Troubleshooting algorithms for common DBS related problems in tremor and dystonia

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Side Effects after DBS

**Stimulation-Related**
- Motor and non-motor signs
- Inappropriate programming
- Loss of benefit/tolerance

**Device-Related**
- Infection
- Skin erosion
- Fracture
- Malfunctioning
- Pain
- Migration

**Disease-Related**
- Loss of benefit
- Tolerance

**Patient-Related**
- Poor compliance
- Wrong expectations
- Ethical Issues
DBS-related issues in Tremor: Vim

- Speech worsening: dysarthria
- Balance issues
- Dystonia
- Contractions
- Taste changes
- Paresthesias
Basic algorithm for management of balance and speech issues in ET patients with Vim DBS

1. Balance and/or speech issues
   - Start reducing spreading of energy
   - Reduce pulse width (if > 60 μsec)

2. End programming
   - Balance and/or speech and tremor are satisfactory
     - Reduce frequency of stimulation (if > 130 Hz)
       - Reduce amplitude of stimulation
         - Balance and/or speech and tremor are satisfactory
           - Switch to a dorsal contact
             - Balance and/or speech and tremor are satisfactory
               - Switch to bipolar stimulation
                 - Balance and/or speech and tremor are satisfactory
                   - Switch to interleaving stimulation
                     - Choose the best settings and start rehabilitation
                       - End programming

Picillo et al, 2016
Individualized current-shaping reduces DBS-induced dysarthria in patients with essential tremor
(Barbe et al, 2014)

Electrode localization of one patient with exemplary tremor and speech parameters. Figure 1. (A) Electrode localization and simulation of the volume of tissue activated was performed with Optivise (Medtronic Inc.) for the left electrode of patient 3 during interleaving stimulation (ILS) and current-shaping ILS (cs-ILS) conditions. Individual anatomical landmarks: the thalamus is shown in magenta, the ventral intermediate nucleus inside the thalamus in dark blue, the red nucleus in orange, the zona incerta in green, and the subthalamic nucleus in light blue. Note that with ILS, the 2 pulses are not applied simultaneously to the tissue (as implicated here) but in a temporally alternating sequence. (B) In this patient, when comparing cs-ILS with ILS, there was an improvement of speech parameters, especially self-reported overall speech on the visual analog scale (VAS) (in pts [points]), with no deterioration of tremor control measured with the Tremor Rating Scale (TRS) and kinematic analysis of postural tremor (TTD postural = total travel distance of postural tremor).
Using Groups

- Clinicians can program up to 4 sets (A-D) of therapy parameters, selectable by the patient
  - Optimal for those who require frequent therapy adjustments and are highly clinician dependent
  - Patients can select from up to 4 groups of different therapy parameters and view their therapy settings on an LCD screen on demand
  - Designed to increase patient involvement, empowerment, independence and freedom
    - Can be adjusted over time
    - Can be targeted at specific daily living activity
The “Art” of DBS Programming

- **Coubes et al, 2000**
  - Low voltage (1-2V), 130Hz, 450 micros
  - Single, double monopolar

- **Kumar et al, 2002**:
  - 130-185Hz, 60micros, monopolar
  - Increase PW if no benefit
  - Double monopolar
  - 50 Hz

- **Vidailhet et al, 2005**: 130 Hz, 60 micros, monopolar

- **Kupsch et al, 2006**: 130 Hz, 120 micros, monopolar

- **Woehrle et al, 2009**: 130 Hz, 210 micros, bipolar stimulation
Issues with programming of Dystonia: GPi

- Programming protocols vary between centers
- Differences in parameters according to the type of dystonia
  - Differences inside the same type of dystonia
- Differences in timing of improvement
- Stimulating with two different brain targets
- Stimulation-related side effects
  - Short-term
  - Long-term
- Non-stimulation-related issues
Deep Brain Stimulation for Dystonia:
The State of the Art
GPi: Medial Observed Effects

<table>
<thead>
<tr>
<th>Anatomy</th>
<th>Location Relative To GPi</th>
<th>Observed Effect If Stimulated</th>
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<tbody>
<tr>
<td>Posterior limb of internal capsule</td>
<td>Medial and posterior</td>
<td>Muscle contractions</td>
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Stimulation spread is primarily within GPe.

- **Anatomy** | **Location Relative To GPi** | **Observed Effect If Stimulated**
--- | --- | ---
GPe | Lateral and anterior | No effect (possible improvement in PD symptoms)
Putamen | Lateral and anterior to GPe | No effect
Stimulation spread is primarily within GPe.

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<td>Lateral and anterior</td>
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<tr>
<td>Putamen</td>
<td>Lateral and anterior to GPe</td>
<td>No effect</td>
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## GPi: Posterior Observed Effects

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</thead>
<tbody>
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<td>Posterior limb of internal capsule</td>
<td>Medial &amp; posterior</td>
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GPI: Ventral (Deep) Observed Effects

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<td>Optic tract</td>
<td>Inferior</td>
<td>Phosphenes (‘flashing lights’) in contralateral visual hemifield</td>
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Left hemisphere, 3387 lead, unipolar contact 0

Putamen

GPe

Caudate nucleus

Optic tract

Stimulation spread into left optic tract

Right orbit

Optic chiasm
If no clear or not satisfactory benefit

- Wider pulse widths for at least a month (120 and 210 micros) (Vercueil et al, 2007; Moro et al, 2009)
- Double monopolar stimulation (the two best contacts)
- Lower (40-60 Hz) or higher (185 Hz) frequencies (Kupsh et al, 2003; Moro et al, 2004; Tagliati et al, 2007; Moro et al, 2009)
- Cycling stimulation? Amperes instead of Vols?
- New electrodes in GPi or STN
Effects of amplitude, frequency and pulse width on cervical dystonia

- 8 pts with idiopathic cervical dystonia and bilateral GPI DBS at 28.6 ± 19.2 (mean ± SD) months after surgery
- Ten settings, including a combination of a wide range of pulse widths, low and high frequencies and voltage, were administered in a randomized double blinded fashion

Clinical improvement (57% TWSTRS severity score) was significantly associated with high frequency (≥60 Hz) and high voltage. Stimulation at 130 Hz showed the best clinical improvement. Increasing PW (from 60 to 450 μs) did not result in a significant improvement (Vercueil et al, 2007).

Moro et al, 2009
Stimulation-related Side Effects

**Onset**
- Acute
- Slowly progressive (delayed)

**Type**
- **Motor**
  - Dysarthria
  - Stuttering
  - Dysphagia
  - Bradykinesia
  - Loss of benefit
  - Other
- **Non-Motor**
  - Neuropsychiatric
  - Other
GPi DBS-induced parkinsonism

- **Berman et al, 2009**
  - Retrospective study in 11 CD and CCD patients
  - 210 micros, 145-185 Hz
  - Slowly after surgery 10/11 pts with changes in handwriting, difficulty in lifting/holding objects and slowness of movements
  - No aberrant location of electrodes
  - Changes of parameters reported unsuccessful
  - Compromise with 110Hz

- **Zauber et al, 2009**
  - 1 CCD patient
  - Subacute onset of bradykinesia, gait shuffling, hypophonia
  - Patient’s related phenomenon? Stimulation of nearby pathways?
Motor Side Effects induced by Stimulation

What to do?

- Identify which is the most responsible GPi
- Decrease stimulation voltage
- Decrease pulse width
- Reduce/increase frequency
- Change contact of stimulation/polar configuration
- Dystonia may worsen

A compromise between benefit and side effects is often required
Basic algorithm for management of gait disturbances and micrographia and speech difficulties in dystonia

Picillo et al, 2016
Final Remarks

- Reset usage/activation counter
- Re-interrogate to ensure IPG is ON
- Determine medication regimen
- Print current IPG settings and post in medical chart
- Instruct patient to:
  - Track symptoms (consider diary)
  - Be aware of device issues (refer to patient manual), e.g., diathermy
  - Read patient manual thoroughly
Warnings and Cautions

- Lithotripsy
- Body coil MRI (heating effect)
- Magnetic fields
  - Metal/theft detectors
  - Store refrigerators, industrial microwave ovens
  - Arc welding equipment, high voltage power lines
- Effect on other medical devices (external defibrillation, cardiac pacemakers)
Thank you