Bilateral Brain Function Monitoring

Chris Pomfrett  Ph.D (Clinical Scientist)
Lecturer in Neurophysiology applied to Anaesthesia

Research School of Clinical & Laboratory Sciences
The University of Manchester

http://www.medicine.manchester.ac.uk/staff/ChrisPomfrett
Selected chapters:

Hemispheric asymmetry, autonomic asymmetry, and the problem of sudden cardiac death Lane, R.D., & Jennings, J.R.

Brain asymmetry in the control of autonomic-physiologic activity Wittling, W.

Anatomic basis of cerebral dominance Galaburda, A.M.

Hemispheric asymmetry for components of visual image processing Brown, H.D. & Kosslyn, S.M.

Handedness and its relation to other indices of cerebral lateralization Peters, M.

Cerebral asymmetry, emotion, and affective style Davidson, R.J.
Figure 1  Language areas with anatomical and functional asymmetries. Broca’s speech area (green) and Wernicke’s language-comprehension area (blue) are identified on a transparent surface model of the human cerebral cortex. All cortical regions are heavily interconnected with corresponding systems in the opposite brain hemisphere, through the corpus callosum (yellow). The language areas show profound asymmetries, both structurally and functionally, the left hemisphere being dominant for language in most right-handed individuals.

Bilateral Brain Structure, Function & Neurochemistry
(as seen in the majority of right-handed subjects)

<table>
<thead>
<tr>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wada test transiently impairs speech</td>
<td>Wada test transiently makes singing monotone</td>
</tr>
<tr>
<td>Dopaminergic (globus pallidus &amp; basal ganglia)</td>
<td>Noradrenergic (ventro-lateral thalamus)</td>
</tr>
<tr>
<td>Language comprehension (Wernicke’s area)</td>
<td>Central sulcus larger (primary motor cortex)</td>
</tr>
<tr>
<td>Language production (Broca’s area)</td>
<td>90% of dyslexics right hemisphere language-dominant</td>
</tr>
<tr>
<td>Handedness (planum temporale)</td>
<td>Regulation of cardiac autonomic function (Lane &amp; Jennings, 1995)</td>
</tr>
<tr>
<td>Semantic dementia &amp; Alzheimer’s show</td>
<td>Brain-heart laterality hypothesis</td>
</tr>
<tr>
<td>increased damage to left side</td>
<td></td>
</tr>
</tbody>
</table>

Nature Reviews Neuroscience 4: 37-48
Baseline brain function differs between awake individuals.

18FDG PET measures absolute brain metabolism (µmoles glucose/100ml/min)

Alkire et al, 1999
Halothane
Loss of response to verbal command

S1; 1% ET;
28% reduction

S2; 0.7% ET;
41% reduction

S3; 0.5% ET;
44% reduction

S4; 0.8% ET;
53% reduction

Alkire et al, 1999
PET functional imaging reveals asymmetry in cerebral metabolic rate with 18FDG; SPM p<0.01; significant reductions in glucose metabolism with halothane.

Alpha | Beta | Delta | Theta

95% Spectral Edge Frequency (SEF)

50% Median Frequency

EEG & PET

Alkire (pers com.)
Asymmetry of vagal autonomic function during hypnotic anaesthesia

SPM96 PET Correlation

GMR: Respiratory sinus arrhythmia: ET Isoflurane p<0.01

TOWARD A MONITOR OF DEPTH: BISPECTRAL INDEX (BIS) AND RESPIRATORY SINUS ARRHYTHMIA (RSA) BOTH MONITOR CEREBRAL METABOLIC REDUCTION DURING ISOFLURANE ANESTHESIA

M.T. Alkire, M.D., and C.J.D. Pomfrett*, Ph.D.
Department of Anesthesiology, University of California-Irvine, Medical Center, Orange CA. 92668,
* Department of Anaesthesia, University of Manchester, UK.

Introduction: Recent Tomography (PET) has rev cerebral metabolic reduct propofol anesthesia can be c

Discussion: These data show that BIS (a construct derived from cortical EEG activity) and RSA (a directly monitored brain-stem physiologic response to anesthesia) are both

Alkire M.T., Pomfrett C.J.D. (1997) Anesthesiology 87(3A):A421
Components of the Bispectral Index

Nassib Chamoun, inventor of BIS
RSM Consciousness & Anaesthesia 12 May 2006

SyncFastSlow
BetaRatio
QUAZI
SR
BIS

BIS/Core Indices

Target [Prop] (ng/ml)

Rampil, Anesthesiology 1998; 89: 980-1002
A-1000 headstage

- 2 channel referential montage
- F7(ground) - FP1(left)
- F8(ref) - FP2(right)
BIS asymmetry after induction (n=3/19)

Propofol

(Pomfrett/Pollard/Longmuir/Kapila, MAA, NYC 2001)
BIS asymmetry
19 day old neonate

BIS asymmetry graph showing BIS values for channels 1 and 2 over time, with sevoflurane concentration as a variable. The graph indicates BIS asymmetry and the use of sevoflurane (% ET) in a 19 day old neonate.

Bryan et al pers.com.
Effect of fEMG on BIS

MB1 Isoflurane GA Volunteer

Elapsed Time (s)

BIS

% Isoflurane

B30U01
EMGHI01
ExAA
InAA
Saline (n=11)

Anaesthetised
Isoflurane 0.92% +- 0.45
Saline (n=11)

**Anaesthetised**
Isoflurane 0.92% ± 0.45

Control 2  Control 3  Control 7  Control 8

**Awake**

BIS

DSIP (25nM.kg\(^{-1}\), n=4)

**Anaesthetised**
Isoflurane 0.73% ± 0.36

A2  A3  A7  A8  Epoch

**Awake**
Figure 1. Aspect’s VISTA Monitor™ and bilateral sensor (under development). The analysis herein used data collected using individual electrodes placed to collect bilateral single-channel EEG for BIS 3.4 processing.

Paul Manberg, Ph.D., Hongmei Cai, Ph.D., and Scott Greenwald, Ph.D. pers comm.
Electrical Impedance Tomography (EIT)

- Array of voltage measurements
- Detects conductance changes as current flows through tissue
- Pairs of current injection and recording electrodes
- Portable
- Relatively inexpensive
- High temporal resolution
- Poor spatial resolution
fEITER
functional EIT from evoked response

CED power1401
Fast ADC (EEG) and programmable pulse generator

LED Driver

Flash Goggles

Neurolog EEG amplifier

Human head

Headphones

PC

 Archived EEG

current signals

voltage signals
fEITER sub-second response to flash visual stimuli

\( n = 1 \) relative to no-flash control

Team:
H McCann, N Polydorides, J C Murrieta-Lee, PCW Beatty, R Waterfall, C Mussel, CJD Pomfrett

A 71 ms
B 126 ms
C 193 ms
D 240 ms
E 334 ms
Conclusions

• The brain has asymmetry of some basic function e.g.
  – Handedness
  – Speech & language
  – Autonomic control

• Bilateral function changes dynamically during some clinical interventions e.g.
  – Anaesthesia
  – Analgesia
  – Administration of one endogenous regulatory peptide

• Monitoring bilateral brain function is of interest for future study
MHRA

- All commercial monitors of anaesthetic depth to be placed on the market in the UK since 2003 need MHRA approval (competent body for the EU Medical Device Directive and CE marking)
- Portfolio of evidence for safety and efficacy
- Similar to US FDA 510k approval process
- Restricts usage to approved consumables and instructions
- Restricts development of commercial products by clinical researchers