28th ANNUAL MEETING
SOCIETY FOR PEDIATRIC ANESTHESIA
NEW ORLEANS, LA

Monitoring the Pediatric Brain Under General Anesthesia

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October 10, 2014

Outline

A. A Clinical Look at General Anesthesia

B. Loss of Consciousness from Propofol in Adults

C. Defining the Anesthetic State As a Function of Age

D. Conclusion: The Dynamics of the Anesthetized Brain

Learning Objectives

1. Learn the neural circuit mechanisms of action of the commonly used anesthetics in adults.

2. Learn how the EEG signatures of the commonly used anesthetics relate to the neural circuit mechanisms of action in adults.

3. Review the principal milestones of brain development in children.

4. Learn to distinguish the differences in the anesthetic states between adults and children of different ages.

A Clinical Look at General Anesthesia in Adults

What is General Anesthesia?

A drug-induced, **reversible** state comprised of

Unconsciousness

Amnesia (loss of memory)

Analgesia (loss of pain perception)

Akinesia (loss of movement)

and

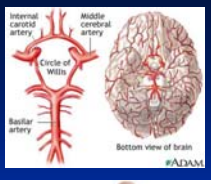
Stability and Control of the cardiovascular, respiratory thermoregulatory and autonomic nervous systems.

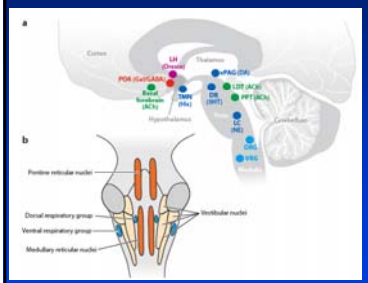
How Drugs Cause General Anesthesia is Unknown?

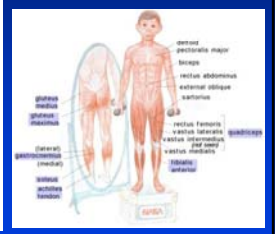
Brown, Lydic, Schiff (2010)

Propofol's Effects in the Brain Stem

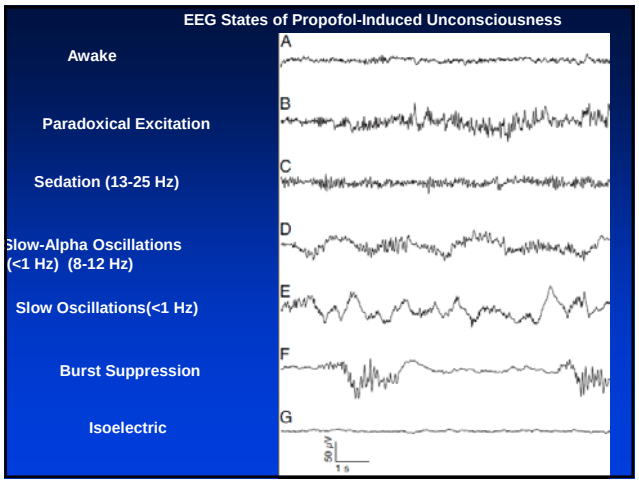
A. Stop Breathing
B. Lose Muscle Tone
C. Unconscious

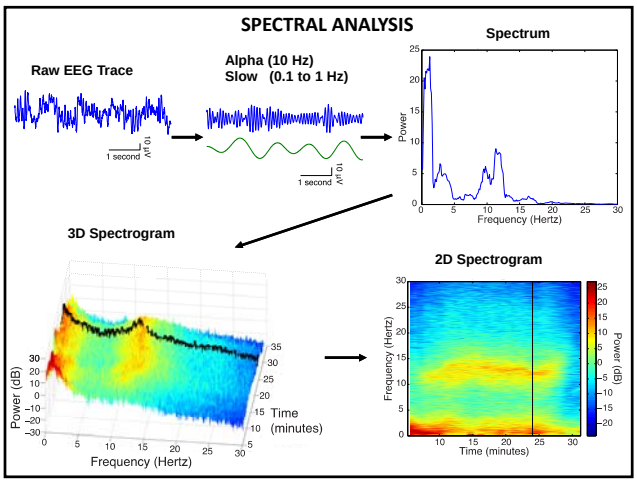


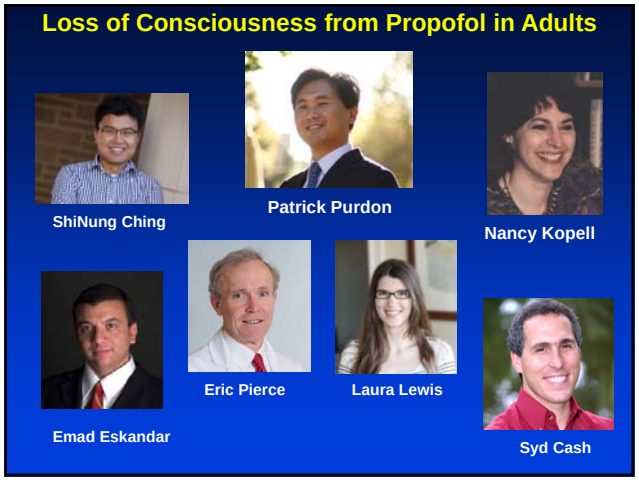


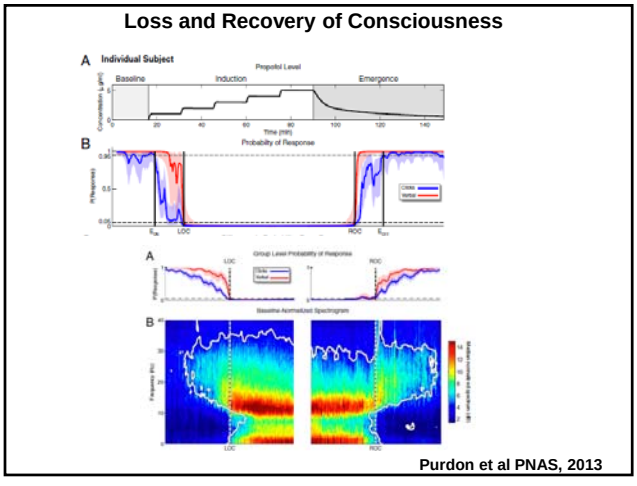


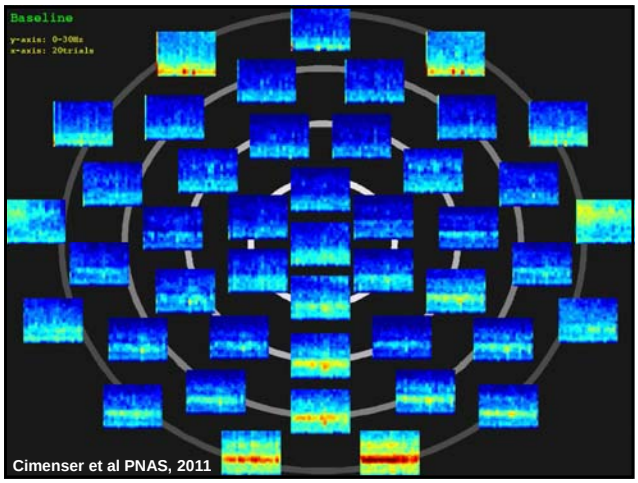
Brown , Purdon, Van Dort Annual Review of Neuroscience (2011)


EEG States of Propofol-Induced Unconsciousness
Awake
Paradoxical Excitation
Sedation (13-25 Hz)
Slow-Alpha Oscillations
(<1 Hz) (8-12 Hz)
Slow Oscillations(<1 Hz)
Burst Suppression
Isoelectric
A
B
C
D
E
F
G


SPECTRAL ANALYSIS
Raw EEG Trace
Alpha (10 Hz)
Slow (0.1 to 1 Hz)
Spectrum
Power
Frequency (Hertz)
3D Spectrogram
2D Spectrogram
Power (dB)
Time (minutes)
Frequency (Hertz)

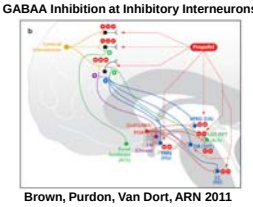

Loss of Consciousness from Propofol in Adults
ShiNung Ching
Patrick Purdon
Nancy Kopell
Emad Eskandar
Eric Pierce
Laura Lewis
Syd Cash


Loss and Recovery of Consciousness
Purdon et al PNAS, 2013

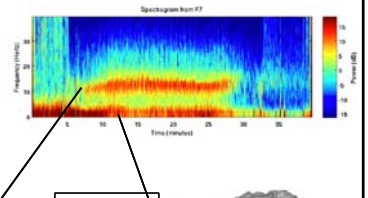


Mechanisms for Alpha and Slow Oscillations

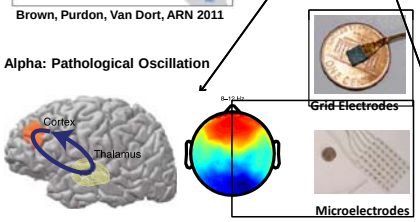
GABAA Inhibition at Inhibitory Interneurons

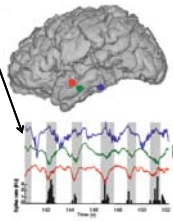


Brown, Purdon, Van Dort, ARN 2011



Alpha: Pathological Oscillation



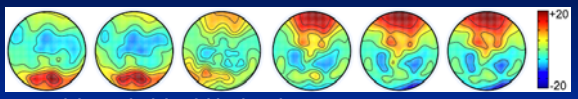


Purdon et al. PNAS 2013; Cimenser et al. *PNAS*, 2011; Ching et al. *PNAS*, 2010

Lewis et al. PNAS, 2012

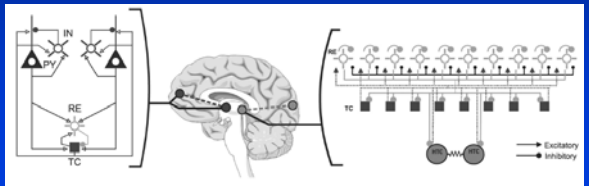
Anteriorization

Electoencephalogram



Tinker and Michenfelder (1977)

Mathematical Modeling



Ching et al. *PNAS*, 2010

Vijayan et al. *J. Neurosci*, 2013

Summary

Loss of Consciousness from Propofol

1. Pathological "Hum" Alpha Oscillations at 8 to 12 Hz.

2. Fragmentation of the Cortex Marked by Slow Oscillations (<1 Hz).

3. Anteriorization (Frontal-Parietal Disconnect).

4. Inactivates the Arousal Centers in the Brainstem.

Defining the Anesthetic State As a Function of Age


Patrick Purdon


Laura Cornelissen

Seong-Eun Kim


Charles Berde


Seun Akeju


Johanna Lee


Jasmine Thum

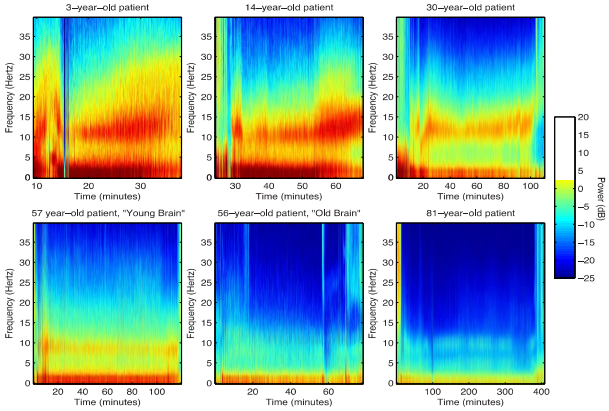

Kara Pavone

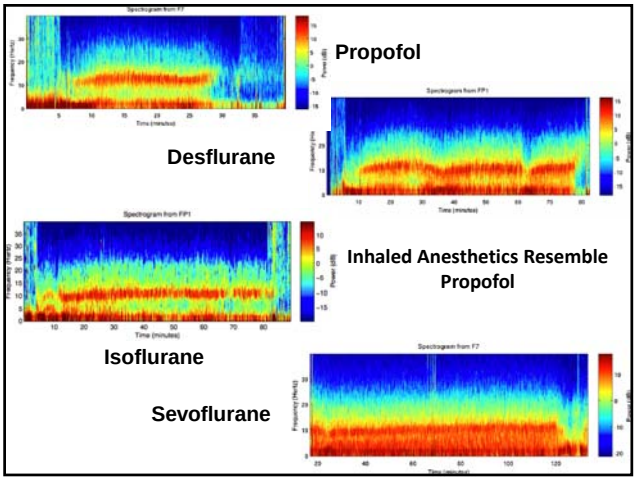

Paul Firth


Kristina Terzakis


Erik Shank

Spectrograms of the Ages





Conclusions: Dynamics of the Anesthetized Brain

Anesthetics creates altered arousal states by changing brain dynamics.

The nature of these dynamics (anesthetic state) changes with age likely in relation to brain development.

Understanding these changes in dynamics will allow us to

i) understand more precisely anesthetic mechanisms

ii) develop better methods for monitoring the brain under anesthesia, especially for children

iii) develop new approaches for creating the states of general anesthesia and sedation.

Funding Support
This research has been supported in part by:

The Department of Anesthesia, Critical Care and Pain Medicine at MGH

NIH Director's Pioneer Award
NIH Director's Transformative Research Award
NIH New Innovator Award

K25-NS057580-01, K08-GM094394, K08-GM083216

Canadian Institute of Health Research Fellowship

NSF Graduate Research Fellowship, Borrough-Wellcome Fund
Foundation for Anesthesia Education and Research