In CV stimulation, the actual current (I) delivered to brain tissue may vary if there are significant magnitude of stimulation was calculated: Charge Density (CD) and Total Electrical Energy Delivered (TEED)

- Impedance (R) is also expected to change in response to stimulation strength: \( V = IR \) (I – current; V – voltage).

- The extent and clinical significance of impedance changes in vivo over long-term DBS treatment are not well characterized.

- CC stimulation devices regulate voltage to deliver a programmed current, which may be advantageous initially.

- Activa® DBS devices (Medtronic Inc, Minneapolis, MN, USA) deliver electrical stimulation in the constant voltage mode, which allow switching to a constant current (CC) mode.

- No evidence-based guidelines exist to choose one delivery method over another.

- CV stimulation devices regulate voltage to deliver a programmed current, which may be advantageous initially after DBS implantation, when tissue impedance is known to fluctuate.

- Impedance changes are also expected to change in response to stimulation strength: \( V = IR \) (I – current; V – voltage).

- The clinical and extent of significance of impedance changes in vivo over long-term DBS treatment are not well characterized.

- Objectives:
  - To follow therapy impedance changes over time in patients with CV DBS
  - To determine if a correlation exists between changes in therapy impedance and changes in DBS parameters

- A retrospective chart review (1/2010 – 3/2013) identified Parkinson’s disease patients with Activa DBS pulse generators (PC, SC) and 3387 leads programmed in CV mode, with documented therapy impedance over at least 3 consecutive visits after the last DBS-related surgery (initial implant, battery exchange).

- Exclusion criteria: change in electrode position; abnormal impedance (therapy or electrode) reading consistent with possible open or short circuit.

- Impedance values documented at beginning of each study visit, before changes to DBS parameters.

- Magnitude of stimulation was calculated: Charge Density (CD) and Total Electrical Energy Delivered (TEED)

\[
CD = \frac{\text{Current} \times \text{Voltage}}{\text{Time}} \\
\text{TEED} = \text{Charge} \times \text{Specific Energy} \times \text{Impedance} \times \text{Time} \quad \text{(1 second)}
\]

- (Surfaces area is assumed unchanged in each patient / same electrodes configuration)

- Changes (Δ) of CD, TEED, and impedance between study visits were calculated in each patient.

Figure 1. Between-visit changes (Δ) in impedance, CD and TEED

**Table 1. Patient and DBS characteristics**

<table>
<thead>
<tr>
<th>Patients / electrodes, N</th>
<th>Patient</th>
<th>DBS device</th>
<th>DBS target</th>
<th>Electrode configuration, N of electrodes</th>
<th>First study visit after surgery (initial implant, IPS exchange), days</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 / 20</td>
<td>Male</td>
<td>Activa PC</td>
<td>GPi</td>
<td>Microquadropolar (N=15), double monopolar (N=1), bipolar (N=3), double bipolar (N=1)</td>
<td>158 ± 24.3 (9-348), all initial implants</td>
</tr>
</tbody>
</table>

**Figure 2. Impedance change (Δ) in relation to time from the last DBS-related surgery**

**Table 2. Mean Impedance, CD, and TEED changes**

<table>
<thead>
<tr>
<th>Between-visit CD changes, %</th>
<th>Between-visit TEED changes, %</th>
<th>Between-visit therapy impedance, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>-50%</td>
<td>149±77 (56-159)</td>
<td>4±11 (10-70)</td>
</tr>
<tr>
<td>-40%</td>
<td>189±79 (50-149)</td>
<td>7±11 (9-60)</td>
</tr>
<tr>
<td>-30%</td>
<td>253±77 (56-149)</td>
<td>13±11 (10-70)</td>
</tr>
<tr>
<td>-20%</td>
<td>323±78 (50-159)</td>
<td>19±11 (10-70)</td>
</tr>
</tbody>
</table>

- **Discussion**

  - Impedance fluctuations in chronic DBS therapy in CV mode are minimal.

  - Despite large changes in CD or TEED, impedance fluctuations were relatively small (e.g., Figure 1, P1 and P7).

  - The largest impedance fluctuations were seen in the initial post-implantation period (~6 months after implantation), likely due to large CD/TEED changes required for DBS optimization.

  - In the chronic phases of DBS therapy (months after implantation), impedance fluctuations are faulty, possibly in the context of relatively small DBS adjustments.

  - Given the inter-patient variability of impedance fluctuations (e.g., P1 vs. P2), it is possible that other factors contribute to impedance measurements, but the overall fluctuation remains small.

- **Conclusions**

  - During active DBS adjustment, intra-patient impedance fluctuations in early DBS therapy in CV mode vary in relation to CD/TEED, though other factors may determine inter-patient variability.

  - Impedance fluctuations in chronic DBS therapy in CV mode are minimal.

  - The results of our study do not support the use of CC DBS delivery over CV in order to accommodate for fluctuating impedance in the early post-implantation period or in chronic DBS therapy.

**References**


