

Electroconvulsive Therapy

Seizure activity and threshold

- defined as the minimum amount of electrical energy that is required to induce cerebral seizure activity of a defined length
- higher in:
 - men
 - older people
 - bilateral ECT
- this results in an initial variation in threshold of up to 4000%
- ECT is anticonvulsant - in some patients there is a gradual reduction in the length of convulsive muscular activity, and a gradual rise in the seizure threshold which is more marked over the first few treatments
- the efficacy of unilateral ECT and the rate of improvement during a course of bilateral ECT correlate with the extent to which the dose of electrical energy exceeds the seizure threshold

Factor	Effect on Seizure threshold
Increasing age	raise
Anti-convulsants	raise
Baldness	raise
Barbiturates	raise
Benzodiazepines	raise
Bilateral electrode placement	raise
Bones (thick)	raise
Caffeine	lower
CO ₂ (low)	lower
Dehydration	raise
ECT (increasing number of treatments)	raise
ECT (previous course in last month)	raise
Electrode contact (poor)	raise
Hyperventilation	lower
Methohexitone in low dose	lower
Methohexitone dose > 1.2 mg/ kg	raise
Oxygen saturation (low)	raise
Propofol	raise
Sex (male)	raise

Electrical activity

- initially, high voltage high frequency spike waves occur simultaneously throughout the brain - correspond to the tonic phase of the convulsion
 - neocortical in origin (compared to epileptic activity which originates in the diencephalon)

- pattern then evolves into a characteristic polyspike and slow-wave complex often at 2-3 Hz - typical of generalized seizure activity
- seizure termination is often associated with abrupt flattening of the EEG, the 'post-ictal suppression' or *fitswitch*
- cerebral seizure activity measured by EEG last about 30 % longer than visible convulsive muscular activity

Effects on the brain

- increased cerebral blood flow

Systemic effects

- rise in body temperature - due to convulsive activity
- tachycardia - due to sympathetic activity

Long-term effects

- reduced frequency and increased amplitude of EEG
- bilateral ECT is associated with either symmetrical slowing or slowing more marked over the dominant hemisphere
- unilateral ECT may result in slowing more marked over the stimulated hemisphere
- these cumulative changes gradually disappear after the course of treatment
 - the time required for this varies inversely with the number of treatments
- in most people, these changes have disappeared by 1 month, and it is rare for changes to persist after 3 months

Endocrine effects

- ACTH and cortisol: increased release
- prolactin: increased release
 - simulated ECT doubles serum prolactin concentration
 - real ECT leads to a several fold rise that peaks 10-15 minutes after treatment
 - bilateral ECT is associated with a peak 25-50% higher than unilateral treatment
- Growth hormone: not affected
- TSH: not affected
- oxytocin and ADH released from the posterior pituitary
 - maximum release occurs within 2 minutes
 - suprathreshold ECT releases more oxytocin

Neurochemical activity

Noradrenergic transmission

Acute:

- increased plasma catecholamines, especially adrenaline
- increased cerebral plasma tyrosine hydroxylase activity
- increased cerebral noradrenaline

Chronic:

- decreased beta-adrenoceptor density

Serotonergic function

Acute:

- increased cerebral serotonin concentration

Chronic:

- increase in post-synaptic 5-HT₂ receptors

Dopaminergic function

Acute:

- increased cerebral dopamine concentration
- increased cerebral concentration of dopamine metabolites
- increased behavioural responsiveness to dopamine agonists

Chronic:

- increased D₁ receptor density
- increased second-messenger potentiation at dopamine D₁ receptors

GABA function

- acute increase in the release of GABA – may be responsible for the neuroal hypometabolic rate subsequent to ECT
- acute increase in GABA_B binding

Cholinergic function

- increased:
 - cerebral acetyltransferase activity
 - cerebral acetylcholinesterase activity
 - CSF acetylcholine concentration
- decreased:
 - cerebral acetylcholine concentration

Chronic:

- reduced muscarinic cholinergic receptor density in the cerebral cortex
 - reduced muscarinic cholinergic receptor density in the hippocampus
 - decreased second messenger response in the hippocampus
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- ECT can reduce the signs of Parkinson's disease (and has been used to treat PD)

Endogenous opioids

Chronic:

- increased cerebral met-enkephalin concentration and synthesis
- increased cerebral β -endorphin concentration and synthesis
- changes in opioid ligand binding

Brain Imaging studies

- no evidence of structural changes
- MRI:
 - small increase in T_1 relaxation that was maximal after two hours, and complete after 24 hours
 - may represent increased permeability to water (and perhaps other psychoactive peptides) in the blood brain barrier
- PET and SPET:
 - small reductions in uptake bilaterally in the *inferior anterior cingulate cortex* 45 minutes after a single treatment