

BISPECTRAL INDEX

DEPTH OF ANESTHESIA

MONITORING

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Awareness Under Anesthesia !!!!!!!!!!!

Is that really a totally unexpected Danger?



How can we avoid this horrible danger??

The answer is quite simple !!!!!

Without BIS monitoring there were 212 cases of awareness among 11,785 patients !!!!

[Sandin RH et al. Lancet 2000]

With BIS monitoring there were only 2 awareness reports among 4,945 prospectively examined patients

[Ekman et al. AAScand 2004]

With BIS monitoring there were only 2 awareness reports in another 1,225 patients in another study

[Myles et al. B-Aware trial. Lancet 2004].

Why Use BIS?

Provides additional information about your patients' status by directly measuring the effects of anesthetics on the brain

- **Over and under-dosing of anesthetics is common**
- **Traditional vitals signs, like HR/BP, are not reliable measures of consciousness**
- **Patient variability is large**

Optimize Dosing

Evidence From Prospective, Randomized Trials

Reduction in drug used compared to standard practice



Pooled Analysis

Sevo: 5 studies; (n) = 523

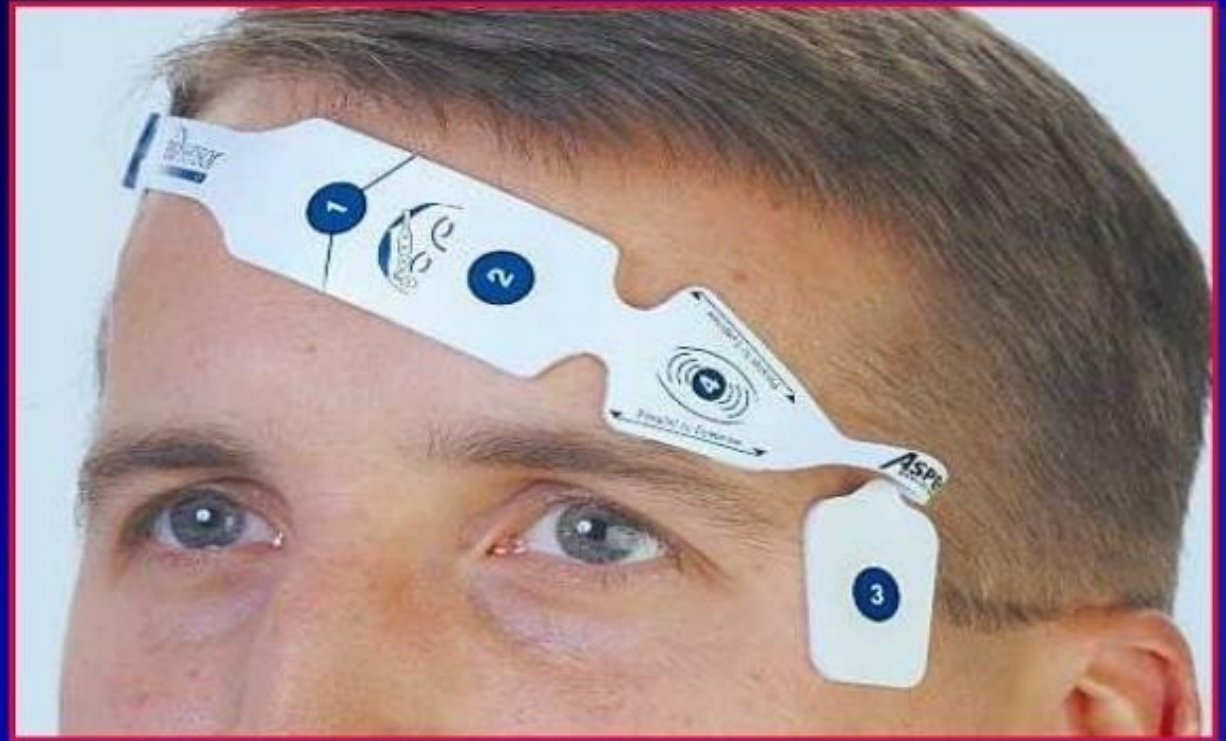
Iso: 4 studies; (n) = 234

Des: 2 studies; (n) = 110

Prop: 7 studies; (n) = 585

Sensor Application

- **Apply sensor on forehead at angle**
- **Press each circle for 5 seconds**
 - Use fingertip
 - Press firmly



**Abnormal
Electroencephalographic
Changes that could Influence
the Bispectral Index
Depth of
Anesthesia Monitoring**

Deepening of Anesthesia

EEG changes

Relaxation (eyes closed)
 α waves predominance

alpha α waves
(7.5-12.5 Hz)



Light anesthesia
Increase in beta β power

beta β waves
(12.5-30 Hz)

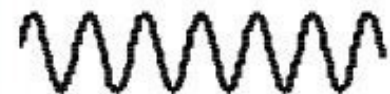


Deep anesthesia
Increase in slow waves
(delta δ and theta θ)

delta δ waves
(1.5-3.5 Hz)



theta θ waves
(3.5-7.5 Hz)



Cortical Silence
Burst Suppression



[Guingo et al. BJA 2001]

Too complicated !!!!!????

Indeed !!!

Just remember that

Light anesthesia

= fast waves

(alpha α and beta β)

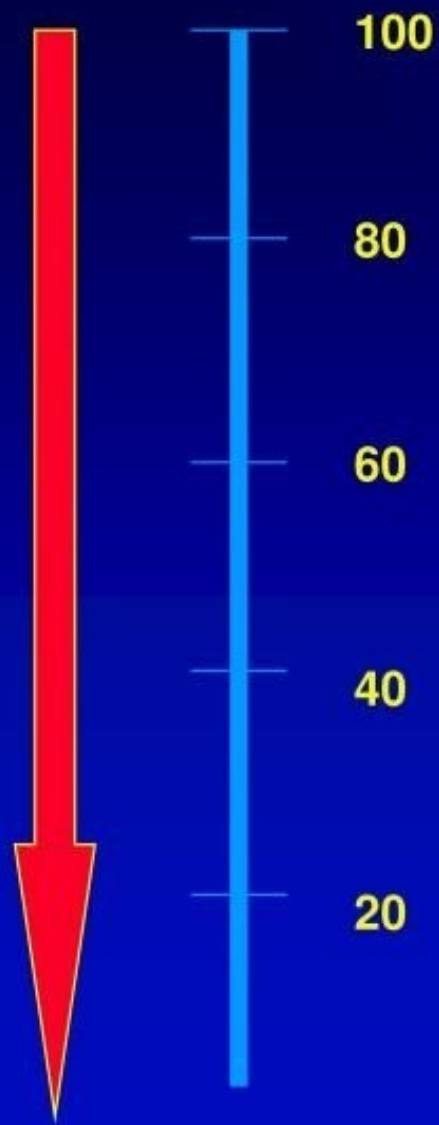
Deep anesthesia

= slow waves

(delta δ and theta θ)



Bispectral index



Awake

**Light /
moderate
sedation**

**Deep Hypnotic
state**

**Cortical
Silence**

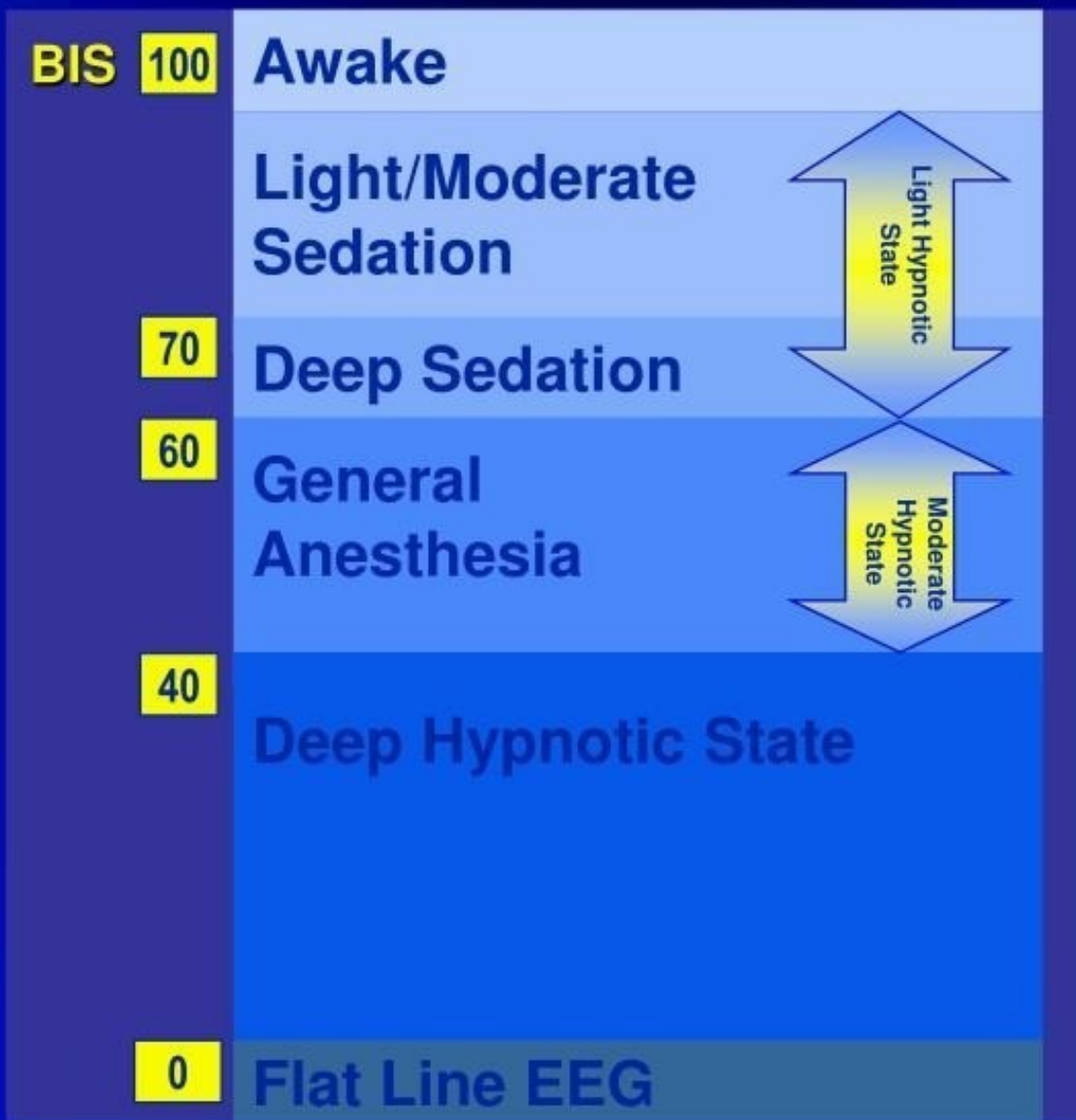
BIS descriptors

**Relative
BetaRatio**

SynchFastSlow

**Burst
Suppression**

BIS Range Guidelines



How does the BIS algorithm works?

- EEG data of 5000 volunteers. The 3 BIS descriptors (sub-parameters) were recorded.
- So if for example fully awake volunteers showed **Betaratio** of 50%, **SynchFastSlow** of 30% and **Burst suppression** of 10% (50:30:10), the BIS would convert that to an absolute 100.
- Now if the deepest propofol level was for example 17:12:3, the BIS would convert that to zero.
- Then the BIS would construct a dimensionless number of all values in-between (from 100 to zero).

**As we see, Since the BIS is an EEG
derived parameter.**

**Would Patients with abnormal EEG
patterns influence BIS monitoring???**

Indeed !!!

**As the BIS monitor is always sensitive
enough to pick up all these abnormal
EEG patterns, this should be kept in
mind during BIS interpretation**

Remember



Light anesthesia
= fast waves
(alpha α and beta β)

Deep anesthesia
= slow waves
(delta δ and theta θ)

Abnormal EEG changes with Inhalational anesthetics

Nitrous oxide Sudden termination

- N_2O has a very peculiar EEG phenomenon in which 6 min after N_2O sudden discontinuation “overswing” of paroxysmal bursts of slow δ and θ waves occurs

[Henrie et al. Anesthesiology 1961]

- This phenomenon was detected by the BIS as BIS declined 6 min after N_2O discontinuation from 95 to 81 and from >90 to 30-50 in another study

[Rampil et al. Anesthesiology 1998]

[Puri. BJA 2001]

Abnormal EEG changes with Intravenous anesthetics Ketamine

- Ketamine does not follow the basic EEG pattern of general anesthesia as it causes a paradoxical opposite effect of $\uparrow$ fast α and β and $\downarrow$ in slow δ and θ waves

[Hering et al. AAScand 1994]

- This odd EEG pattern would be reflected by BIS monitoring as BIS was reported to increase from 44 to 59 following ketamine administration

[Vereecke et al. Anaesthesia 2003]

[Hirota et al. EJA 1999]

EEG changes with Opioids

- Unlike intravenous or inhalational anesthetics, opioids produce **minimal** EEG changes on cerebral cortex.
- “Non-cortical” structures, undetectable by the EEG, (locus coeruleus-noradrenergic system) are responsible for opioids drug effect

[Pan et al. Brain Research 2004]

- That is why neither **remifentanyl** alone in step-by-step **increasing** concentrations, nor its step-by-step **reductions** did not change the BIS values

[Guignard et al. AA 2000]

[Schmidt et al. AA 2002]

Hold on one second !!!

What about the famous

“Opioid Effect” ????

- Opioids could still directly influence BIS monitoring through attenuation of responses to **noxious stimuli**
- Under constant propofol, **μ agonist opioids** abolished **BIS** increases in response:
 - to tracheal intubation
 - to the pinning of the Mayfield head holder fixator
 - to endotracheal suction

[Guignard et al. AA 2000]

[Hans et al. J Neurosurg Anesthesiol 1999]

[Brocas et al. ICM 2002]

Arousal EEG changes with Cardiovascular Drugs

Epinephrine

- Epinephrine causes direct arousal effect through stimulating the reticular activating system beta-receptors

[Rothballer. Pharmacol Rev 1959]

- This arousal phenomenon was detected by the BIS as BIS value rose from 63 to 76 following epinephrine administration

[Andrzejowski et al. Anaesthesia 2000]

Arousal EEG changes with other Cardiovascular Drugs

Ephedrine, Phenylephrine

- However, not all catecholamines exhibit the same arousal effect !!!!
- Ephedrine can cross the blood brain barrier and have a powerful stimulant arousal effect, whereas phenylephrine does not cross the blood brain barrier.

[Steffey et al. BJA 1975]

- There was an increase in the BIS value from 63 to 76 after ephedrine administration, whereas BIS did not change with phenylephrine administration

[Ishiyama et al. AA 2003]

Remember



Light anesthesia
= fast waves
(alpha α and beta β)

Deep anesthesia
= slow waves
(delta δ and theta θ)

Abnormal EEG changes with Hypoglycemia

- Hypoglycemia of 32 - 54 mg/dl causes an ↑ slow δ and θ waves and ↓ in α and β waves, a pattern similar to that of general anesthesia.

[Bjorgaas et al. Diabetic Med 1998]

[Tribl et al. Eur Neurol 1996]

- Two hypoglycemic coma patients (21-35 mg/dl) manifested BIS values of as low as 45. BIS rapidly increased to 80 with the increase of blood glucose levels and return of consciousness.

[Wu et al. J Clin Anesth 2002]

[Vivien et al. AA 2002]

Abnormal EEG changes with Hypovolemic Cardiac arrest

- In one rare recorded case, EEG showed generalized isoelectricity 10 s after the onset of asystole.
- Low-voltage EEG activity began to return 15-20 s after manual chest compression. Return of cardiac rhythm was associated with the return of normal EEG signal.

[Lasasso et al. AA 1992]

- In two cases, hypovolemic cardiac arrest evoked a parallel decline in BIS values to 0 with an isoelectric EEG.
- As blood pressure was restored by volume replenishment BIS score increased to normal levels

[England. Anesthesiology 1999]

[Azim et al. Anaesthesia 2004]

Abnormal EEG changes with Hypothermia

- Hypothermia produces a decrease in inhalational anesthetic requirements.
- As a matter of fact at 20°C hypothermia itself serves as a complete anesthetic!!!

[Antognini Anesthesiology 1993].

- During isoflurane hypothermic cardiopulmonary bypass, BIS decreased by 1.12 BIS units for each °C decrease in body temperature .

[Mathew et al. J Clin Anesth 2001]

- Similarly, mean BIS value of 41 was lower during propofol hypothermic CPB than a mean BIS value of 49 during normothermic CPB

[Schmidlin et al. BJA 2001]

Abnormal EEG changes with Neurological disorders

Low-voltage EEG

- Genetically determined low-voltage EEG variant is EEG amplitude of <20 mV over all head regions.
- This is a normal variant occurs in 5-10% of the population, and not associated with any brain dysfunction

[Niedermeyer EEG. Basic principles 1999].

- An interesting case of fully conscious volunteer exhibiting an unreasonably low awake BIS 40 on two separate sessions 3 days apart. A 16-lead EEG showed a genetically determined low-voltage EEG

[Mathew et al. J Clin Anesth 2001]

Abnormal EEG changes with Neurological disorders Alzheimer

- Patients with Alzheimer's type dementia, show reduced power in the β band

[Holschneider et al. Neuro psych pharm 1997]

- In patients with Alzheimer's type dementia the mean awake BIS was 89 compared to a mean BIS value of 95 in control elderly patients

[Renna et al. AA 2003]

Abnormal EEG changes with Neurological disorders

Mental retardation, Coma, Brain dead !!!

- Mean BIS values at sevoflurane 1% and after emergence from anesthesia were significantly lower in cerebral palsy mentally retarded children compared to normal children

[Choudhry et al. AA 2002]

- 24 h after all sedative drugs were withdrawn, the mean BIS value was 43 in severe brain-injury comatose state ICU patients.

[Fabregas et al. AA 2004]

- BIS value of Zero was shown to accurately indicate brain death

[Vivien et al. ICM 2002]

High EMG activity and Muscle Relaxants

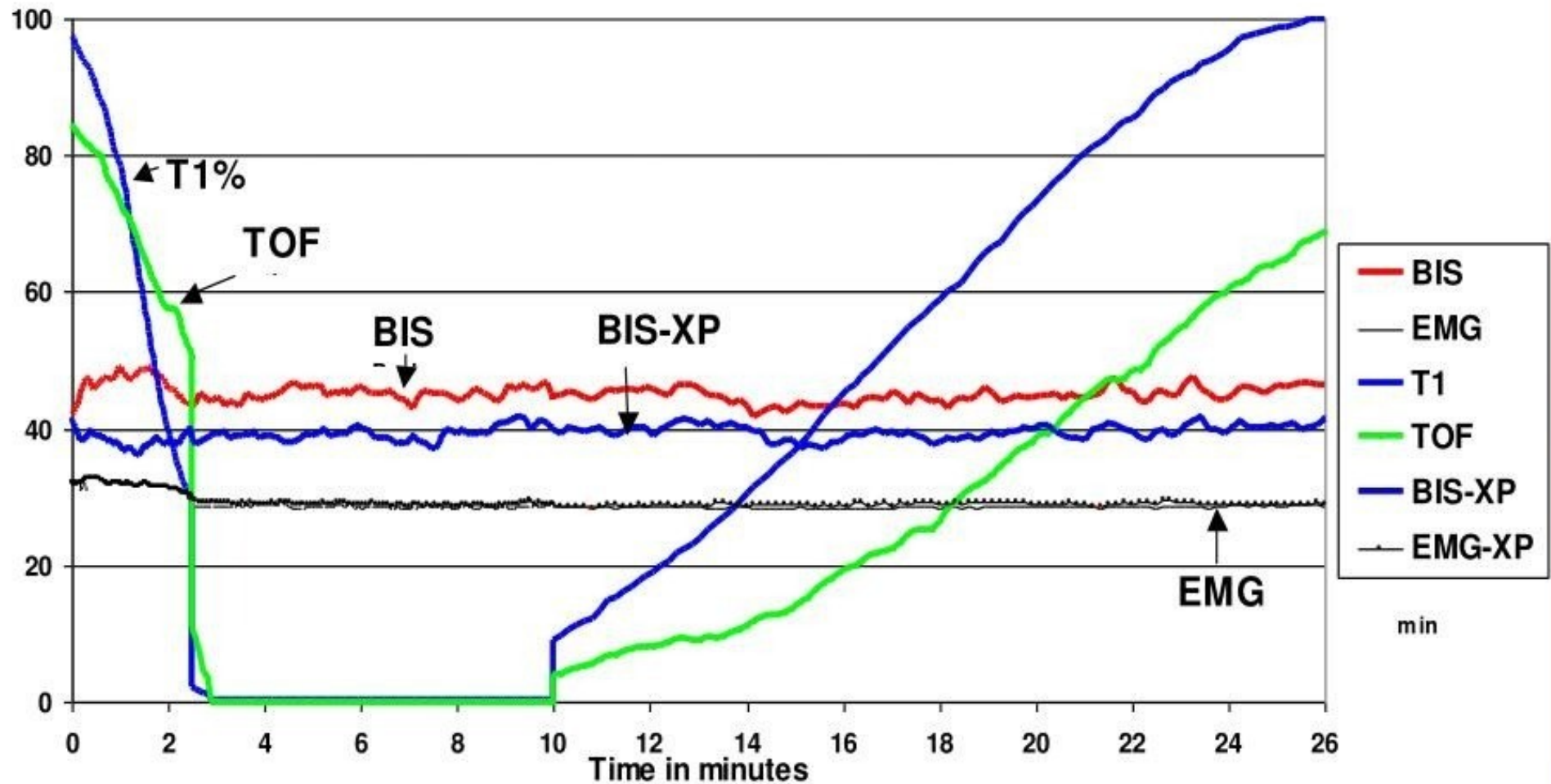
- EMG activities are artifact signals that occur within the frequency “range of interest” of the bispectrum.
- EMG frequencies could simulate the BIS BetaRatio typically associated with awake or light anesthesia.
- This would be misinterpreted by the BIS algorithm as EEG activity, making deeply anesthetized patients appear awake
- The administration of MR would decrease BIS by alleviating the artifact and “unveiling” the true BIS

Effect of neuromuscular block on the Bispectral Index under remifentanil propofol anesthesia

- We administered Mivacurium muscle relaxant to patients under deep surgical levels of remifentanil-propofol anesthesia (BIS 40)
- In absence of painful stimuli or high EMG activity, all stages of neuromuscular block had NO effect on BIS monitoring

[Dahaba et al AA 2004]

Effect of Mivacurium neuromuscular block on bispectral Index



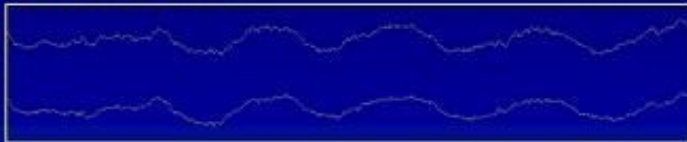
Dual-Channel Processing



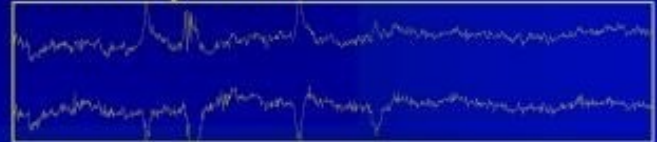
- EEGs are typically Symmetrical

- Artifacts are typically Asymmetrical

Unconscious



Awake Eye Blinks



- Improved artifact detection (i.e., isolate EMG from the signal before BIS calculation)

Conclusions

- During BIS depth of anesthesia monitoring, always keep in mind factors that could affect the EEG, e.g. genetic low voltage EEG (start the BIS before induction of anesthesia)
- hypothermia, hypovolemia, hypotension, hypoglycemia, neurological disorders do change the EEG, and the BIS is always sensitive enough to pick up these abnormal EEG changes.
- Could the BIS monitor be used as a surrogate monitor for many of these conditions??
Indeed !!!!
- As a matter of fact we are using the BIS for the assessment of “Hepatic Encephalopathy”

Adoption Rate to Date*

10 million patients monitored worldwide in OR, ICU and for procedural sedation

32% of all Operating Rooms in the U.S.

68% of U.S. Teaching Hospitals

62% of the Top US Hospitals

(US News & World Report 2003)

160 countries using BIS

27,200 worldwide installed base

+1500 peer reviewed publications



*April 2004

BIS...

Complementing Your Expertise

- **Better patient management**
- **Optimize dosing**
- **Improve patient recovery**
 - **Post OP benefits/potential cost savings**
- **Assess for risk of awareness**

“Using the BIS Monitor has made me more of a scientist and a more perceptive clinician. It is, in short, an essential part of modern anesthesia”

Dr. Irene Osborne, Mt. Sinai Medical Center

BIS XP Platform...An important refinement in brain monitoring



BIS_x



New Quatro – Jan 05



**Shaped and designed to improve
fit and adhesion,**

Ensuring the quality of the signal.

Semi Reusable Sensor (SRS) System



- 100 uses of semi-reusable cable
- 1 cable per kit
- 100 sets of 4 sensor electrodes



SRS Cable with Sensor



SRS Cable attached to sensor set
(Prior to patient placement)