Brain Function Monitoring and it’s Role in Anesthetic Management

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Learning Objectives

• Explore the rationale for monitoring brain function
• Review Bispectral Index™ (BIS) fundamentals
• Examine evidence-based results of BIS monitoring
• Provide an update on Intraoperative Awareness
• Using case studies, illustrate BIS responses during anesthesia
• Discuss clinical applications and benefits of BIS monitoring

Why Monitor Consciousness?

Anesthetic Effect Management

- BEST OUTCOMES: Quality + Safety
- Complications: Adverse Outcomes
- OVERDOSEING
- ADEQUATE/OPTIMAL
- UNDERDOSEING
- ANESTHETIC DEPTH

Side-effects
Costs
Adverse Outcomes

Adverse Outcomes
**Hemodynamics and Consciousness**

*Recovery of Consciousness after Thiopental or Propofol*

Hemodynamic signs do not correspond with a state of awareness.


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**Why Measure Brain Effects Directly?**

**Hemodynamics lack precision and utility**

**Poor correlation**
- Anesthetic dose
- Sedation and consciousness

**Inherent patient variability**
- Children/elderly patients
- Patients on cardiac medications

**Dosing considerations/restraints**
- Elderly: ↓ Requirement and ↑ CV sensitivity
- Patient profiles: Obese, ESRD, ESLD
- Altered requirements: Drug dependencies
- Intraoperative cardiovascular instability

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**Bispectral Index (BIS)**

- A practical, processed EEG parameter that measures the direct effects of anesthetics and sedatives on the brain
- Numerical scale correlates to hypnotic endpoints
- Extensive clinical validation
- Provides objective information about an individual patient’s response to anesthesia
Signal Processing

EEG/BIS Response to Anesthetics

BIS Correlates with Brain Metabolism
Clinical Impact of BIS Monitoring

Meta-analysis to examine the clinical impact of BIS monitoring on anesthetic use, incidence of PONV, duration of PACU stay and time to discharge in ambulatory anesthesia.

- 11 randomized controlled trials enrolling 1,380 subjects
- Comparison of BIS monitoring to standard practice (sp)

Key Results

BIS monitoring:
- Significantly reduced anesthetic use by 19% compared to sp
- Reduced the incidence of PONV by 16%
- Reduced PACU time by 4 minutes

Author estimated net cost of $5.55 per patient

Documented Anesthesia Benefit Summary

- Drug Savings
- Decreased PONV
- Faster Wake-Ups
- Shorter PACU Stays

Documented Benefits in Children

BIS-guided titration during general anesthesia:

- Correlates with the hypnotic component of anesthetics accurately reflecting level of consciousness
- Improves titration of general anesthetics
- 25-40% reduction in measured recovery times
- Useful during pediatric anesthesia, including cardiac

References:

Is Intraoperative Awareness a Problem?

- General Incidence: 0.1-0.2%
  Sandin, Lancet 2001; Sebel, Anesth Analg 2004
- Preoperatively, many patients are concerned
  Royston & Cox, Lancet 2003; 362:1648-58
- Patients would pay $35 to prevent awareness
- Highest risk factor for patient dissatisfaction
  Myles et al., BJA 2000; 84: 6-10
- 65% of patients do not tell their anesthetist
  Moerman et al., Anesthesiology 1993; 79:454-464

Patient Concerns Before Anesthesia

<table>
<thead>
<tr>
<th>N</th>
<th>Death</th>
<th>Awareness</th>
<th>Pain</th>
<th>PONV</th>
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<tbody>
<tr>
<td>382</td>
<td>23%</td>
<td>19%</td>
<td>5%</td>
<td>6%</td>
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<tr>
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<td>5%</td>
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<tr>
<td>800</td>
<td>37%</td>
<td>24%</td>
<td>34%</td>
<td>22%</td>
</tr>
<tr>
<td>166</td>
<td>43%</td>
<td>52%</td>
<td>38%</td>
<td>-</td>
</tr>
<tr>
<td>132</td>
<td>19%</td>
<td>-</td>
<td>39%</td>
<td>-</td>
</tr>
<tr>
<td>1216</td>
<td>12%</td>
<td>20%</td>
<td>9%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Awareness in the United States

- Large, prospective, multicenter study
- 19,576 Patients interviewed
- Postoperatively and after one week
- Convenience sampling of all patients types

Why Does Awareness Occur?

- Selection of inadequate anesthetic dose
- Resistance to anesthetics
- Mechanical malfunction or misuse of anesthetic machine

INADEQUATE ANESTHETIC EFFECT

CONSCIOUSNESS

EXPLICIT RECALL

JCAHO Sentinel Event Alert - Issue 32
Preventing, and managing the impact of anesthesia awareness

- Definition, Role of NMB
- Patient Experience & Sequelae
- Incidence (0.1-0.2%)
- “High risk” Scenarios
- Current Monitoring Limitations
- Brain monitoring devices
- Anesthesia Challenge:
  - Balance psychological risk vs. physiologic risk
- Recommendation: Develop Awareness Policy

Brain Function Monitoring
in Anesthesia Practice

Practice Advisory for Intraoperative Awareness and Brain Function Monitoring

A Report by the American Society of Anesthesiologists Task Force on Intraoperative Awareness

- Not routinely indicated for general anesthesia patients
- The decision to use a brain function monitor should be made on a case-by-case basis by the individual practitioner for selected patients

http://www.asahq.org
Emerging Role of Brain Monitors

ASA Practice Advisory Member Survey

Brain function monitors are valuable and should be used to reduce the risk of intraoperative awareness for patients with conditions that may place them at risk for intraoperative awareness.

- Strongly Agree
- Agree
- Uncertain
- Disagree
- Strongly Disagree

http://www.asahq.org

Avoiding Awareness Algorithm

1. Assess Individual Risk
2. Change Care Appropriate to Risk
3. Use Multiple Modalities

BIS Monitoring

Broad Clinical Applications

<table>
<thead>
<tr>
<th>Patients</th>
<th>Procedures</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elderly</td>
<td>Outpatient procedures</td>
<td>MAC &amp; Procedural Sedation</td>
</tr>
<tr>
<td>Obese</td>
<td>Cardiac surgery</td>
<td>Perioperative Adjunct therapy</td>
</tr>
<tr>
<td>Medically-compromised</td>
<td>Neurosurgery</td>
<td>Beta-blockers, Alpha-2 agonists</td>
</tr>
<tr>
<td></td>
<td>Office procedures</td>
<td>Closed lung anesthesia</td>
</tr>
<tr>
<td>Pediatric</td>
<td>Increased awareness risk</td>
<td></td>
</tr>
<tr>
<td>Labile</td>
<td>cardiac, trauma, obstetric,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>expected hypotension, airway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>surgery, limited cardiac reserve</td>
<td></td>
</tr>
</tbody>
</table>

086-0092 1.01
BIS Sample Profile: GA

Patient Management Table

<table>
<thead>
<tr>
<th>Physical signs</th>
<th>Clinical profile</th>
<th>BIS Index*</th>
<th>Management strategy</th>
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</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>Light</td>
<td></td>
<td>Assess level of surgical stimulation</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>Desired range (&lt;40)</td>
<td></td>
<td>Confirm delivery of hypnotic/analgesic</td>
</tr>
<tr>
<td>Movement</td>
<td>Low Value</td>
<td></td>
<td>Assess level of surgical stimulation</td>
</tr>
<tr>
<td>Autonomic responses</td>
<td></td>
<td></td>
<td>Consider ↑ hypnotic / ↓ analgesic dosing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Consider antihypertensive administration</td>
</tr>
</tbody>
</table>

*Potential impact of artifact should be considered when interpreting BIS values.

Important Information about Using BIS Monitoring

- Clinical judgment should always be used when interpreting BIS in conjunction with other available clinical signs.
- Reliance on the BIS alone for intraoperative anesthetic management is not recommended.
- As with any monitored parameter, artifacts and poor signal quality may lead to inappropriate BIS values.
- BIS values should be interpreted cautiously in patients:
  - with known neurological disorders
  - taking psychoactive medications
  - in children below the age of one

Important Considerations

EMG Tone & Neuromuscular blockers may influence BIS

- EMG Artifact: Excessive forehead muscle tone may increase BIS
- Administration of NMBA may alleviate EMG artifact & decrease BIS
- During stable anesthesia without EMG artifact, NMBA have no BIS effect

Mechanical and electrical artifacts may increase BIS values

- Forced-air warmers, surgical navigation systems
- Pacemakers, endoscopic shaver devices

Certain anesthetics may produce different BIS responses

- Ketamine
- Halothane

BIS Monitoring: Key Practical Issues

Sensor Application

SQI - Signal Quality Index
EMG - High-freq activity

BIS "Hollows" then blanks during low SQI

BIS Calculations:

- BIS values may lag 15-30 s behind clinical state due to signal processing & averaging
- Real-time EEG display available
- EMG Tone or Artifact may impact BIS value

Stryker Snap II

- Different Algorithm
- Different values
- Same intent
**Important Considerations**

- EMG tone & neuromuscular blockers may influence BIS
- Mechanical and electrical artifacts may increase BIS values
- Certain serious clinical conditions have been associated with low BIS values intraoperatively
  - Hypovolemia, hypoglycemia, hypothermia, cerebral ischemia
- Certain anesthetics may produce different BIS responses

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**Responding to a Sudden BIS Increase**

- Examine for presence of artifacts (e.g., EMG, electrocautery or high frequency signals)
- Ensure anesthetic delivery systems are operating properly
- Ensure that the anesthetic dose is sufficient
- Assess current level of surgical stimulation
- Additional patient parameters (e.g., hemodynamics)

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**Responding to a Sudden BIS Decrease**

- Assess for new pharmacologic changes
- Assess current level of surgical stimulation
- Assess for other potential physiologic changes
- Assess raw EEG for large delta waves (paradoxical delta)
70 year old female, 89 kg, ASA III, undergoing lumbar spinal decompression, fusion, instrumentation (L2-L5)

Cardiac evaluation: EF=27%

Anesthesia care:
- Premedication: Midazolam 2 mg
- Induction sequence:
  - Midazolam 2mg / Fentanyl 100mcg - divided doses during preoxygenation
  - Propofol 50mg - observed response to BIS ~40
  - Rocuronium 40 mg to facilitate endotracheal intubation
  - Esmolol 20mg and labetalol 2.5mg in response to BP 165/80

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Tulane University School of Medicine

Clinical Perspectives: Induction Management

Awareness: A Delivery Problem

80 yo female
Right shoulder surgery
GA with interscalene block
Anesthesia: propofol and remifentanil

Noted that the anesthetics were "backed up" in the IV line.

Patient was not paralyzed, but did not move during this time.

An Algorithm to Avoid Awareness

1. Assess Individual Risk

Preoperative Patient Assessment
- Previous episode of awareness
- Anticipated tolerance to opioid or narcotics
- Known or anticipated difficult airway
- Known or anticipated hemodynamic instability
- Surgical procedure with increased risk of awareness

Anesthesia Management Plans
- Muscle relaxant use during maintenance phase
- Reduced anesthetic doses during paralysis
- Total intravenous anesthesia
- Nitrous oxide-opioid anesthesia

Luginbühl, M and Schnider T. Detection of Awareness with the Bispectral Index: Two Case Reports. Anesthesiology 2002;96:241-243
An Algorithm to Avoid Awareness

2. Change Care Appropriate to Risk

3. Use Multiple Modalities

Summary

• BIS measures the hypnotic effects of anesthetics and sedatives on the brain.

• Substantial evidence demonstrates the impact of BIS-guided anesthesia care:
  • Drug use
  • Speed and quality of recovery
  • Safety

• New ASA Practice Advisory provides guidance on awareness & brain function monitoring role.

• BIS monitoring can facilitate decision-making and patient management.
**Clinical Utility in Elderly Patients**

<table>
<thead>
<tr>
<th>Average Isoflurane (% inspired)</th>
<th>Reduced Anesthetic Dosing</th>
<th>Faster Time to Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIS Titrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
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<tr>
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<td>13.1 minutes</td>
<td></td>
<td></td>
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<tr>
<td>9.5 minutes</td>
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</tbody>
</table>

- Standard Practice
- BIS Titrated

**Organ Transplantation**

- Mayo Clinic, Jacksonville Florida
- Largest liver transplant program
- 50% of patients extubated in OR
- 30% bypass ICU to floor
- BIS very important part of anesthetic plan

**New Generation Medications**

- Precedex (dexmedetomidine)
- Significant decrease in narcotics
- Significant decrease in volatile agent
- Bradycardia, hypotension masks depth of anesthesia
**BIS Monitoring Adoption**

**Published Scientific Literature**
- > 2,200 published studies

**Broad clinical experience**
- Over 13 million patients monitored to date

**Significant BIS adoption**
- Over 29,000 monitors & modules installed worldwide
- BIS monitoring available in 68% of “best” US hospitals

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**B-Unaware Trial**

+ First large independently funded evaluation of the technology
+ Reports that BIS provides no greater reduction of anesthesia awareness than a protocol guided by levels of end-tidal anesthetic gases


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**B-Unaware Trial**

+ Critics say marketing and public demand, not science drove hospitals to adopt the monitor
+ Looked at BIS vs. End Tidal Anesthetic Gas
  + ETAG - 0.7 - 1.3 MAC
  + BIS 40-60 target range
  + N= 950+ in both groups
B-Unaware Trial

+ Two patients in each high risk group had awareness
+ Aspect defended their studies
+ Rate of awareness was 80% lower with the BIS than expected in high-risk patients
+ Did not look at TIVA

Legal Aspects

+ Washington v. Washington
+ What is standard of care for patients
+ How will this change your practice

Questions?

Thank you for your attention