The neurology of consciousness: what can we learn from the vegetative state?

Steven Laureys

Coma Science Group
Cyclotron Research Centre & Neurology Dept.
University of Liège, Belgium
Overview

Disorders of consciousness
Behavioural evaluation
Electrophysiology
Neuroimaging
Ethics & quality of life

Terry Schiavo °1963, vegetative 1990, † 2005
Mind brain beliefs

- The Mind and Brain are two separate things: 67% agree, 33% disagree.
- The Mind is fundamentally physical: 36% agree, 64% disagree.
- Some spiritual part of us survives death: 70% agree, 30% disagree.
- Each of us has a soul which is separate from the body: 65% agree, 35% disagree.
Disorders of consciousness
Clinical evaluation
Motor activity in brain death

residual spinal activity:
- finger jerks
- undulating toe flexion sign
- triple flexion response
- Lazarus sign
- pronation-extension reflex
- facial myokymia

Lazarus’ sign in brain death
Bueri et al Mov Disord. 2000, 15:583-6
Blink and you live
Electrophysiology
EEG-BIS in coma

Schnakers, Majerus and Laureys, Neuropsychological Rehabilitation, 2005
Cognitive evoked potentials

minimally conscious state

Laureys, Perrin et al., Neurology, 2004

www.comascience.org
P300 to given name

Perrin et al, Archives in Neurology, 2006
Neuroimaging

① resting brain function
② brain activation studies
  • passive paradigms
  • active paradigms
Neuroimaging
Resting metabolism

Laureys, Owen & Schiff, Lancet Neurology, 2004 (sleep data from Pierre Maquet; anesthesia data from Mike Alkire)
Regional changes

Laureys et al, New Encyclopedia of Neuroscience (Ed.) Larry Squire, in press

n=60
“default” resting state
default activity predicts perception

3 seconds before simulation:

- default *lateral fronto-parietal* activity is high
  \( \Rightarrow \) stimuli will be *perceived*

- default *medial parietal* activity is high
  \( \Rightarrow \) stimuli will be *missed*
Functional connectivity
Thalamic stimulation

![Thalamic stimulation image]

Object Naming During Titration

![Object Naming graph]

- **OFF**: P < 0.001
- **ON**

**Frequency of rating (Object Naming)**

- Intelligible
- Non-intelligible
- No response

Schiff et al., Nature, 2007
Pharmacological stimulation

Schnakers et al, JNNP in press
Neuroimaging

① resting brain function
② brain activation studies
  • passive paradigms
  • active paradigms
Vegetative is not brain dead

Cortical activation

Controls (n=15)

PVS (n=15)

Laureys et al., Neuroimage, 2002
Disconnected S1
"...a (wo)men’s brain is a mystery... and even more so in this state."

Pedro Almodóvar

www.comascience.org
Do they hear anything?

Laureys et al., Brain, 2000
Boly et al, Archives of Neurology, 2004
Emotional processing

Laureys et al., Neurology, 2004
Neuroimaging

① resting brain function

② brain activation studies
  • passive paradigms
  • active paradigms
When thoughts become action
Passive paradigms

Speech minus acoustically-matched noise

Patient

Controls

X = -60

Y = -30

Owen, Coleman, Boly, Davis, Laureys and Pickard, Science, 2006
Active paradigms

*Tennis Imagery* and *Spatial Navigation Imagery*

- **Patient:**
  - SMA
- **Controls:**
  - SMA

*Owen, Coleman, Boly, Davis, Laureys and Pickard, Science, 2006*
fMRI precedes the clinic

Di et al, Neurology, 2007
Ethics & quality of life
Locked-in syndrome (LIS)
Quality of life in LIS

Short Form-36
n=17
duration 6±4 y
Conclusions
Not all “coma”

Laureys, Owen and Schiff, Lancet Neurology, 2005

www.comascience.org
Take home

- **Need for objective markers** of consciousness in comatose states

- **Vegetative state**: disconnection syndrome with dysfunction of fronto-parietal network of “higher order” cortices (default network)

- **Minimally conscious state**: intact pain & emotional perception

- **Locked-in syndrome**: unexpected self-scored quality of life

- Much more **research** is needed