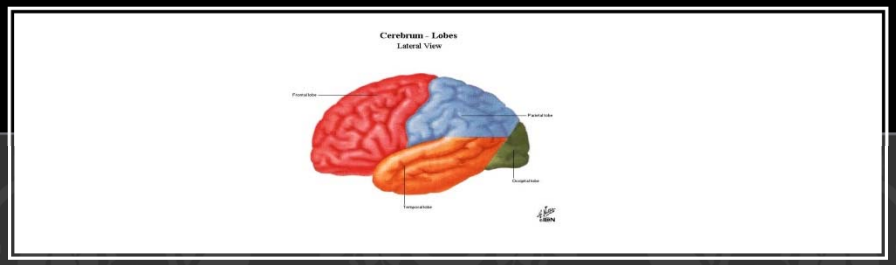
# EEG IN IOM




David Betts,
R.EEG/EP T.,CNIM, CLTM, R.NCS T., CNCT
Beaumont Health System

# TOPICS

**Relationship of cerebral metabolism to surface EEG**

**Gross arterial blood supply**

**Indications for EEG in surgery**

**Value of EEG in OR**

**Effect of anesthesia on EEG**

**Mechanism of cortical damage**

# TOPICS

**Derived EEG display – CSA**

**EEG signs of cortical distress**

**EEG revealing depth of anesthesia for neuroprotection**

**Adaptation for OR use - technique**

Not discussing
direct cortical recording
in this presentation
nor the use of EEG in BIS or Entropy
anesthesia monitors

# Neuron Metabolism

- Constant need for glucose and oxygen
- Brain 2% of body weight,

  20% of O2 consumption

  25% of glucose consumption

Cerebral Blood Flow (CBF) 57ml per 100g of brain weight per minute

P. Magistretti, Fundamental Neuroscience (1999). Chapter 14 p. 389

# Mechanism Of Cortical Activity Resulting In EEG Waveforms

EEG is reflective of post-synapic ion fluctuations in the outer radially orientated neurons

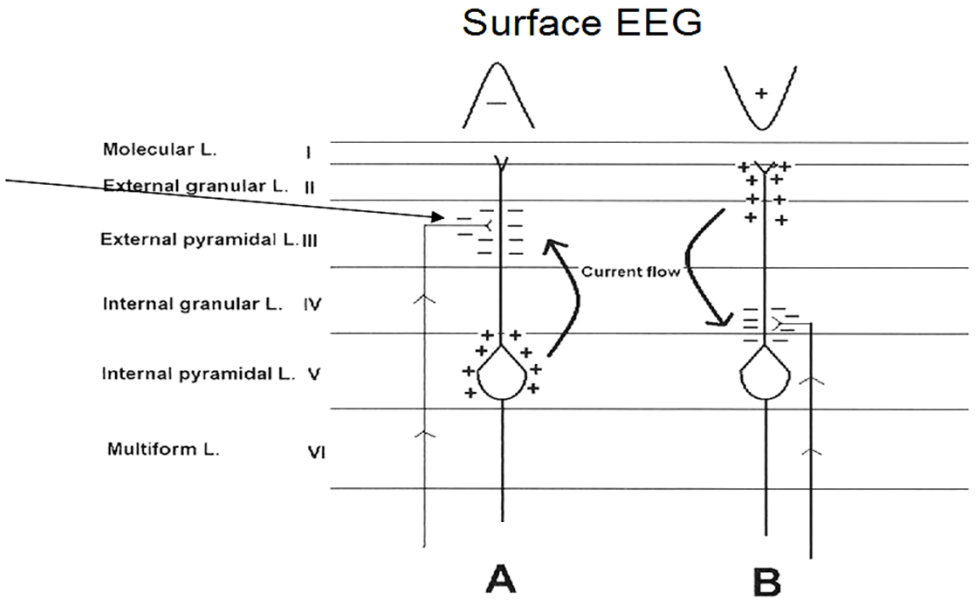
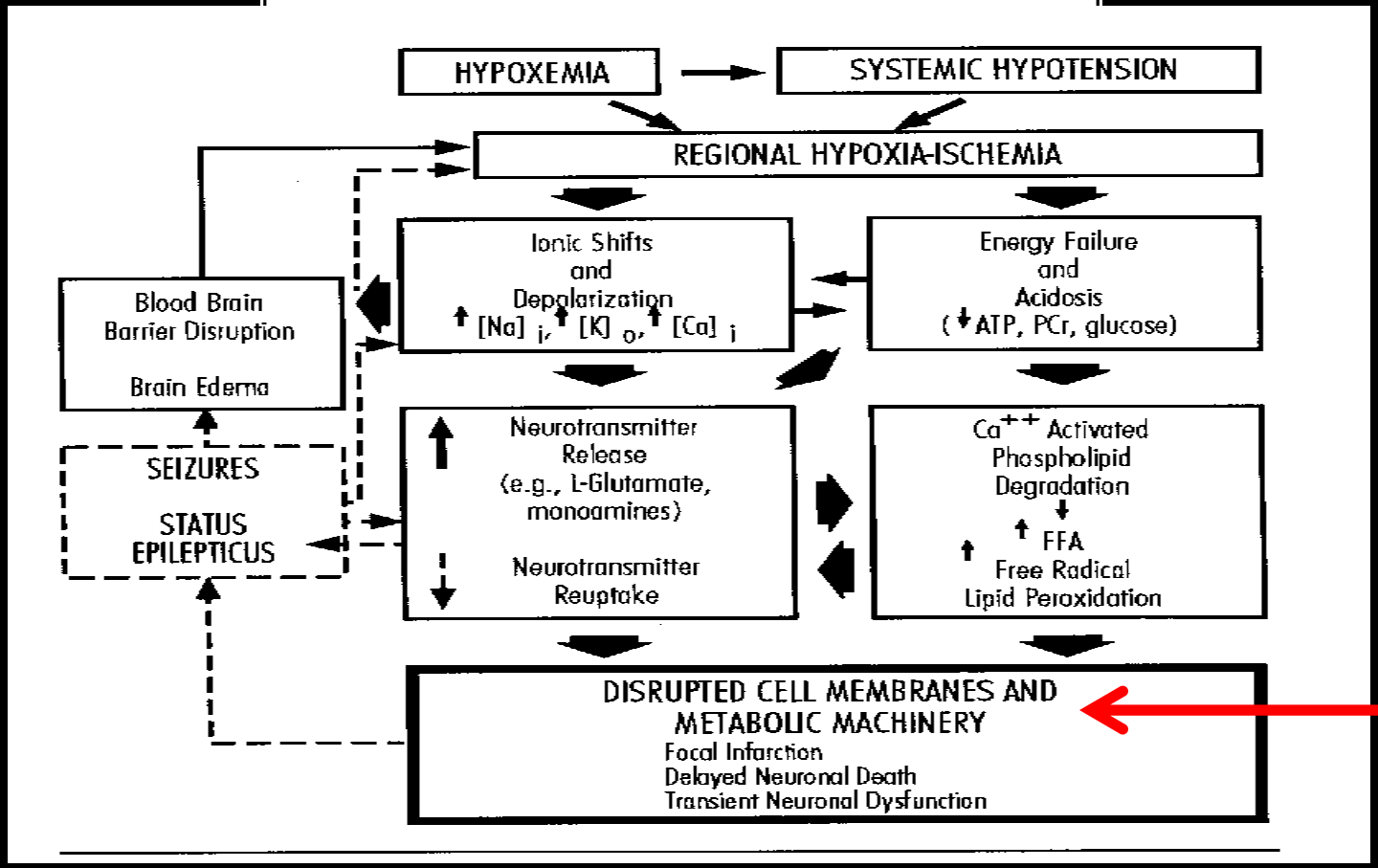



**Figure 5-26.** Schematic model of cortical activity (polarity) in relation to cellular activity. Note the polarity of surface cortical activity is dependent upon the depth of the source and sink of the current flow. In **A,** thalamo-cortical input enter superficial layer of the cortex, while in **B,** it enters into deeper layer of the cortex.

Practical Guide for Clinical Neurophysiologic Testing, Yamada & Meng

# HYPOXEMIA




www.nichd.nih.gov/.../pubs/acute/acute.cfm

## REFRESH TERMINOLOGY

α alpha 8-12 Hz

β beta 13 Hz and above

θ theta 4-7 Hz

δ delta 3 Hz and below

Burst suppression = electrical inactivity punctuated by brief (1-4 seconds) of paroxysmal EEG activity.

# RELATIONSHIP BETWEEN EEG ACTIVITY AND PERFUSION

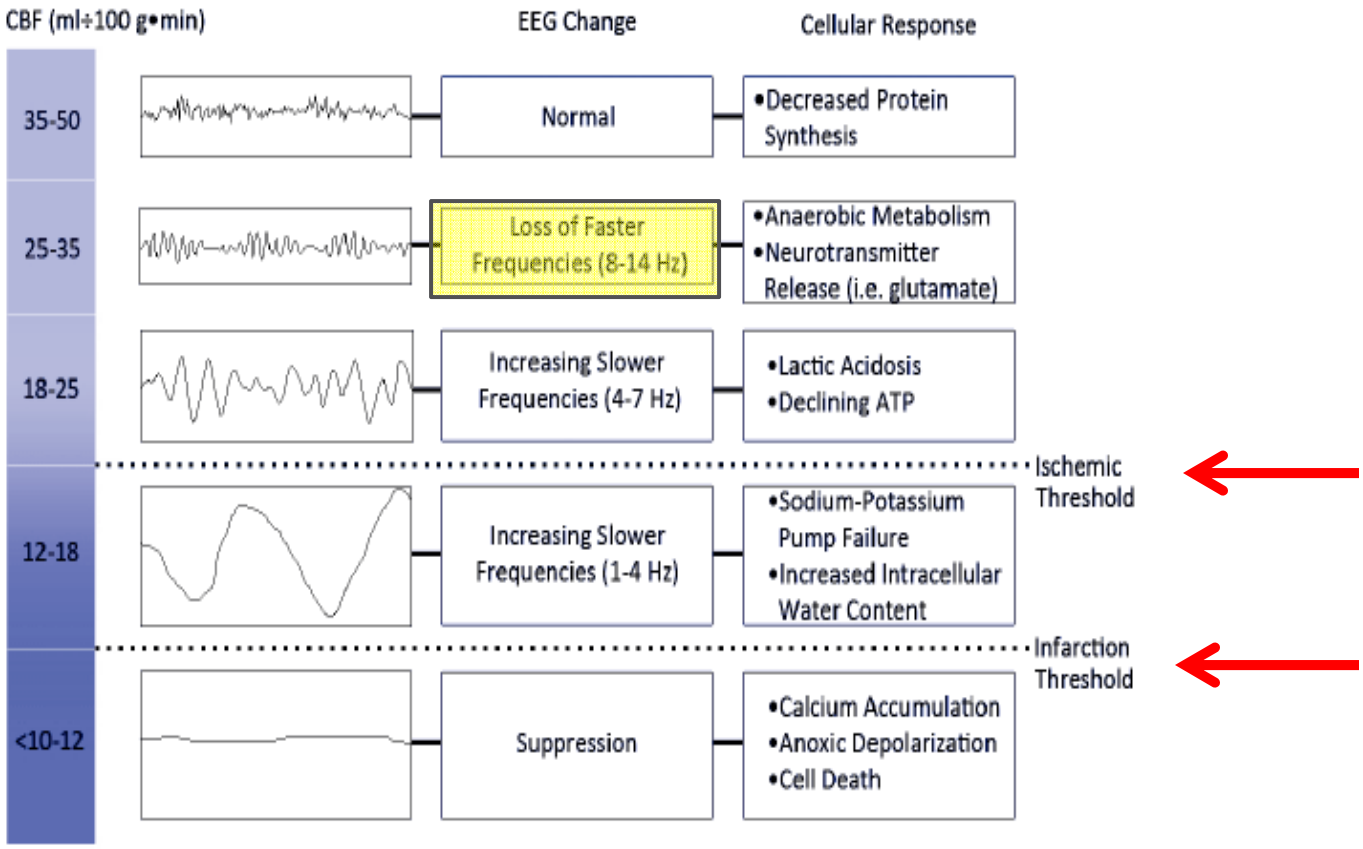



**Figure 1. The relationship of cerebral blood flow to electroencephalogram (EEG) and pathophysiology.** ATP, adenosine triphosphate (CBF). Data from [2,4].

Foreman and Claassen *Critical Care* 2012, 16:216
http://ccforum.com/content/16/2/216

# EEG FEATURES OF ISCHEMIA

"The most common and sensitive analog EEG change is attenuation of anesthetic-induced, fast activity (low beta, high alpha), which occurs in 14-47% of the patients following carotid cross-clamping [41, 42]. Increased delta activity is almost always associated with decreased amplitudes of higher frequency activity."

ASNM Guideline IOM using EEG, V4.2

# DEGREES OF CHANGE

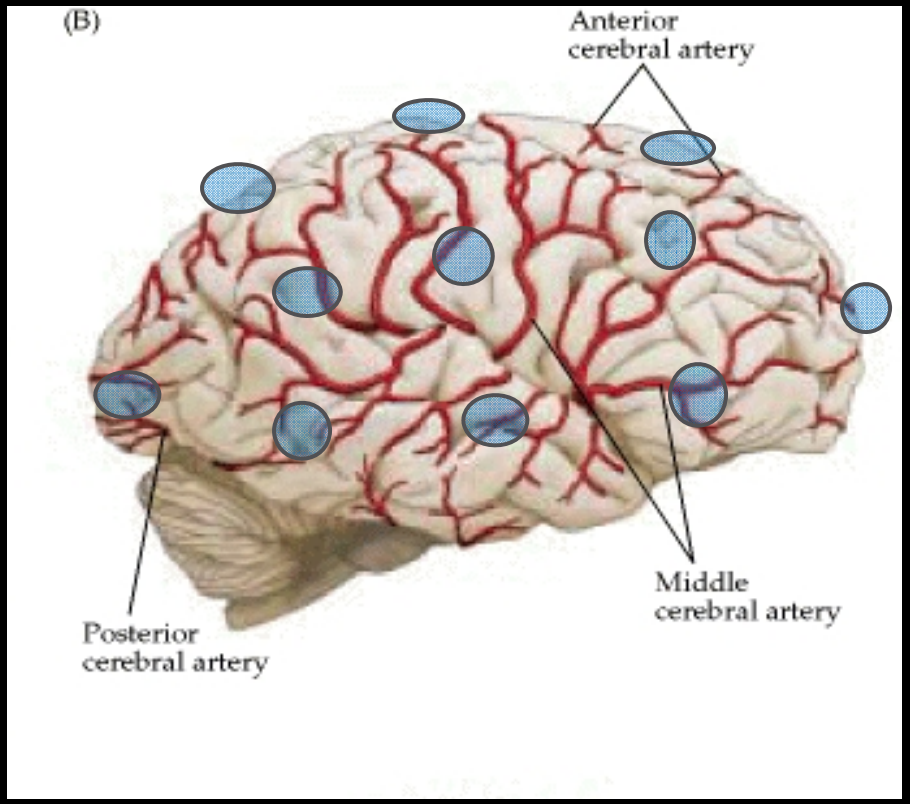
ACNS's intraoperative EEG guidelines (2000) defined three degrees of EEG changes caused by ischemia:

1) the first degree--a decrease in background fast activity, most apparent when using anesthetic agents that generate such fast activity (the diminution is considered significant if it exceeds 50-60 % of baseline),

2) the second degree--an increase in slow (delta-theta) which should be considered clinically significant if it exceeds 50% of baseline (a decrease in fast activity may be simultaneous)

3) the third degree--all EEG activity progressively diminishes in amplitude and approaches iso-electricity

# GROSS ARTERIAL DISTRIBUTION IN RELATIONSHIP TO EEG LEADS




Neuroscience. 2nd edition.
Purves D, Augustine GJ, Fitzpatrick D, et al., editors.
Sunderland (MA): Sinauer Associates; 2001.

Approximate locations in relationship to surface EEG.

## Anterior Cerebral

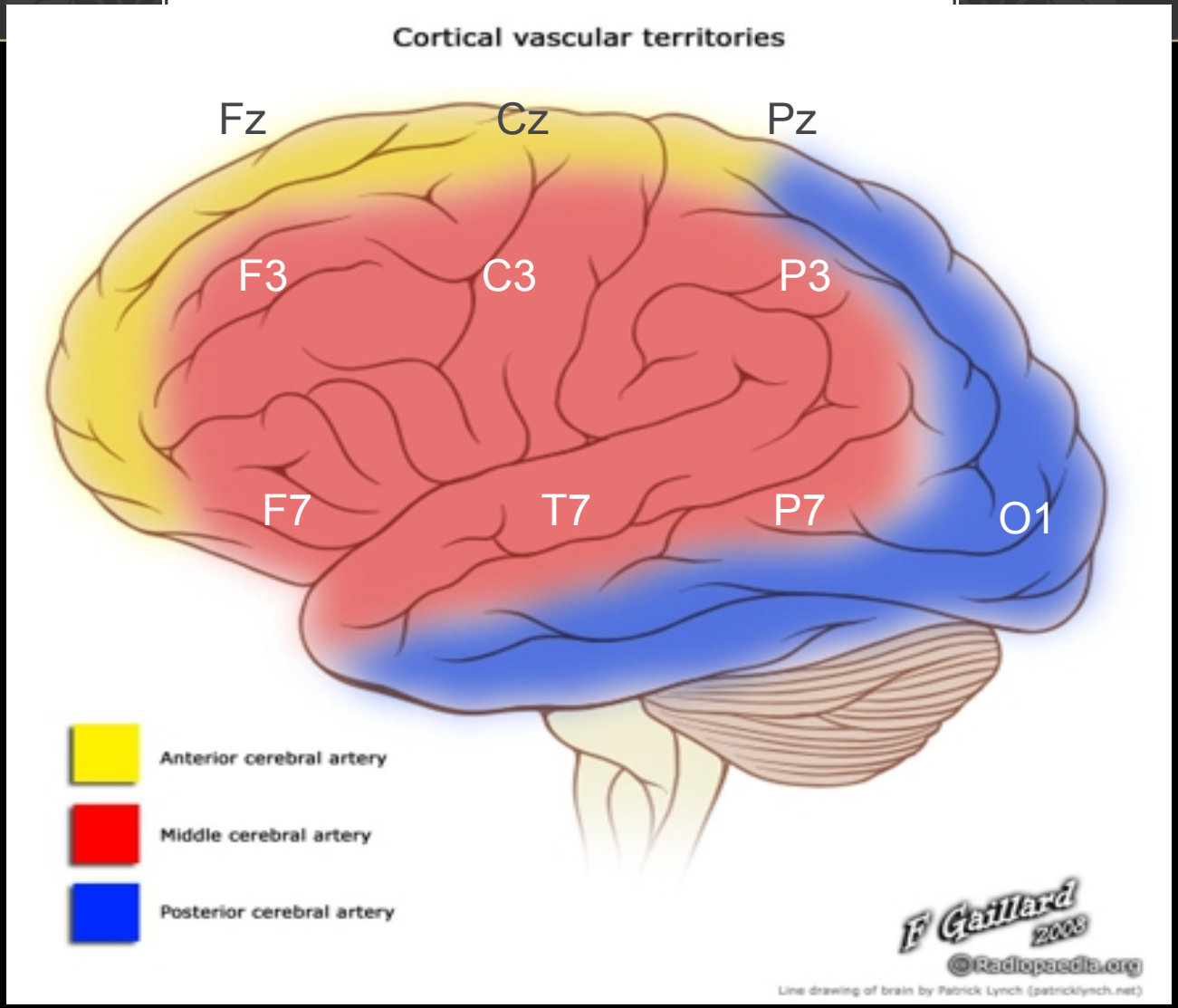
Artery – FZ, CZ

## Middle cerebral

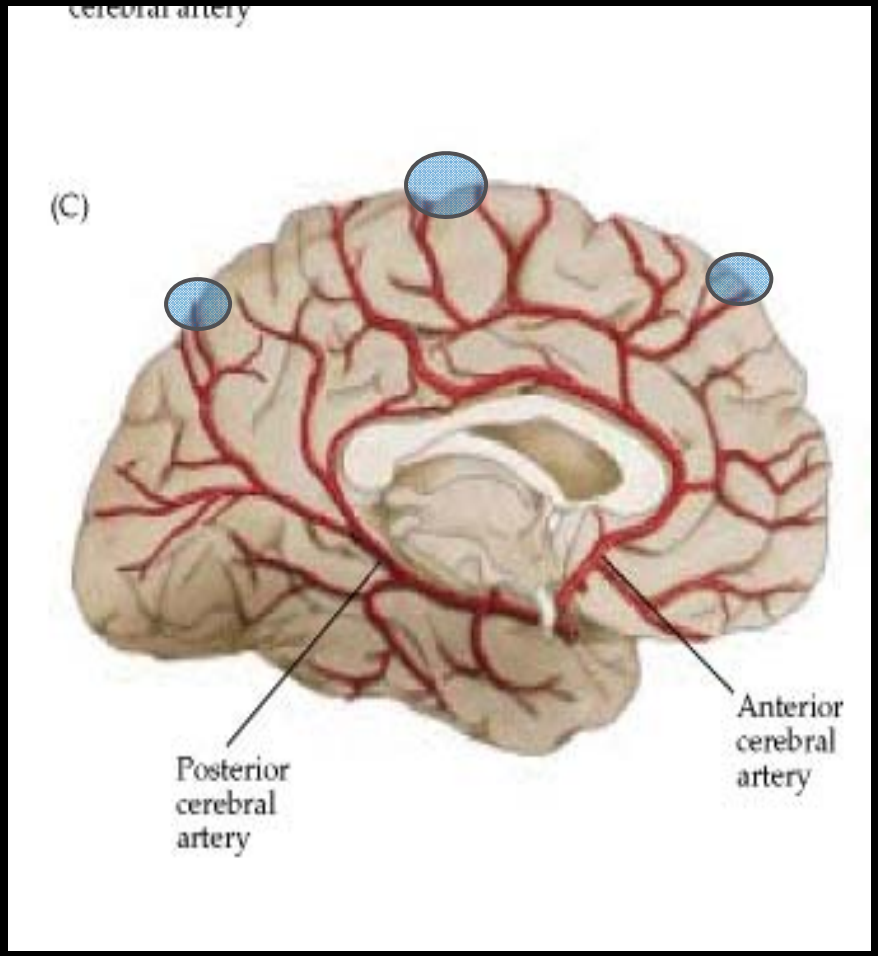
Fpz, F3,4 C3,4, P3,4
F7,8 T7,8, P7,8

## Posterior cerebral

O1,2


Cortical vascular territories
Fz
Cz
Pz
F3
C3
P3
F7
T7
P7
O1
Anterior cerebral artery
Middle cerebral artery
Posterior cerebral artery
F Gaillard 2008
©Radiopaedia.org
Line drawing of brain by Patrick Lynch (patricklynch.net)

# MEDIAL VIEW – BLOOD SUPPLY




Note that

anterior

cerebral artery is mostly medial brain and along the vertex.

## TO USE EEG OR NOT TO USE IN SURGERY

EEG is a good indicator of cortical neurological activity, BUT does that translate in to usefulness in surgery?

The evidence is not conclusive.

What works in rats doesn't mean routine human use.

# INDICATIONS FOR EEG IN SURGERY

Why some use EEG.

## Carotid Endarterectomy (CEA)

*Results:* The mean reported perioperative stroke rate for CEAs with routine shunting was 1.4% and for routine nonshunt was 2%. Meanwhile, the mean perioperative stroke rates for selecting shunting were **1.6% using EEG**, 4.8% using TCD, 1.6% using SP, 1.8% using SSEP, and **1.1% for CBA [regional anesthesia]**. Similar results were noted for perioperative stroke and death rates. *Conclusions:* The use of routine shunting and selective shunting was associated with a low stroke rate. Both methods are acceptable, and the individual surgeon should select the method with which they are more comfortable. **( J Vasc Surg 2011;54:1502-10.) Ali F. AbuRahma, MD, Albeir Y. Mousa, MD, and Patrick A. Stone, MD,**

## INDICATIONS FOR EEG IN SURGERY

### OTHER POSSIBILIES

# Tumor resection near major arteries

Unintentional occlusion of artery

# Cerebral aneurysm clipping

Gage anesthesia for "Burst suppression"

Inadvertent clipping supply to brain

# Neuroprotection

Drug induced coma

Hypothermia

# INDICATIONS FOR EEG IN SURGERY

## Neuroprotection

### Hypothermia

"We included four trials of cooling for cerebral protection during brain surgery, involving a total of 1219 patients. We did not find any evidence that hypothermia for neuroprotection in patients undergoing brain surgery is either effective or unsafe when compared to normothermia".

**Cooling for cerebral protection during brain surgery**

Wilson Roberto Oliveira Milani[1,*],

Pedro L Antibas[1],

Gilmar F Prado[2]

Published Online: 5 OCT 2011 Cochrane Reviews

# INDICATIONS FOR EEG IN SURGERY

## Neuroprotection

Drugs

Electroencephalographic burst suppression surgery with propofol during cardiac valve replacement did not significantly reduce the incidence or severity of neurologic or neuropsychologic dysfunction. The authors' results suggest that neither cerebral metabolic suppression nor reduction in cerebral blood flow reliably provide neuroprotection during open heart surgery.

Anesthesiology. 1999 May;90(5):1255-64.

**Ineffectiveness of burst suppression therapy in mitigating perioperative cerebrovascular dysfunction. Multicenter Study of Perioperative Ischemia (McSPI) Research Group.**

Roach GW, Newman MF, Murkin JM, Martzke J, Ruskin A, Li J, Guo A, Wisniewski A, Mangano DT.

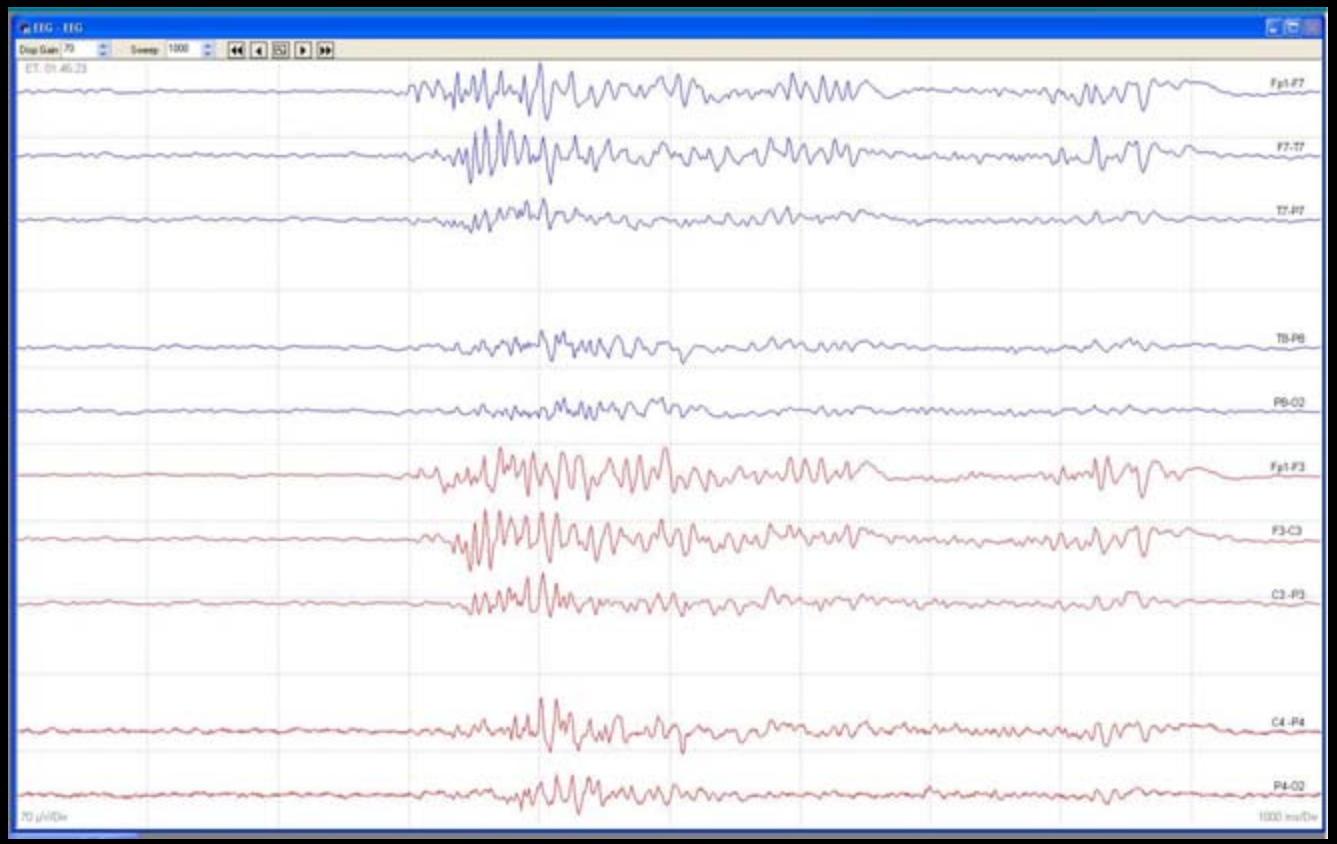
Ischemia Research and Education Foundation, San Francisco, California, USA. dtb@crucis.iref.org

**IF YOU ARE ASKED:**

# DESPITE THE FOREGOING CONSIDER THE TECHNICAL ASPECTS OF DOING EEG IN OR

# Anesthesia effects on EEG

# LOOKING SOLELY AT EEG, THE EFFECTS OF ANESTHETIC DRUGS CAN MIMIC GLOBAL HYPOXIA.



# ANESTHETIC DRUG EFFECTS ON EEG

Adapted from Black S, Mahla ME, Cucchiara RF. Neurologic Monitoring. In RD Miller. (ed). Anesthesia. New York: Churchill Livingston, 1994:1323.

Found on Epilepsy.com/Professionals

# GAS

## Isoflurane (Desflurane similar)

| | Effect on EEG Frequency | Effect in EEG Amplitude | Burst Suppression |
|---|---|---|---|
| | | | Yes, >1.5 MAC |
| Sub-anesthetic | Loss of α, ↑ frontal β | ↓ | |
| Anesthetic | Frontal 4- to 8-Hz activity | ↑ | |
| Increasing dose >1.5 MACDiffuse θ and δ → burst suppression → silence↑ → 0 | | | |

## Nitrous oxide (alone)

| | | |
|---|---|---|
| Frontal fast oscillatory activity (>30 Hz) | ↑, especially with inspired concentration >50% | No |

# IV ANESTHESIA DRUGS

## Barbiturates

| | Effect Frequency | Effect Amplitude | Burst Suppression |
|---|---|---|---|
| | | | Yes, with high doses |
| Low dose | Fast frontal β activity | Slight ↑ | |
| Moderate dose | Frontal α frequency spindles | ↑ | |
| Increasing high dose | Diffuse δ → burst suppression → silence | ↑↑↑ → 0 | |

## Etomidate

| | | | |
|---|---|---|---|
| | | | Yes, with high doses |
| Low dose | Fast frontal β activity | ↓ | |
| Moderate dose | Frontal α frequency | ↑ | |
| Increasing high dose | Diffuse δ → burst suppression → silence | ↑↑ → 0 | |

# IV ANESTHESIA DRUGS

## Benzodiazepines

| | Effect on EEG Frequency | Effect in EEG Amplitude | Burst Suppression |
|---|---|---|---|
| | | | **NO** |
| Low dose | Loss of α,<br>increased frontal β activity | ↓ | |
| High dose | Frontally dominant δ and θ | ↑ | |

# IV ANESTHESIA DRUGS

## Opiates

| | Effect on EEG Frequency | Effect in EEG Amplitude | Burst Suppression |
|---|---|---|---|
| | | | No |
| Low dose | Loss of β, α slows↔ | ↑ | |
| Moderate dose | Diffuse θ, some δ | ↑ | |
| High dose | δ, often synchronized | ↑↑ | |

# IV ANESTHESIA DRUGS

## Propofol

| Effect on EEG Frequency | Effect in EEG Amplitude | Burst | Suppression |
|---|---|---|---|
| | | | Yes |
| Low dose | Loss of α, ↑ frontal β | ↓ | |
| Moderate dose | Frontal δ, waxing-waning α | ↑ | |
| Increasing high dose | Diffuse δ → burst suppression → silence | ↑↑ → 0 | |

# IV ANESTHESIA DRUGS

## Ketamine

| | Effect on EEG Frequency | Effect in EEG Amplitude | Burst Suppression |
|---|---|---|---|
| | | | No |
| Low dose | Loss of α, ↑ variability | ↑ ↓ | |
| Moderate dose | Frontal rhythmic θ | ↑ | |
| High dose | Polymorphic δ, some β↑ | ↑ (β is low amplitude) | |

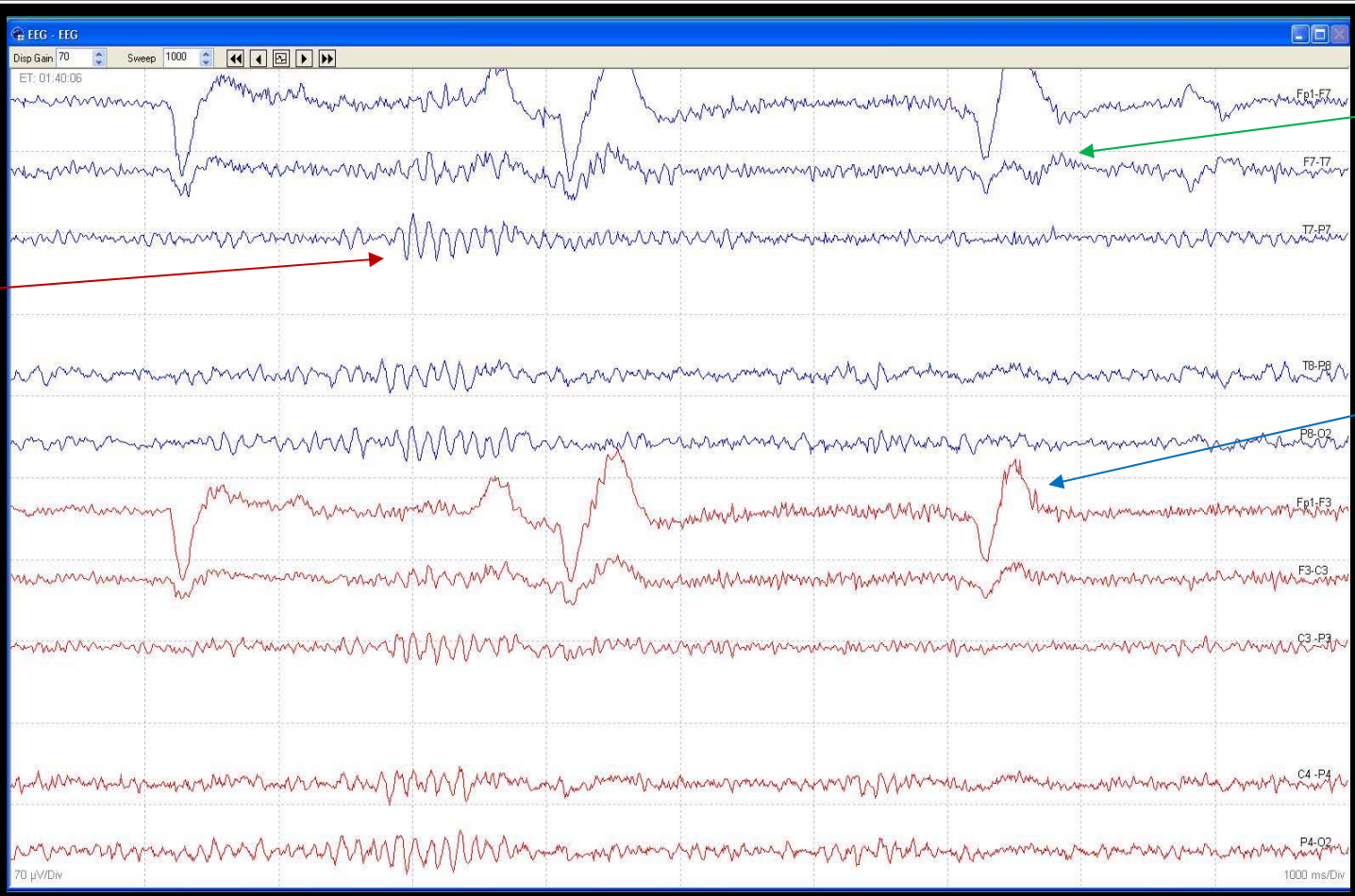
# EFFECT OF ANESTHESIA ON EEG DEMONSTRATED DURING INTUBATION

Starts with patient awake and proceeds to burst suppression

Right frontal leads omitted because that was the area of surgery.

O1 omitted in early recording because of artifact.

# AWAKE




Beta

alpha

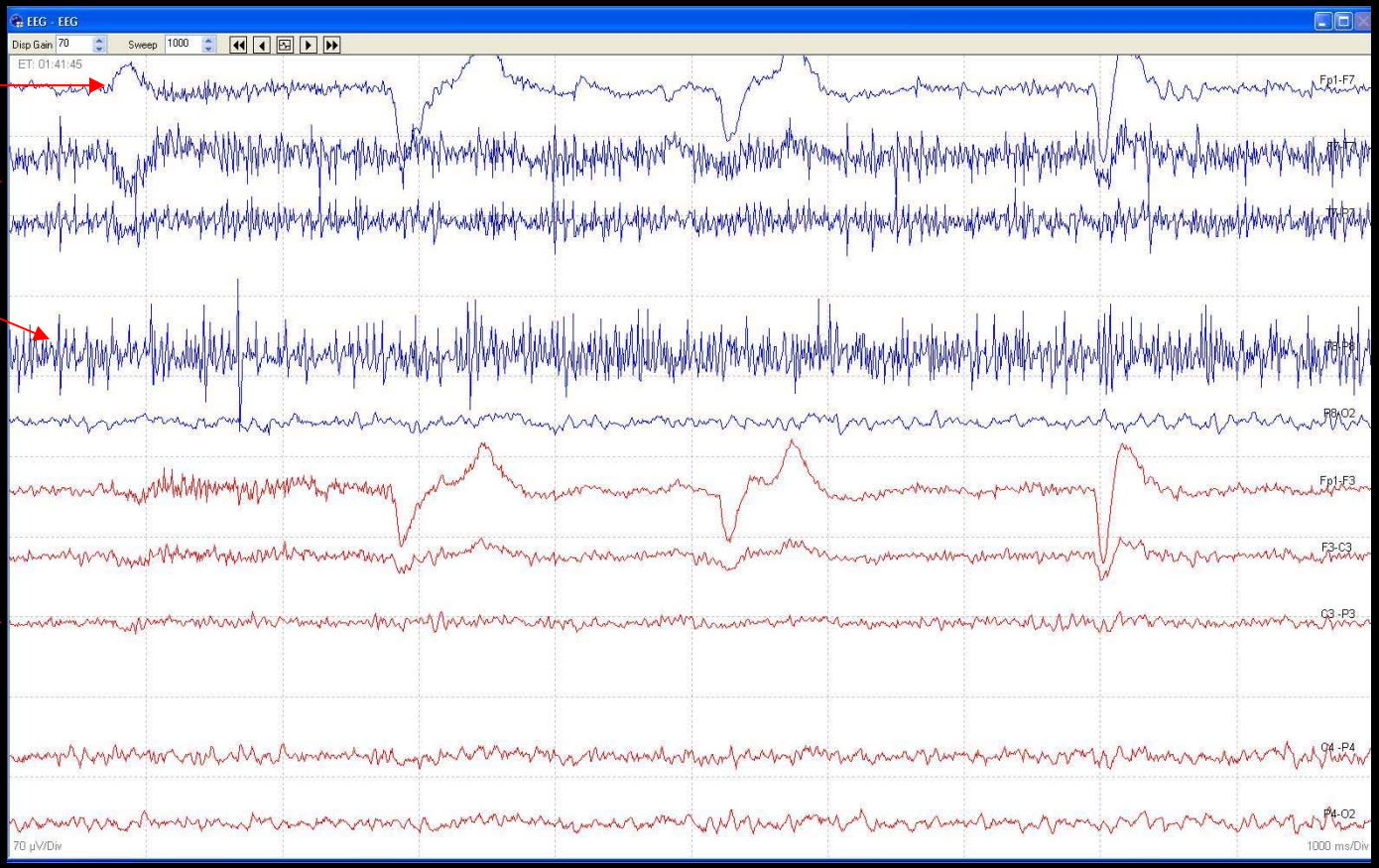
Eye blinks

# AWAKE TENSE

Eye Blinks

EMG Activity From Tense Muscles

Lack of Posterior Alpha

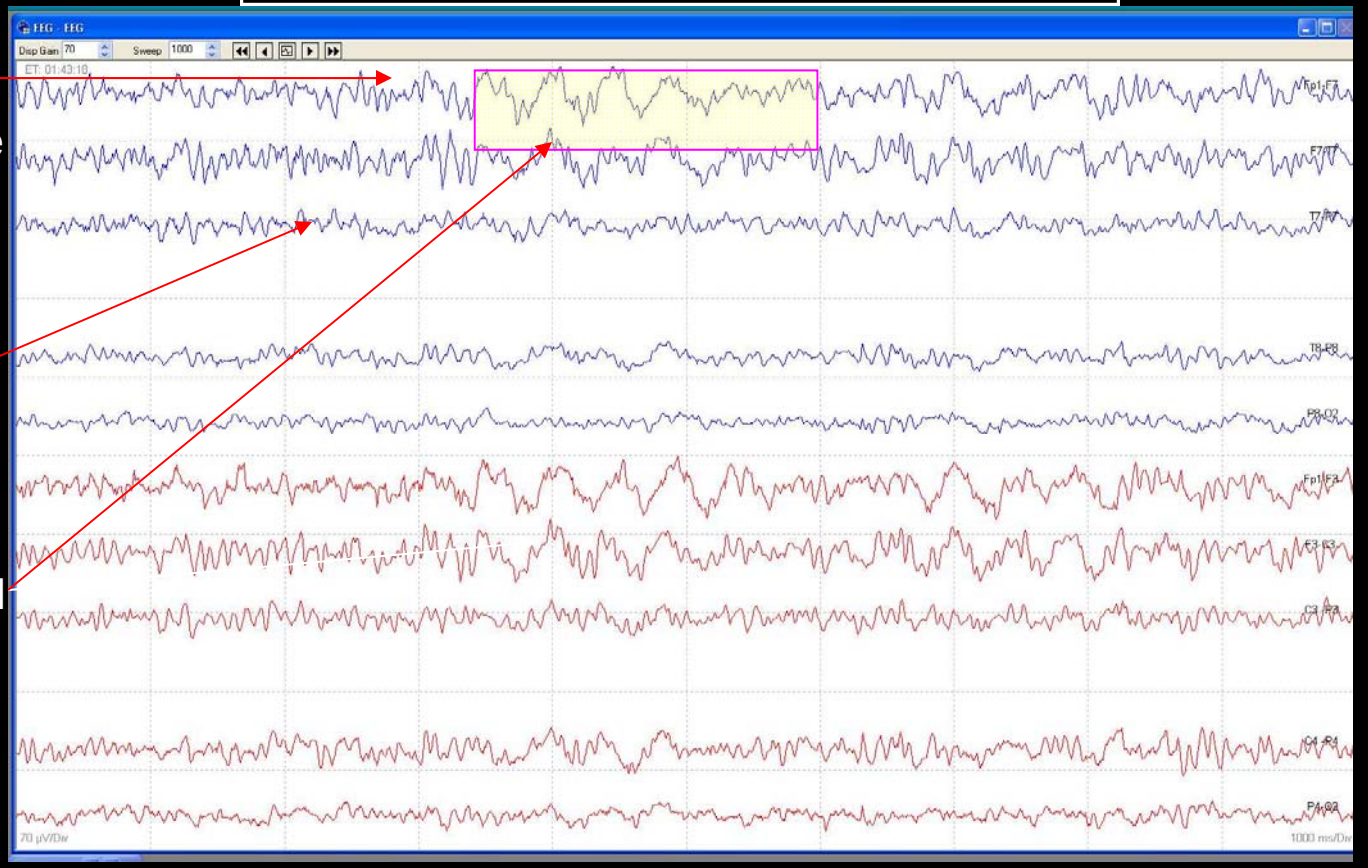


# PROPOFOL INDUCTION OF ANESTHESIA IMMEDIATELY POST BOLUS

Higher amplitude frontal beta

Alpha replaced by beta

Bi-frontal 2-3 Hz



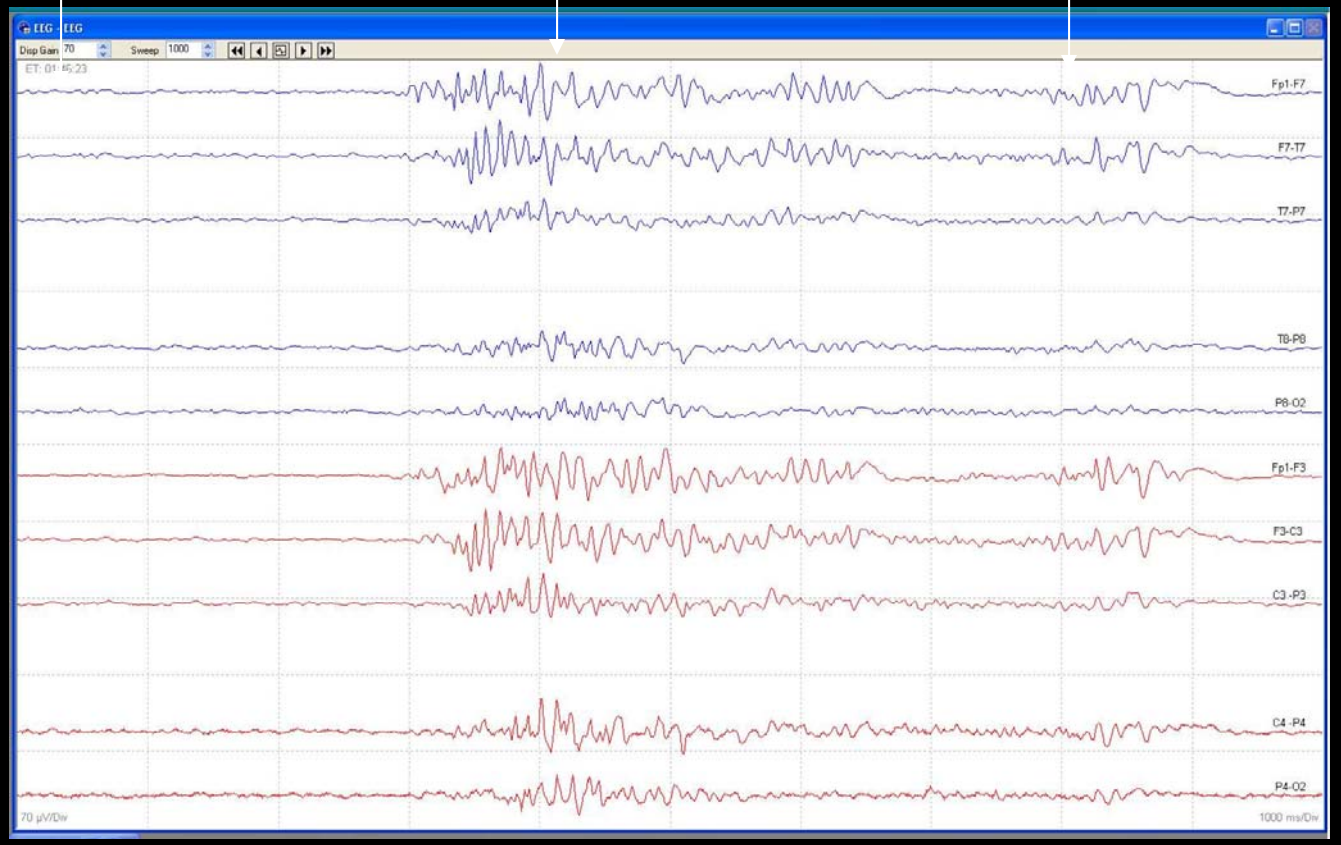
# ISOFLURANE AND PROPOFOL

## PRE-INTUBATION

Suppression

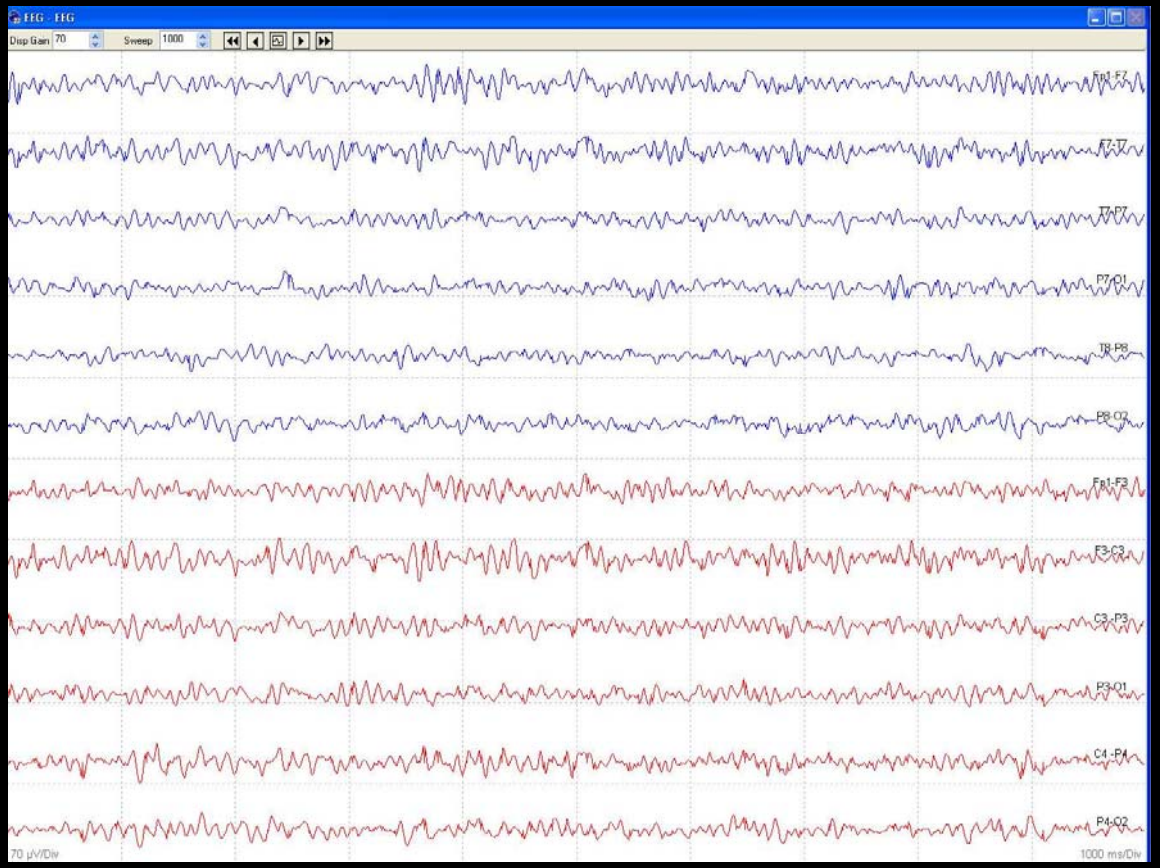
Burst

Suppression



EEG

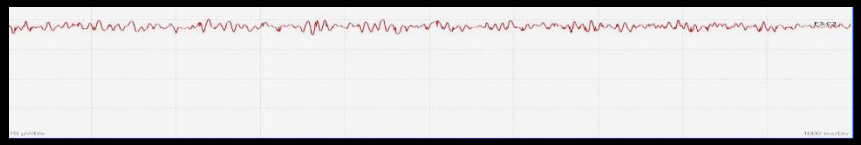
# ISOFURANE 0.9%
# SUFENTA 0.2 MCG/KG/HR



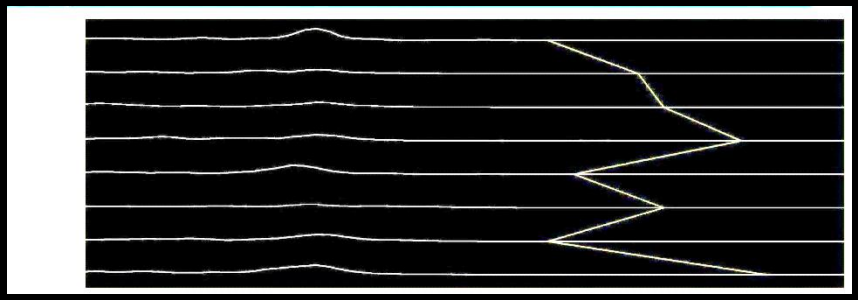
# COMPRESSED SPECTRAL ARRAY (CSA)

Converts EEG from time domain to frequency domain (x-axis)

EEG 10 seconds



CSA displays amount of frequency in 8 seconds



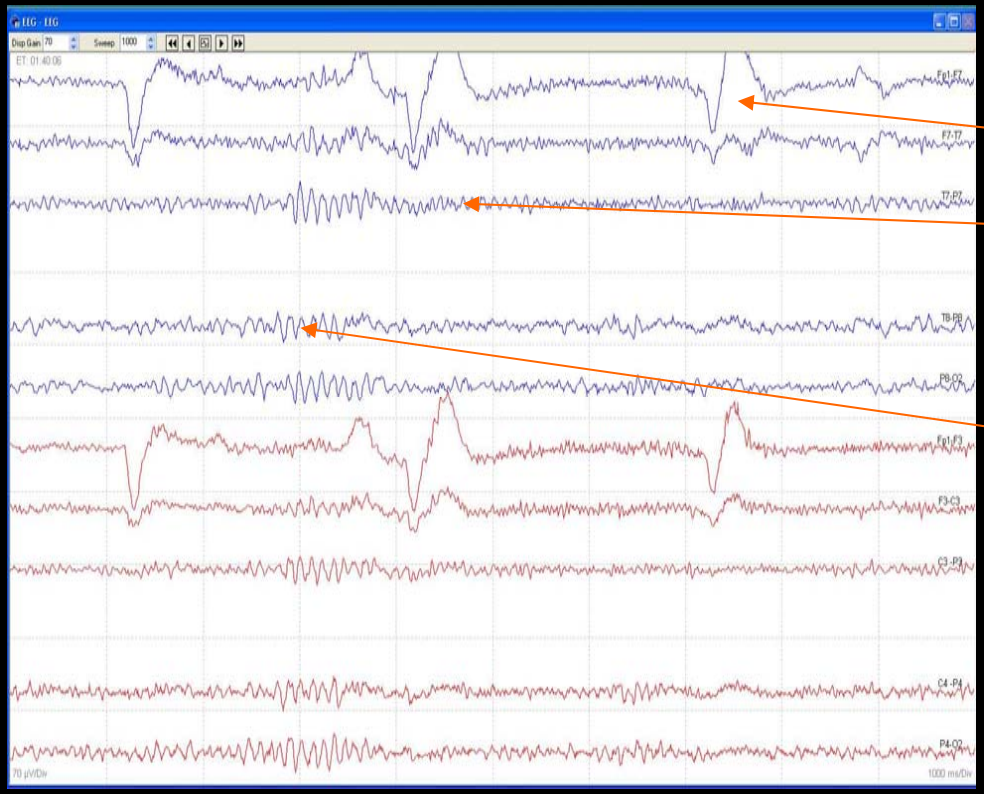
# COMPRESSED SPECTRAL ARRAY (CSA)

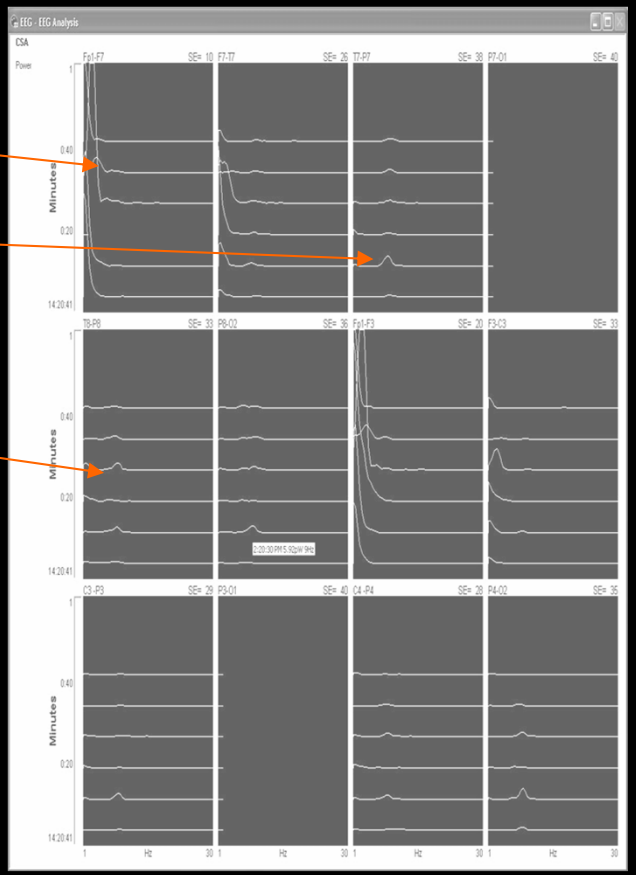
Condense information

EEG 10 seconds per screen

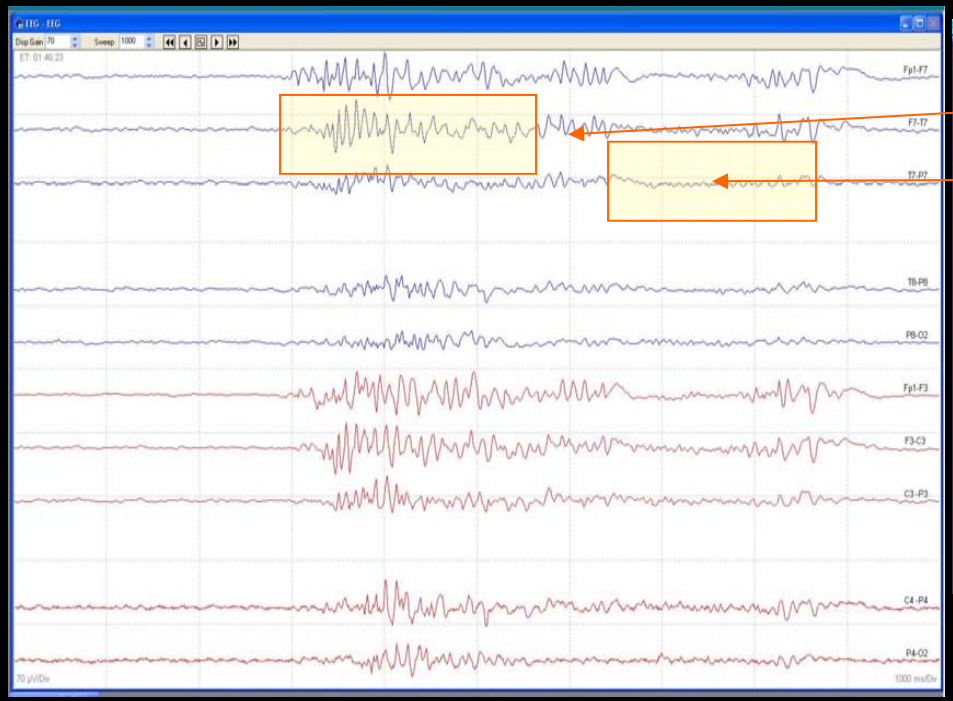
CSA 20 lines shows 160 seconds

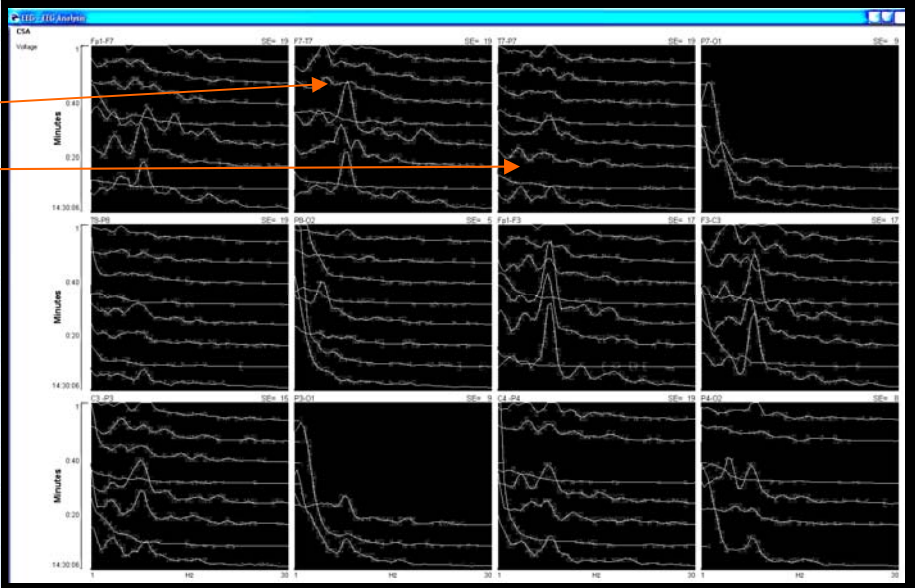
# COMPRESSED SPECTRAL ARRAY (CSA)
# COMPARE DISPLAY OF INFORMATION AWAKE EEG



# COMPRESSED SPECTRAL ARRAY (CSA)
# BURST – SUPPRESSION EEG

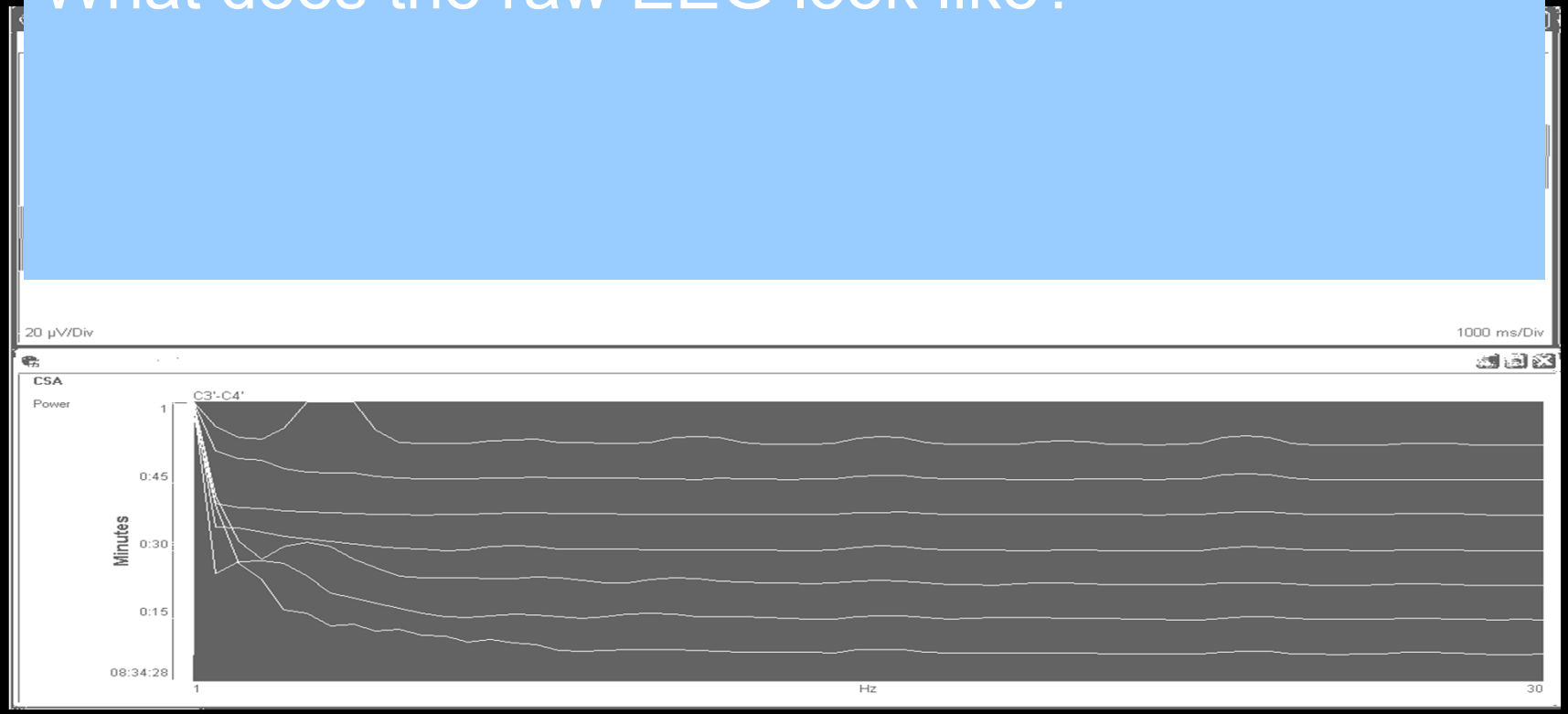


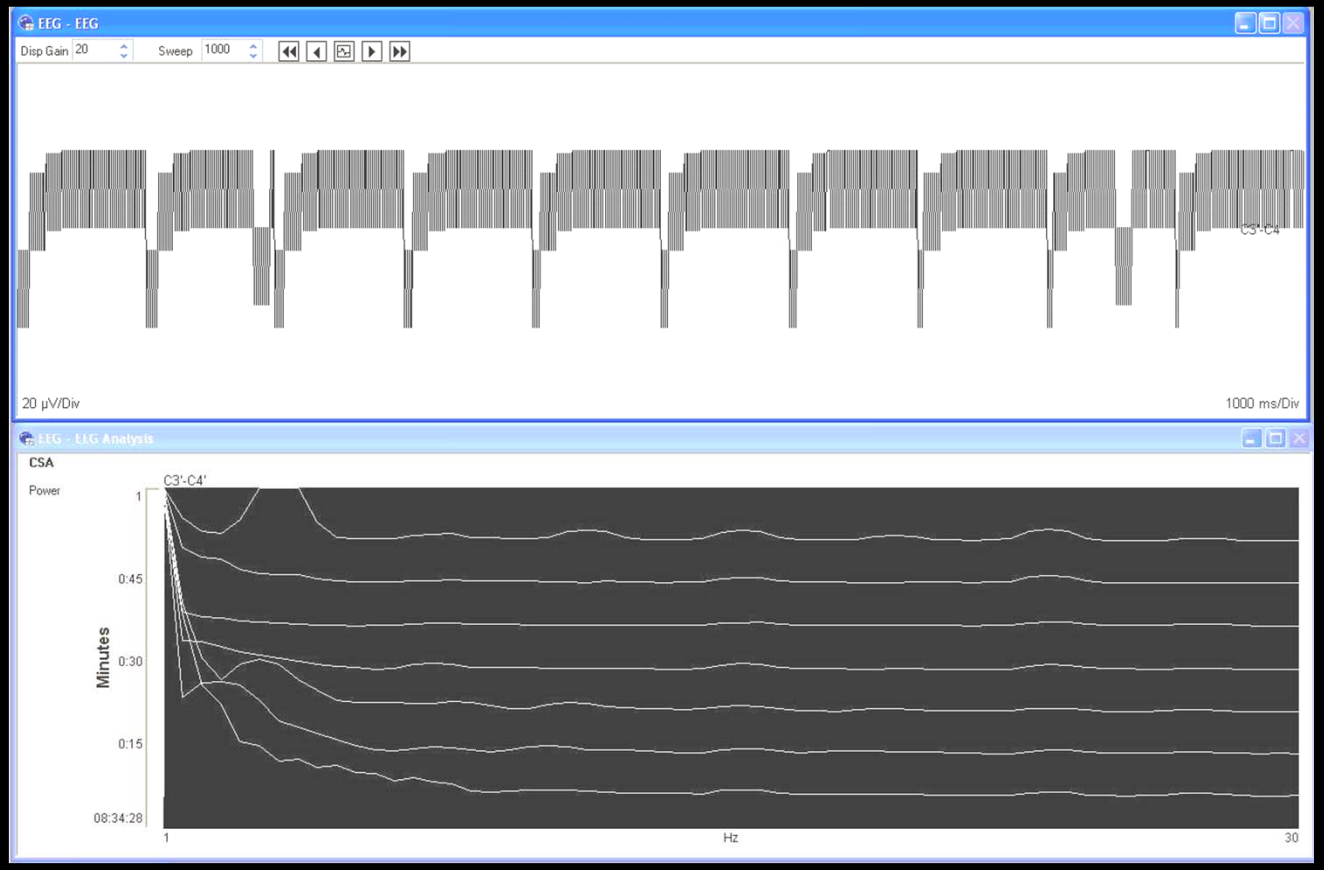
# COMPRESSED SPECTRAL ARRAY (CSA)

Be Aware – Artifact can look like EEG on the CSA

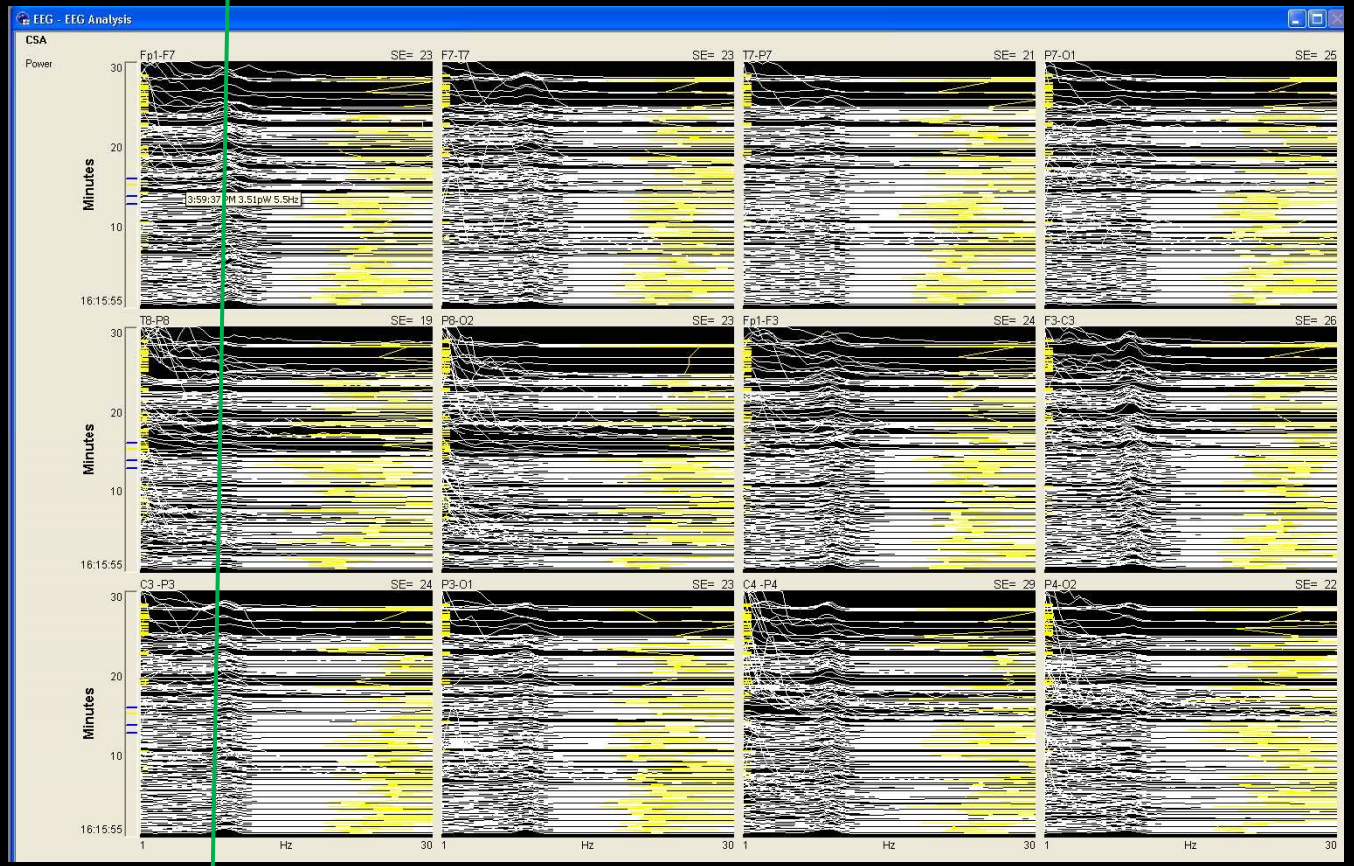
What does the raw EEG look like?



# ELECTRODES IN WATER

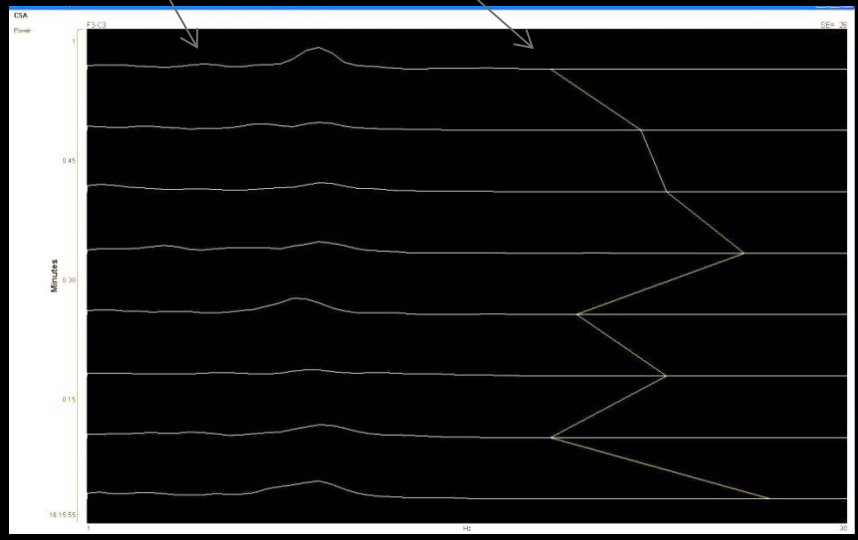


# CSA 30 MINUTES OF DATA



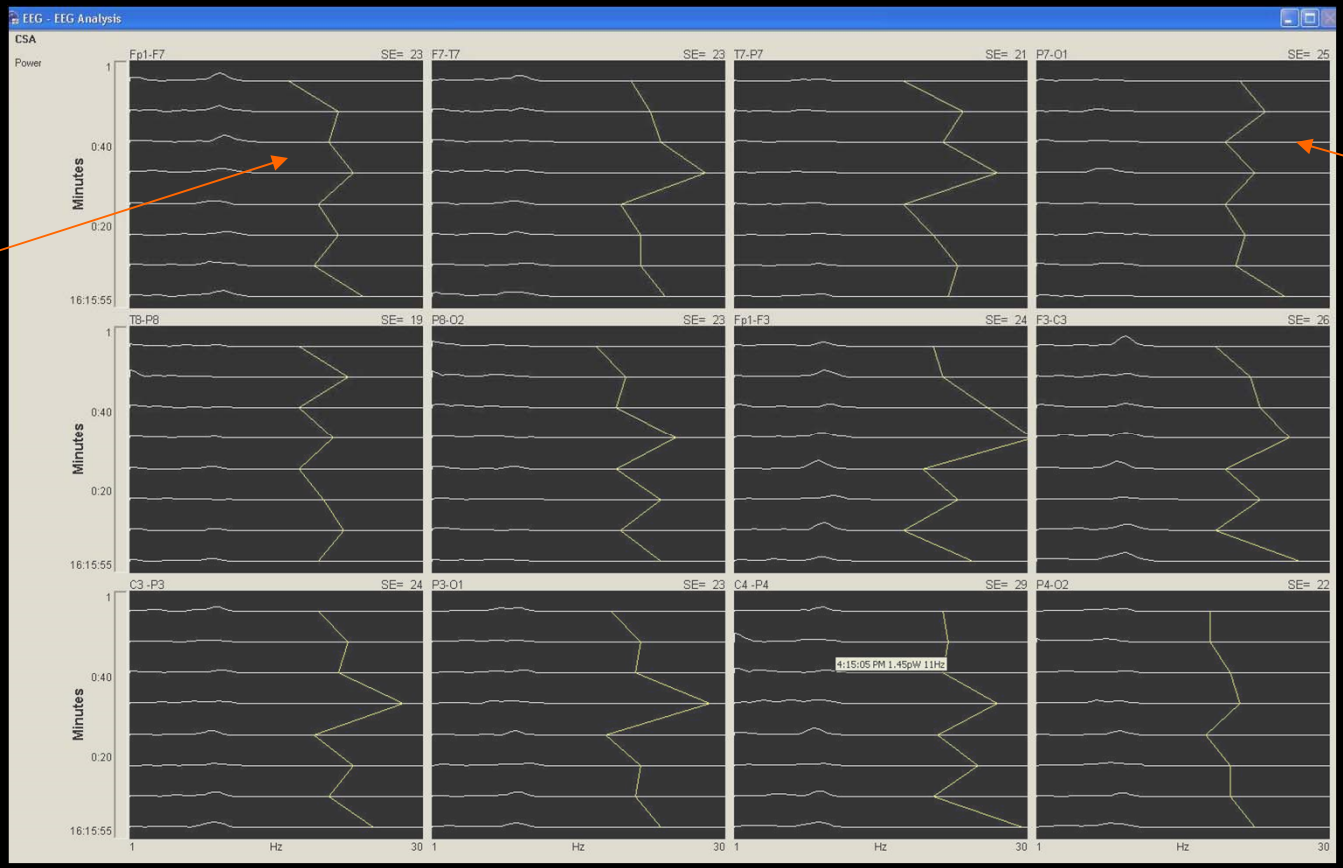
# SPECTRAL EDGE FREQUENCY (SEF)

EEG CSA SEF


Spectral edge = frequency at which 95% (or another frequency of choice) power occurs below.

# CSA &
# SPECTRAL EDGE FREQUENCY (SEF)



## SSEP AND EEG TOGETHER

SSEP sensitivity

SSEP localization

UE SSEP – Middle Cerebral Artery

LE SSEP – Anterior Cerebral Artery

SSEP will be maintained during burst-suppression EEG

Can monitor for ischemia when EEG is not dependable

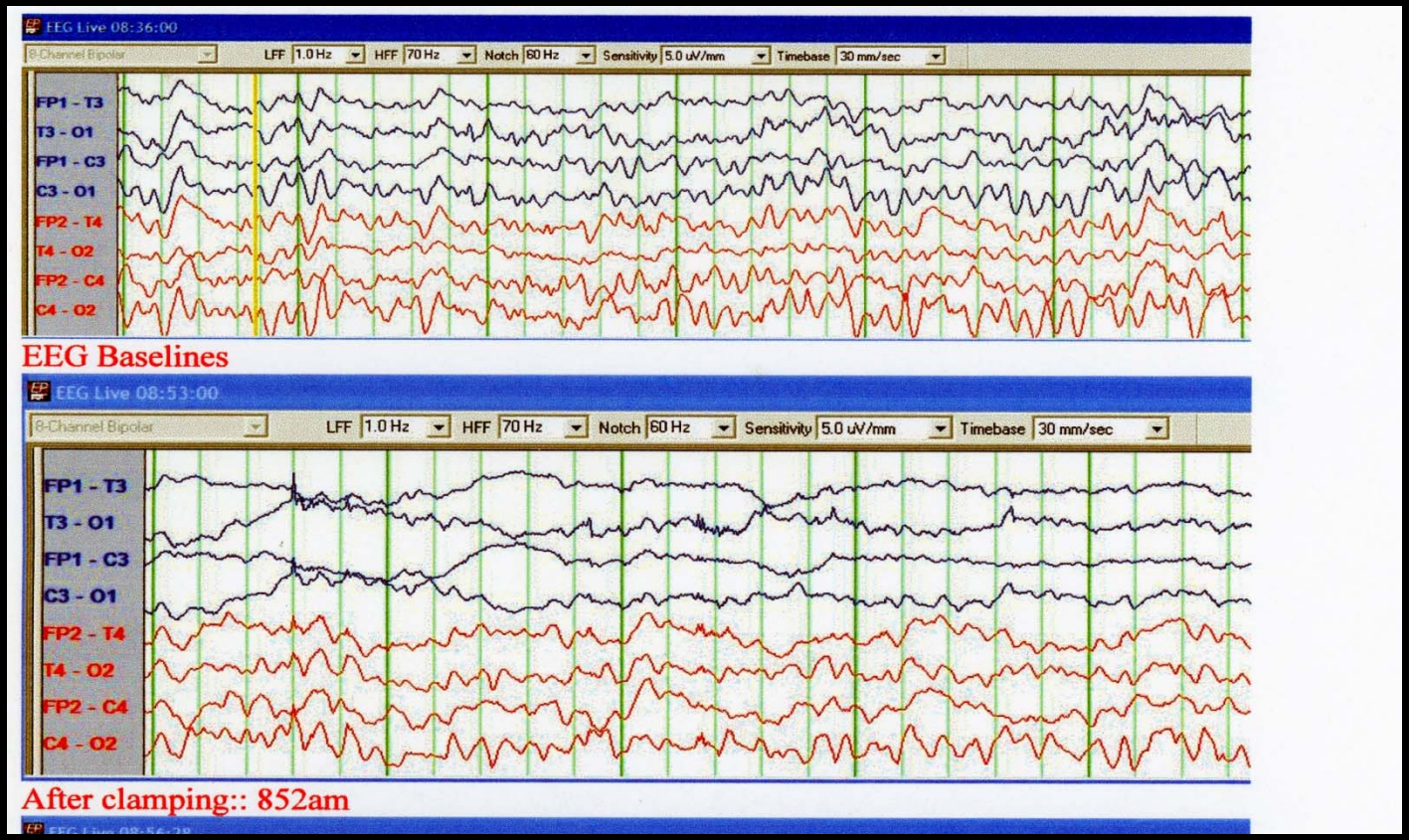
EEG is quickly effected by ischemia

SSEP take the time of the average about 1-2 minutes

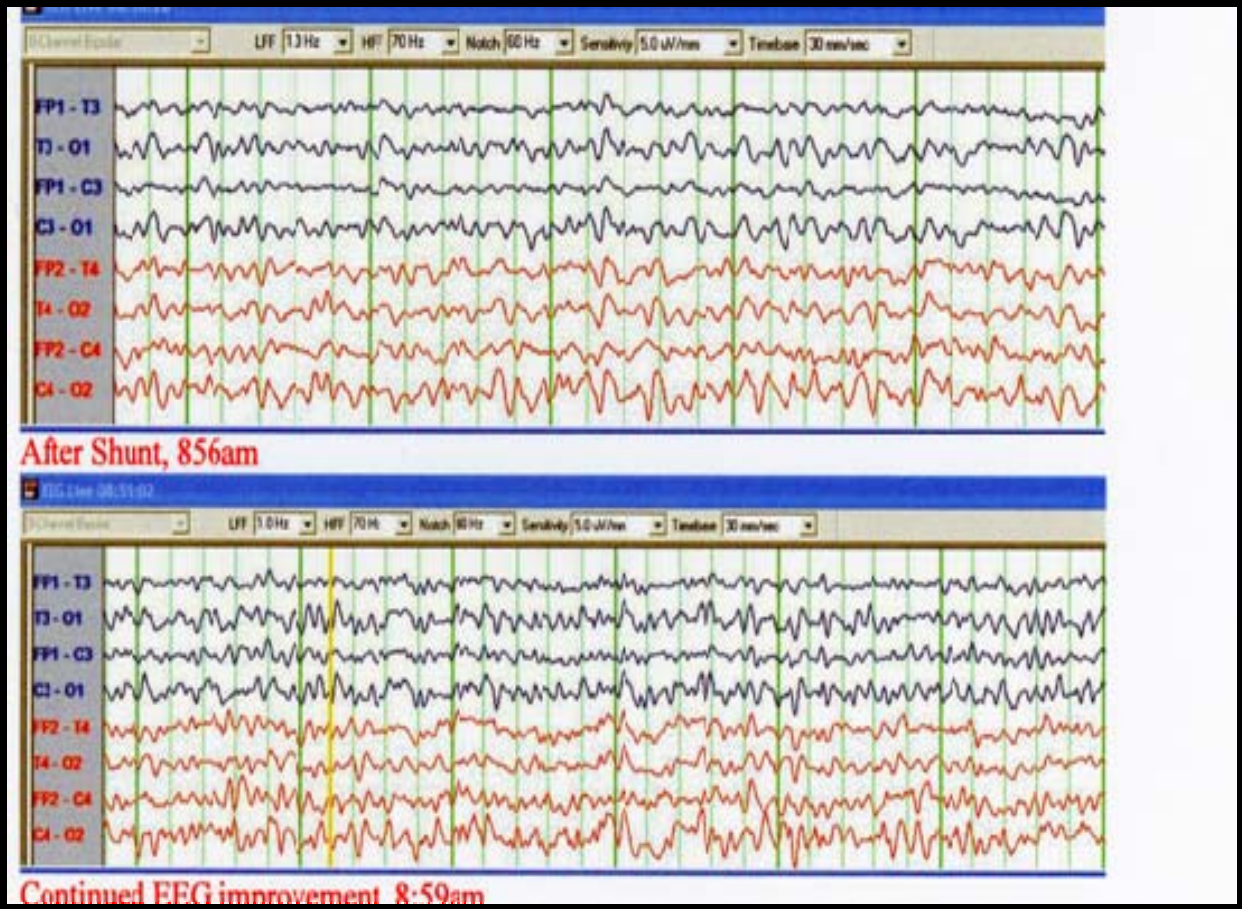
# SPECIFIC APPLICATIONS - CEA

Carotidendarectomy – CEA

1. ischemic changes from clamping

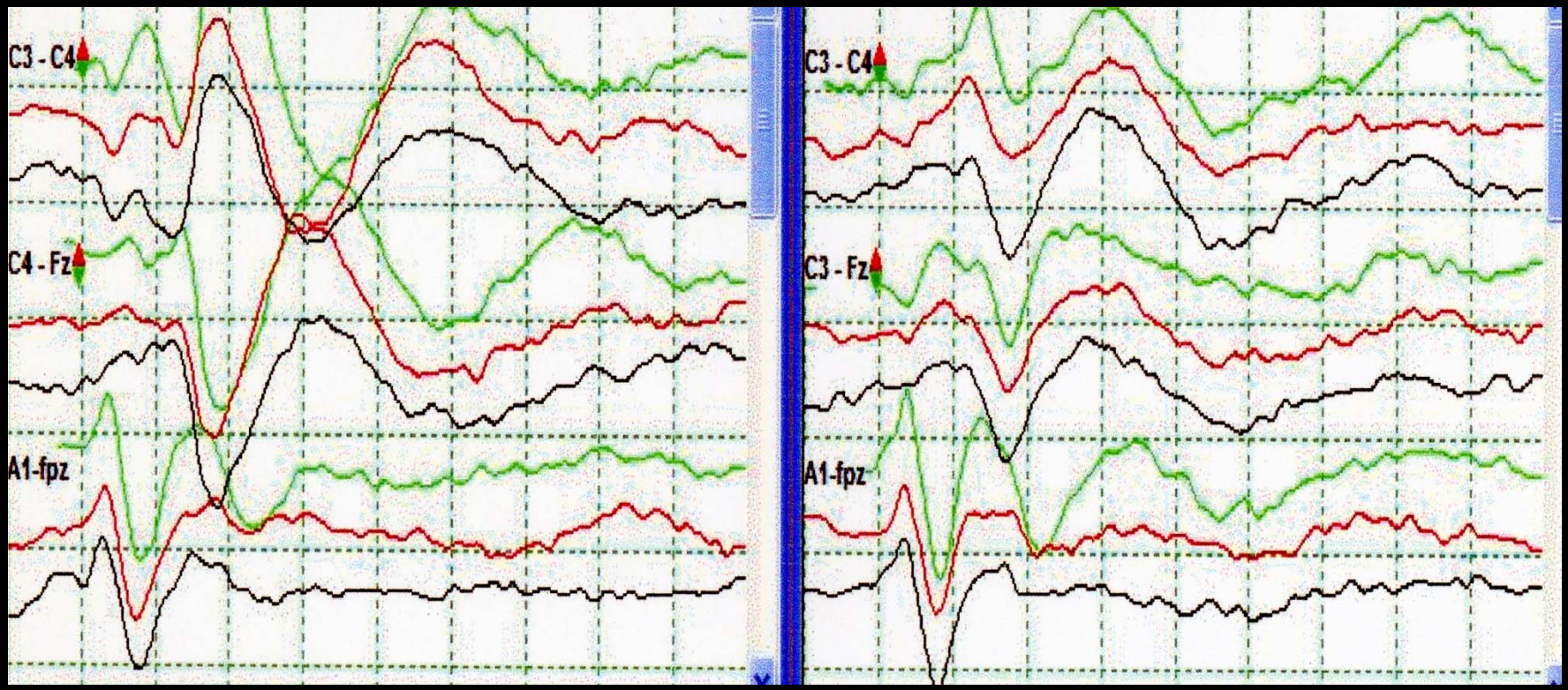


# SPECIFIC APPLICATIONS -

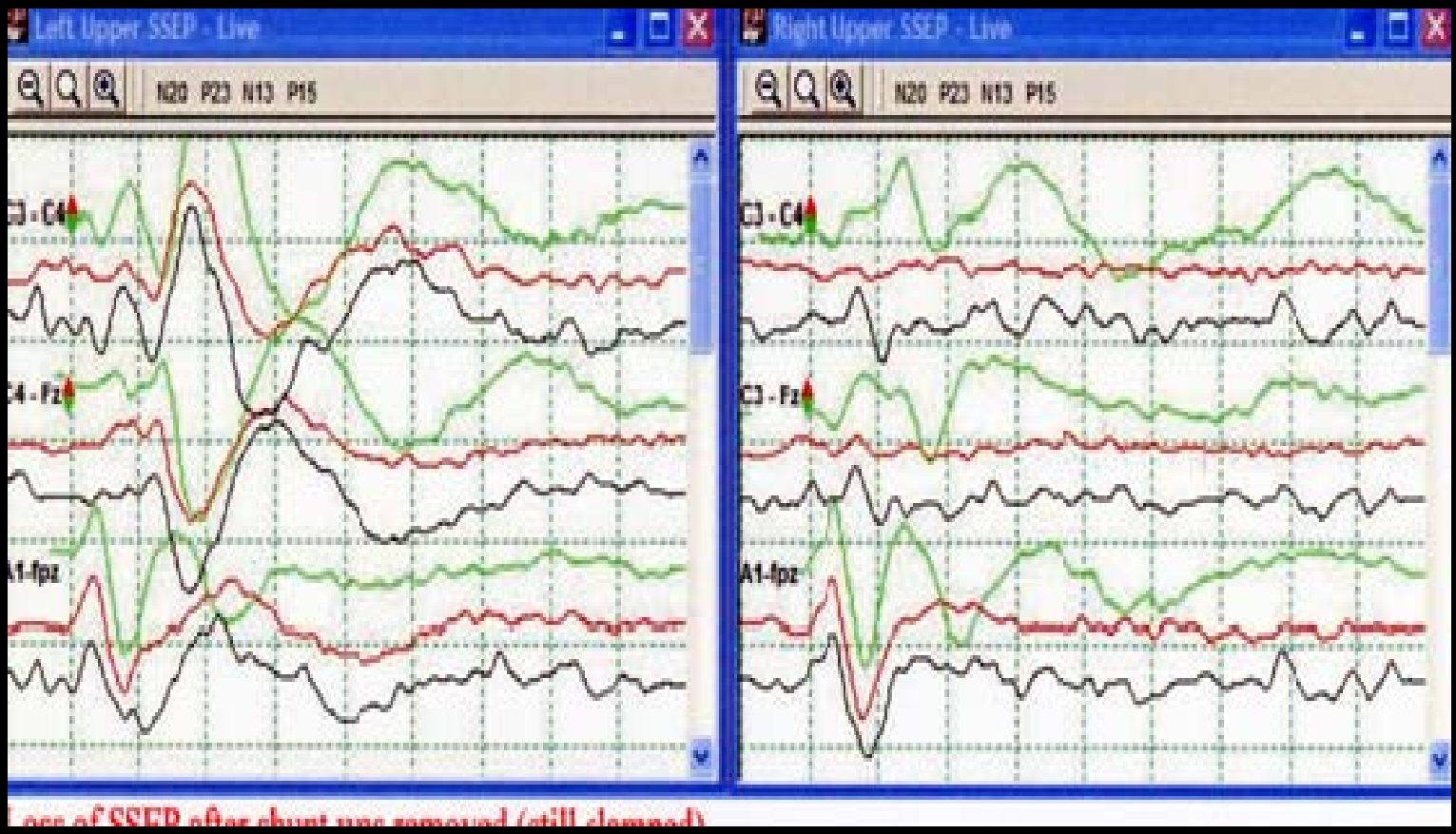


## SPECIFIC APPLICATIONS - CEA

Baseline Median SSEP

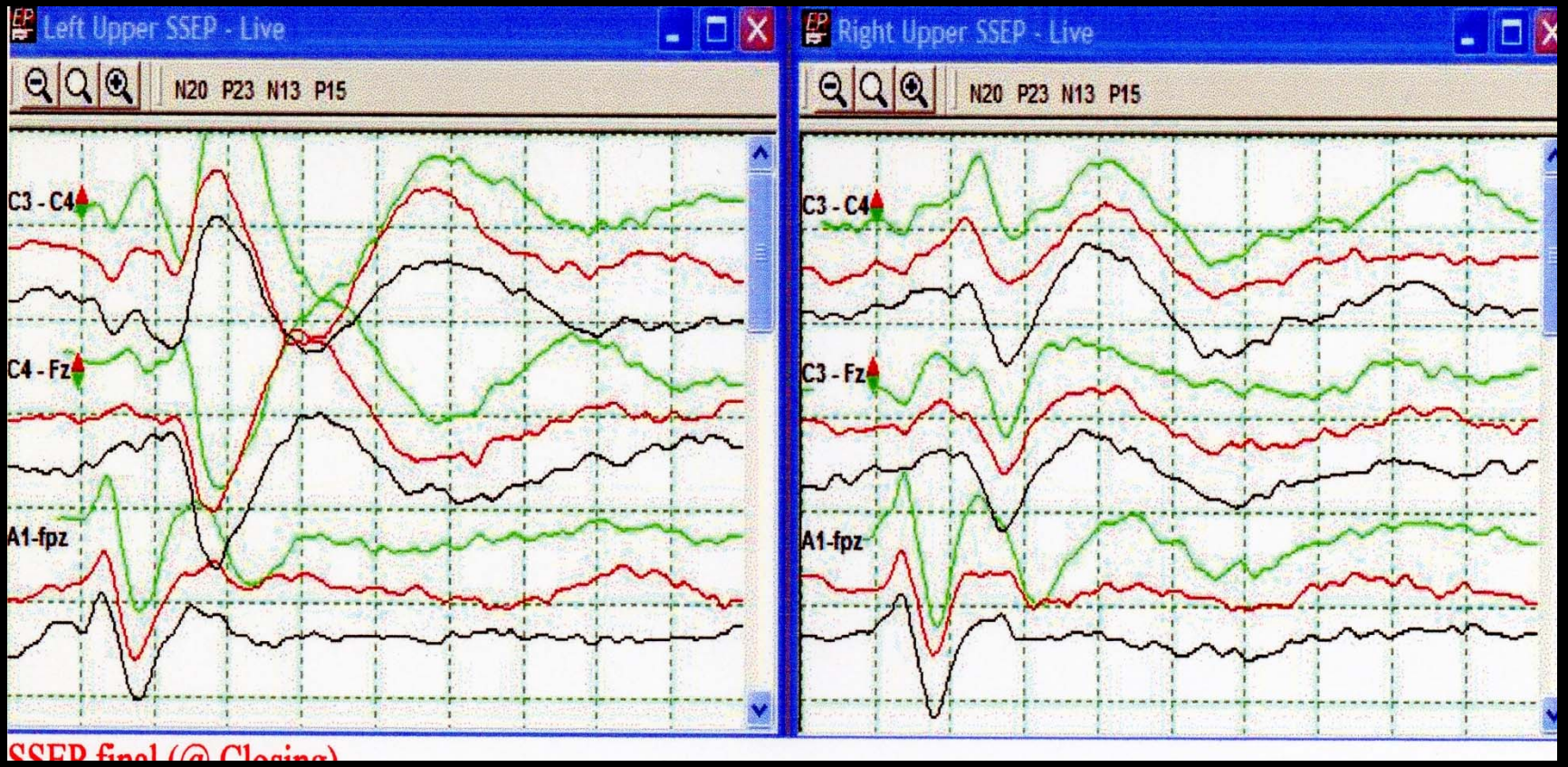


# CLAPING


Left Upper SSEP - Live
N20 P23 N13 P15
C3 - C4
C4 - Fz
A1-fpz
Right Upper SSEP - Live
N20 P23 N13 P15
C3 - C4
C3 - Fz
A1-fpz

# SSEP DURING CEA

## FINAL TRACING – RETURN TO BASELINE



## EEG DURING HYPOTHERMIA

Goal – total suppression of cerebral activity

EEG – Iso-electric $18C^0$

Burst Suppression $23C^0$

## SPECIFIC APPLICATIONS – ANEURYSM

1. Neuroprotection by deep anesthesia – burst suppression

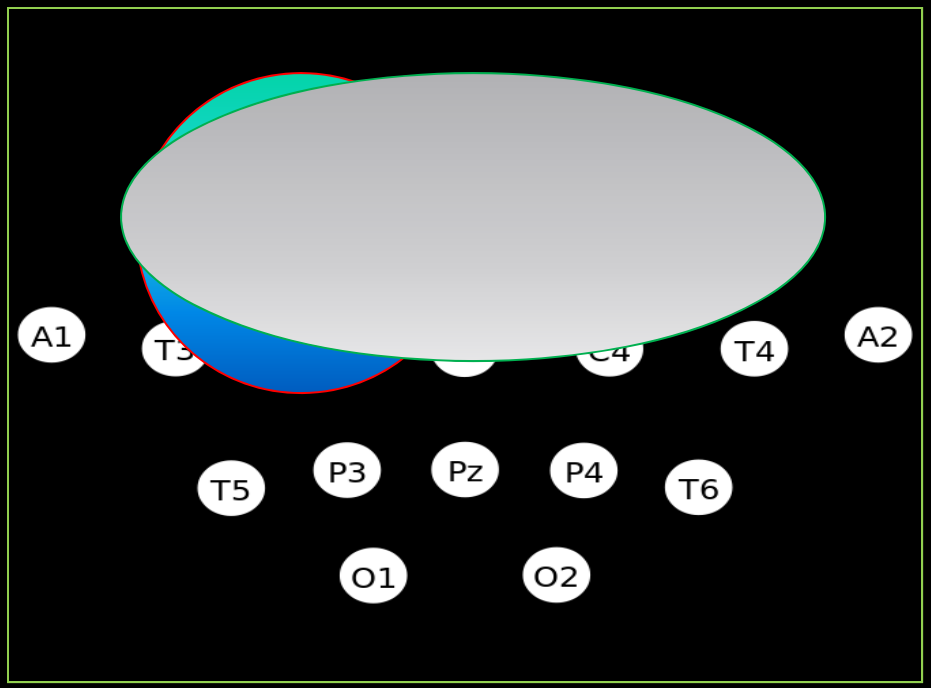
2. Ischemic changes secondary to clipping

# ALTERNATE EEG MONTAGE

http://stu.westga.edu/~wmaples/images/stott_reid_incision.jpg

# USE AVAILABLE SPACE

Possible Surgical Sites- Aneurysm Circle of Willis



# QUIZ

What are progressive EEG changes with reduced blood flow?

Loss of fast

Increase of slow

Flat

# QUIZ

What is the significant of these blood flow values?

| | | |
|---|---|---|
| Normal | 57 | ml/100gm/min |
| EEG changes | 35 | |
| Ischemic threshold | 18 | |
| Infarction | 12 | |

# A FIM