Electroconvulsive Therapy Workshop

ECT: Technique and Equipment

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No disclosures to declare.
The Art of ECT

- Ensure medical safety
- Minimize cognitive adverse effects
- Optimize symptom reduction
Symptom recovery/ cognitive outcome determined by:

- electrode placement
- pulse parameters
- stimulus dose in relation to seizure threshold
- degree of cognitive impairment prior to ECT
- ECT frequency
- concurrent use of medications
Electrode Placements in ECT

- Bitemporal
- Right (or left) unilateral
- Bifrontal
Clinical Application:
Does where we place electrodes impact cognition and degree of benefit?
Current Density

Weaver, Williams and Rush
1975 Biological Psychiatry

Grid: 1154 1-cm³ volumes; current density of each calculated
Current Density in Bilateral and Unilateral ECT: Findings

Unilateral Electrode Placement

- Current densities are greatest directly underneath the electrodes and
- In the areas of the brain in the cortex along the inter-electrode axis i.e. “the entire scalp region serves as a virtual electrode”

Bilateral Electrode Placement

- The bilateral placement induces a significantly higher current density in almost all areas of the brain than RUL
- Current density is greatest directly underneath the electrodes and
- Current density is next greatest in the frontal lobes anterior to the inter-electrode axis

Weaver, Williams and Rush
1975 Biological Psychiatry
The influence of electrode placement on electrical current:

Excitability of the brain varies:
i.e. the motor strip has the lowest intrinsic seizure threshold

Theoretically → unilateral ECT should require a lower dose than bilateral ECT

*But:* Unilateral (UL) electrodes are closer together than bitemporal electrodes → increased shunting through the scalp results
i.e. a 1/3 decrease of overall current density is lost

D’Elia position = the preferred UL placement maximizes inter-electrode distance

1986 Mukherjee & Sackeim:
Bifrontal Electrode Placement

1969 J. Inglis
1972 Abrams/Fink

Goal: Avoid hippocampal gyri

Abrams: electrodes 2” apart, daily ECT, sine wave device
Result: - skin burns
       - little benefit over UL
       → abandoned
Bifrontal Electrodes

Letemendia 1993
   5 cm. above outer corner of eye on a sagittal plane

Bailine 2000
Delva 2001
Heikman 2002
Sienart 2009
Kellner 2010 & 2010
Dunne 2012
Phutane 2013
Left Unilateral ECT

1968-1970:
6 studies all conclude RUL>LUL
Bad reputation results
*BUT*: Sinewave devices, non-d’Elia positions

1989: Abrams, R.
30 depressed Veterans
Ham-D after ECT #3 & #6: excellent recovery
ECT in Left-handed patients

- ~70% are left-hemisphere dominant for language
- ~15% are right-hemispheric dominant
- ~15% have bilateral hemispheric language representation
  
  Bryden 1982

Caution:

- "handedness" for writing may not be in keeping with hemispheric representation for language
  
  ie: many left-handed people have been forced to write with their right hand
- Some "right handed" people are actually ambidextrous

Bottom line: Right unilateral ECT is usually administered, regardless of handedness
CANECTS/ECANEC 2008

Preferred electrode placement according to number of treatments per year
Schools of Dosing Protocols

- Half age-based
- Fixed high dose RUL
- Titration Method
Modern ECT Devices

Brief Pulse Device

Pulse Width

Current

Frequency
Modern ECT Devices

Brief Pulse Device

Duration ("Pulse Train")

+ -
Brief Pulse Device

- Brief Pulse = 0.5-2 msec
- Ultra brief Pulse = <0.5 msec
- Brief rectangular shaped pulses with an instantaneous rise and fall are a more efficient way of neuronal excitation than are sine waves and create dramatically less cognitive side effects
Charge in ECT

- ECT treatment response depends on dosage

- By convention Total Charge mC – the amount of electricity - has been adopted as the “equivalent” of dose

- Charge has been used for decades as an outcome measure in ECT research but the appropriate equivalent of “mg” in ECT is in fact unknown.

- “Total Charge” obscures the ECT pulse parameters

- An infinite number of pulse parameter combinations exist which all result in the same total Charge (see next slide)

  e.g. Much less Charge is required to induce a seizure with a pulse width of 0.3 msec than with a pulse width of 1.5 msec.
Figure A: Total Charge = 3.2 mC  PW 0.5 msec  Frequency 100 pps  amp 800mA  pulses = 8

Figure B: Total Charge = 3.2 mC  PW 8 msec  Frequency 100 pps  amp 50 mA  pulses = 8
Effects of pulse parameters on ECT outcome

High ST is *amplified* by ECT pulse parameters which are inefficient at high doses

“This is an artefact of the titration schedule itself, rather than a true indication of biological differences between patients.”

Namely:

Titration schedules which drive up the frequency and the pw rather than the pulse trains iatrogenically raise seizure thresholds – which is *not* a reflection of a patient’s own inherent ST

Peterchev, Rosa, Deng, Prudic, Lisanby
J ECT 2010;26: 159-174
Longer pulse trains require less Charge

**Mounting evidence:**

shorter pw + lower amplitude + larger # of pulses results in the same benefit as pulses with

longer pw + higher amplitude + less # pulses

*but with less cognitive side effects*
ECT Dosing Strategies (cont’d)

The Half-Age Method

- Bilateral ECT
- Twice Weekly
- Starting dose = energy level of ½ patient’s age
  
e.g. Age 60- start at 30% of the maximum output deliverable by the device.

- Petrides, Fink 1996
ECT Dosing Strategies (Cont’d)

Fixed High-Dose Right Unilateral

- All ECT at maximum capacity
- 0.25-0.5 ms pulse width
- 8 sec. pulse train

If no improvement, switch to Bilateral ECT

Abrams 2002
ECT Dosing Strategies (Cont’d)

Titration Method

Response Rates

Low-dose RUL: 17%

High-dose RUL: 43%

Low-dose BL: 65%

High-dose BL: 63%

Seizure Threshold in ECT

B.

A.

Seizure threshold
ECT Dosing Strategies

- Titration Method

ECT # 1: “Finding” Seizure Threshold

- Stimulate with a low electrical test dose (sub convulsive for majority of patients)

- If no seizure results, **under the same anesthetic**, restimulate at a higher dose until a seizure is obtained - up to 4 stimuli: 3 is usual

*Sackeim, Decina, Kanzler, 1987*
### Table 5–6. Dose titration techniques for MECTA SpECTrum models (ultra-brief-pulse stimuli)

<table>
<thead>
<tr>
<th>Dose level</th>
<th>MECTA SpECTrum 4000Q/5000Q</th>
<th>MECTA SpECTrum 4000M/5000M</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>PW (msec)</td>
<td>F (/sec)</td>
</tr>
<tr>
<td>1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.3</td>
<td>20</td>
</tr>
<tr>
<td>2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.3</td>
<td>30</td>
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<tr>
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<td>0.3</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>0.37</td>
<td>120</td>
</tr>
</tbody>
</table>

**Note.** 
amp = amperes; mcoul = millicoulombs; msec = milliseconds; sec = seconds; /sec = Hertz. 

<sup>a</sup>Percent of maximum output charge. 
<sup>b</sup>Start at dose level 1 for unilateral ECT in female patients. 
<sup>c</sup>Start at dose level 2 for bilateral ECT in female patients or unilateral ECT in male patients. 
<sup>d</sup>Start at dose level 3 for bilateral ECT in male patients.
ECT #2: if necessary continue to restimulate at higher doses until a seizure ensues

Various dosing protocols are available to select increasing doses from, to avoid the Gestalt method

In general:
For BF & BL ECT: increase by 1.5-2.0 X threshold
For UL ECT: increase by 2.5-6.0 X threshold
Maintain same dose, or gradually increase using:

1. EEG morphology AND
2. Clinical response

as a guide.
6.12 If the ECT electrical stimulus results in no seizure activity, what procedure is usually followed at your facility? (check one only)

- No specified procedure (88.6%)
- Immediately re-stimulate at the same stimulus intensity (3.8%)
- Immediately re-stimulate at a higher stimulus intensity (1.9%)
- Use a higher stimulus setting at the next treatment session (5.7%)
ECT “Adequacy”

A. Clinical response

B. EEG Morphology

1. High Amplitude

2. Presence of polyspike and slow wave activity = Delta Waves

3. Interhemispheric ictal coherence = “symmetry”

4. Sharp onset of and sustained post-ictal suppression

Krystal, Weiner, Coffey 1995
- Simply creating a seizure is not good enough

- Seizure length is not a measure of seizure adequacy
Schools of Dosing Protocols: Concerns

- Titration: sub-threshold stimuli may bear risk (parasympathetic response)

- The Age-based and Fixed-high Dose methods:
  - seizure threshold (ST) varies from 36 to 869 mC (24-fold) yet
  - age accounts for only 17% of the variability (Boylan L) therefore

*risk of treating with unnecessarily high stimuli in patients with low ST and visa versa*
General Agreement Exists:

- Patients respond faster to BT ECT than RUL ECT

- Patients who do not respond to RUL ECT may undergo a significant clinical improvement with BT ECT

- BT ECT results in greater cognitive SE that RUL ECT

- Relative stimulus intensity – but not absolute stimulus intensity is a significant predictor of response
Basis for choosing treatment intensity of the 1st stimulus for:

- bilateral (BL)
- bifrontal (BF)
- right unilateral (RUL) electrode placements
Missed or Aborted Seizures

Possible Causes:

- excessive impedance from poor skin contact
- stimulating electrodes not screwed in firmly enough
- hypercarbia from inadequate ventilation
- hypoxia from inadequate ventilation
- dehydration
- medications (benzodiazepines, anticonvulsants)
- insufficient stimulus
Missed or Aborted Seizures (cont’d)

correct above measures

missed:
  - restimulate after 20 sec at a higher dose

aborted:
  - restimulate after 45 sec at a higher dose to allow repolarization
  - caffeine sodium benzoate 500-2000 mg. po 1 hour pre-ECT with 50cc H2O
  - **flumazenil** 0.2 - 0.4 mg. I.V. (max. 1 mg.)
  - if high dose benzodiazepines
  - midazolam in P.A.R. to prevent withdrawal
  - **LIFE SAVING**

*Bailine 1994; Krystal 1998*
Elements of ECT Technique

- Skin Preparation
- Mouth guard & non-conducting jaw support
- Rails down, footboards off
- Peripheral nerve stimulator +/-
- Pre-oxygenation
- Optimize electrode-to-scalp contact
Only 10 – 20% charge delivered by the ECT device enters the brain.

**Impedance** = resistivity + capacitance

*Capacitance* = the property of being able to *accumulate charge*

**Resistivity:**

- **CSF:** 65 ohms/cm  
  (Geddes & Baker, 1967)
- **scalp + brain:** 220 ohms/cm  
  (Rush & Driscoll, 1968 and 1970)
- **skull:** 17,760 ohms/cm  
  (Driscoll, 1970)

**Result:**

80 – 95% current is resisted by the skull and shunted through the scalp.
Monitoring Seizures

EEG

Ictal Motor Activity

➢ Cuff Method
  • Prior to succinylcholine, inflate cuff above ankle to 100 mm Hg above Systolic B.P.

➢ Peripheral nerve stimulator
  • Takes the guesswork out of finding the Point of Maximum Relaxation (PMR) Average: 90 seconds
  • Essential for patients with
    – Osteoporosis
    – Slowed circulation time
    – Co-existent fractures (e.g. post-suicide attempt)