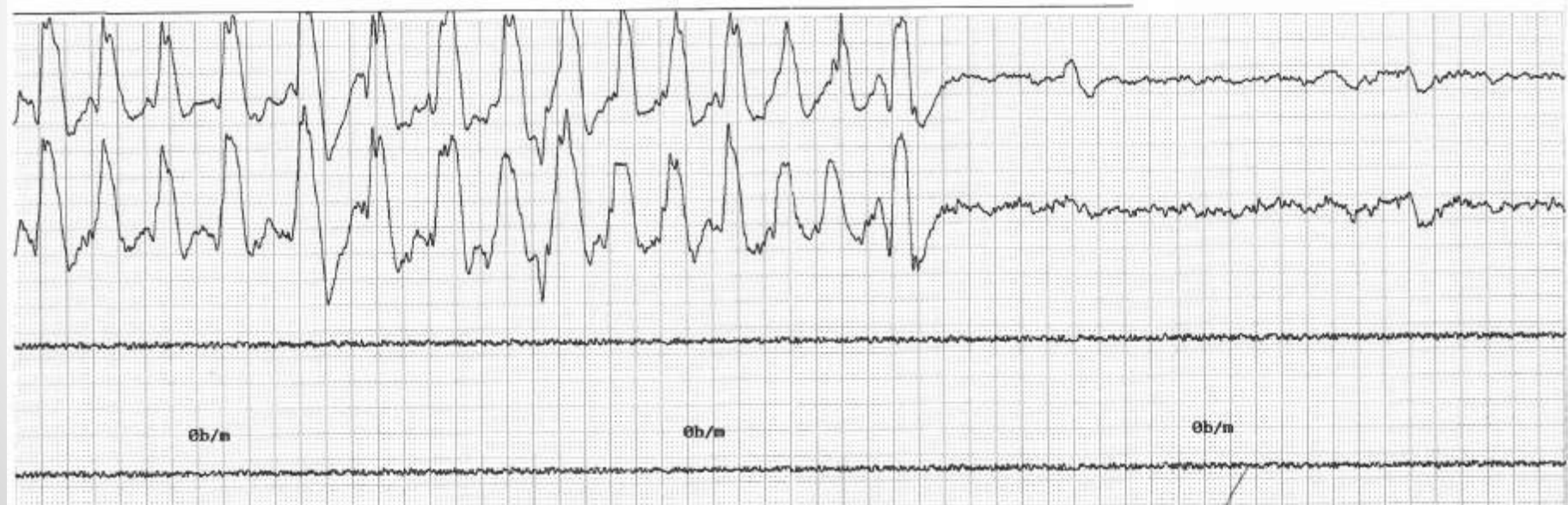
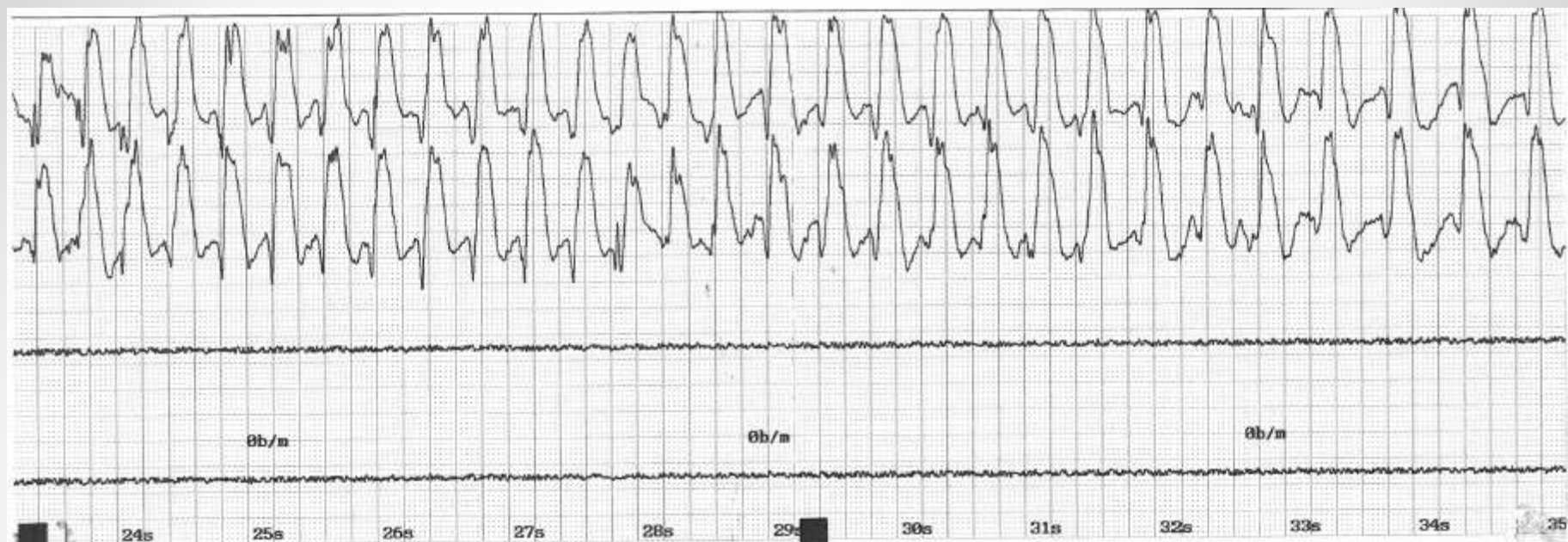
Program Selected: DGX



1. Spike and wave? 2. Bilateral activation? 3. Duration OK? 4. Seizure terminated? 5. PSI OK?



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Sykehuset Innlandet HF - Sanderud

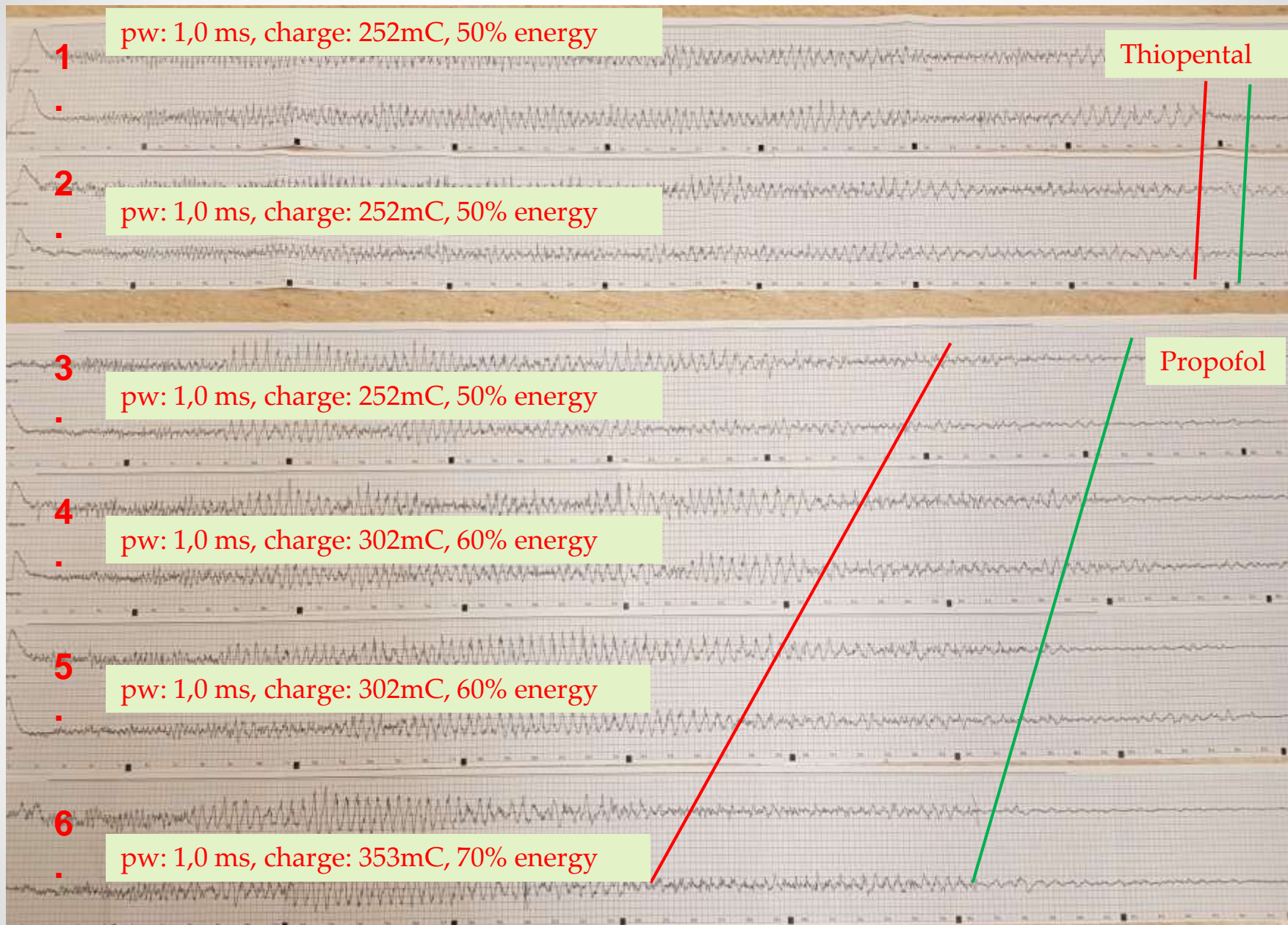
13/01/16 08:29:33

% Energy Set.....	30 %
Charge Delivered.....	153.4 mC
Current.....	0.91 A
Stimulus Duration.....	1.7 Sec
Frequency.....	50 Hz
Pulse Width.....	1.00 mSec
Static Impedance.....	1370 Ohm
Dynamic Impedance.....	230 Ohm
EEG Endpoint.....	42 Sec
EMG Endpoint.....	N/A
Base Heart Rate.....	N/A
Peak Heart Rate.....	12 b/m
Average Seizure Energy Index..	28685.5 μV^2
Postictal Suppression Index...	90.0 %
Maximum Sustained Power.....	51636.3 μV^2
Time to Peak Power.....	13 Sec
Maximum Sustained Coherence...	98.1 %
Time to Peak Coherence.....	32 Sec

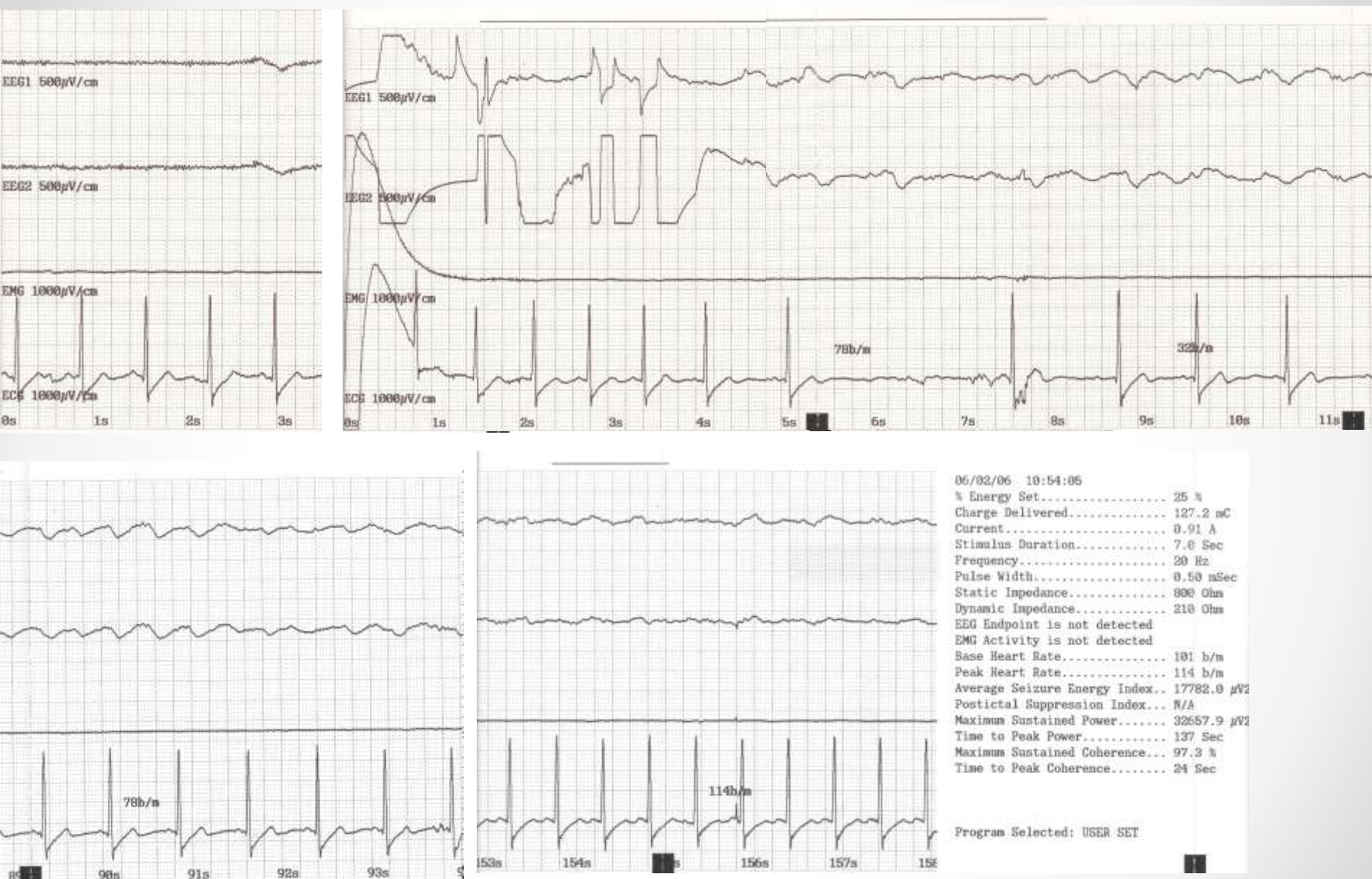
Program Selected: DGX

Avoiding problems with parameters

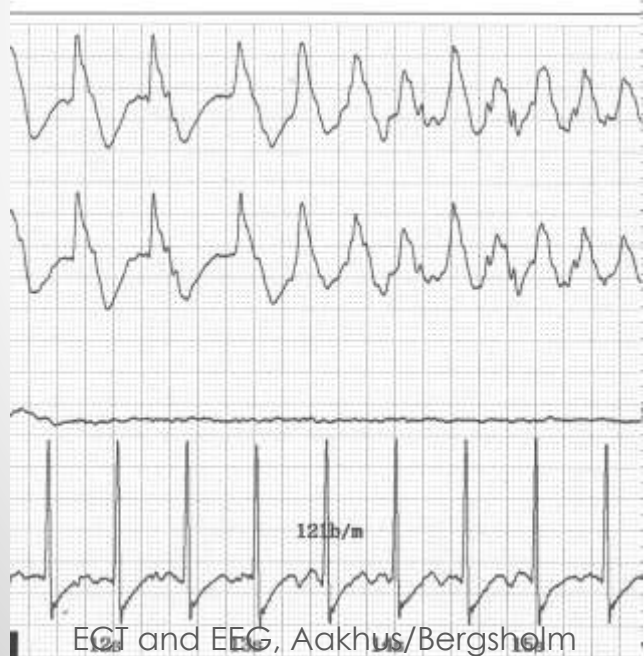
- Don't stop print-out unless you're sure seizure is terminated
 - Thymatron IV requires at least 5 secs registration after termination of the ictal line to calculate quality parameters
- NB! >10 secs continuous ictal registration to calculate EEG/EMG duration and PSI.
- Make sure that electrodes are firmly attached, and no cord damages
- Avoid using dried up electrodes
- Does anaesthesia or other medication contribute to poor print-out?



Woman 28. Dysphoric mania, long-lasting, near psychotic. **EEG seizure inhibited by lamotrigine**



Woman 28 yrs. Dysphoric mania. EEG seizure less inhibited 2 days after withdrawal of lamotrigine



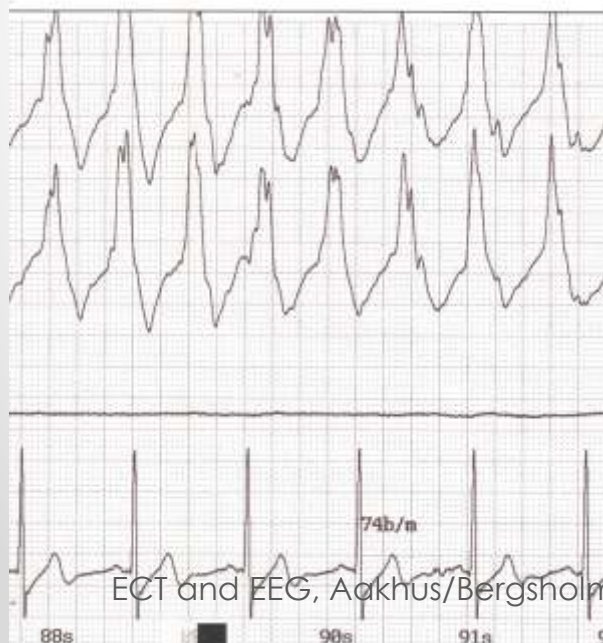
ECT and EEG, Aakhus/Bergsholm

Woman 28. Dysphoric mania. EEG better 4 days after withdrawal of lamotrigine



10/02/06 10:41:51

% Energy Set.....	50 %
Charge Delivered.....	247.7 mC
Current.....	0.88 A
Stimulus Duration.....	7.0 Sec
Frequency.....	40 Hz
Pulse Width.....	0.50 mSec
Static Impedance.....	1600 Ohm
Dynamic Impedance.....	330 Ohm
EEG Endpoint is not detected	
EMG Endpoint.....	14 Sec
Base Heart Rate.....	87 b/m
Peak Heart Rate.....	110 b/m
Average Seizure Energy Index..	13965.6 µV2
Postictal Suppression Index...	N/A
Maximum Sustained Power.....	29122.3 µV2
Time to Peak Power.....	6 Sec
Maximum Sustained Coherence...	99.0 %
Time to Peak Coherence.....	88 Sec



ECT and EEG, Aarhus/Bergsholm



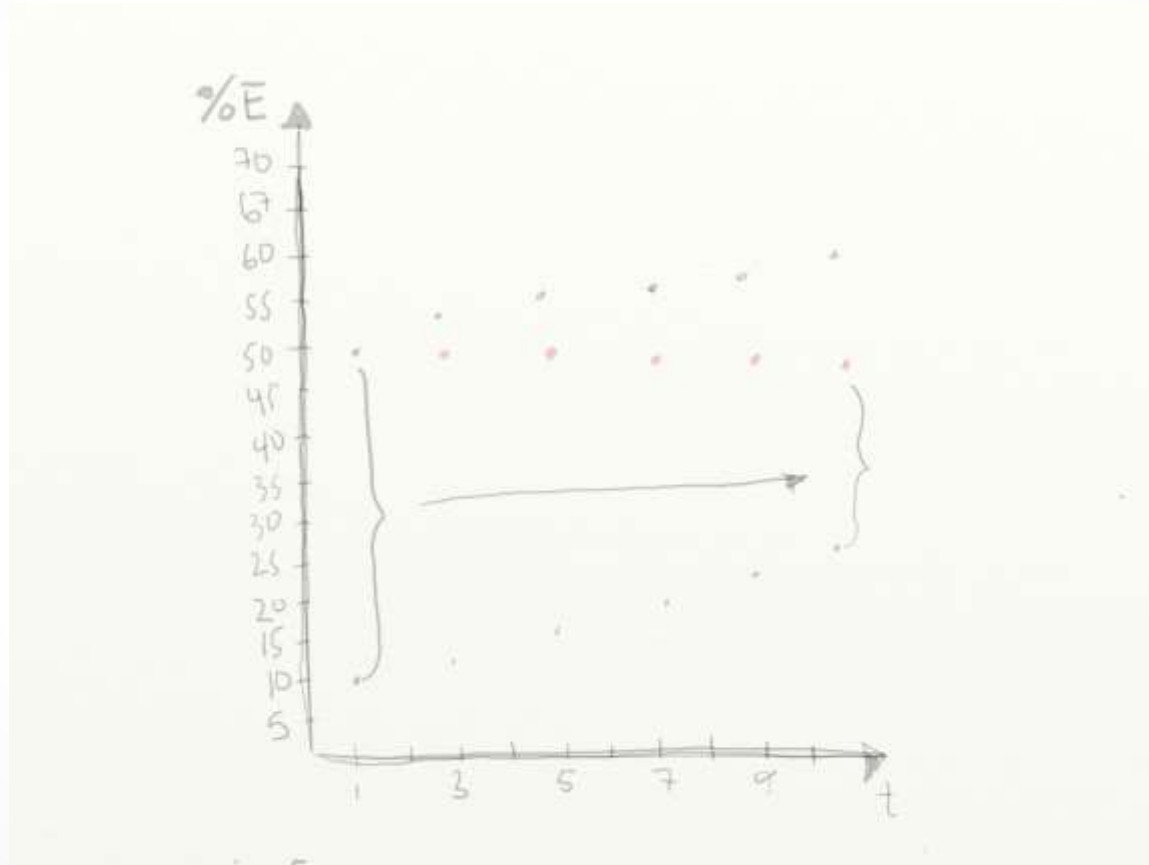
Some end-point errors (Thymatron IV)

- Baseline not available
 - Did not wait for «ready» after measuring Baseline
- EEG endpoint not available
 - Did not wait sufficiently long after ictal line (5-6 secs)
- EEG activity not detected
 - Insufficient EEG-activity(subthreshold)
 - Frontal EEG electrodes too close
 - Mechanical problems (loose electrodes, breakage)
- Seizure not detected
 - Thymatron requires a continuous registration of at least 10 seconds to acknowledge that a seizure has occurred

Typical observation

Treatment #	Charge (%E/mC)	EEG (secs)	PSI (%)
1	50 (252)	45	72
2	50	44	70
3	50	32	70
4	55 (277,2)	29	50
5	55	26	55
6	???		

Possible explanation



Clinical implications

- EEG duration is reduced during a course of ECT
 - Increased seizure threshold? Medication?
 - Expect to increase electrical dosage
- EEG quality may be worse in older patients or patients with CNS disease og polypharmacy
- To improve duration or morphology, consider:
 - Increasing electrical dosage or
 - Reduce or change anaesthetics or add shortacting opiate
 - Review patient's medication
 - Benzodiazepines, antiepileptics including lamotrigine and pregabalin/gabapentin
- Treat the patient, not the EEG!

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