**Approved by**

|  |  |  |
| --- | --- | --- |
|  | Signatures | Date |
| Bradley Greger, PhD |  |  |
| Francisco Ponce, MD |  |  |

**Reviewed by**

|  |  |  |
| --- | --- | --- |
|  | Signatures | Date |
| Meg Lambert |  |  |

1. **Purpose**
   1. The purpose of this SOP is to describe the procedure for recording electrophysiological data from the brain during an awake DBS surgery.
2. **Scope**
   1. This SOP will apply to the research and clinical staff working in a BNI OR during cases in which the patient has consented to participate in DBS research during an awake surgical procedure.
3. **General Information**
   1. A single micro-electrode is used to record action potentials and local filed potentials in the Basal Ganglia.
   2. An array of micro-electrodes is used to record local field potentials from the cerebral cortex.
   3. Total time to complete the intra-operative experimental paradigm of this SOP is approximately 35 minutes (see stimulation & recording duration worksheet).
4. **Materials**
   1. Sterilized
      1. One of each of the following will be given to the scrub nurse for use during the recording procedure. The second set will be kept by the research team for backup.
         1. Two FHC microelectrodes
         2. Two cable connectors with active head-stages for FHC microelectrode
         3. Two micro-ECoGs
         4. Two GateLock cable connectors with active head-stages for micro-ECoG
         5. Two Ground cables (long) – banana plug to alligator clip
   2. Non-sterilized
      1. Electrophysiological recording cart
      2. TDT PZ5 amplifier
      3. Tremor monitor
      4. Video camera
5. **At least 48 hours prior to surgery start time**
   1. Assure that all materials are available.
   2. Assure that recording cart is functioning properly by recording simulated data.
   3. Assure that TDT PZ5 amplifier is fully charged.
6. **Day of surgery, prior to start**
   1. Move research cart into OR.
   2. Setup speaker for monitoring FHC microelectrode signal for action potentials (connect to audio output on RZ5).
   3. Place tremor sensor on the patient’s wrist contralateral to the microelectrode and micro-ECoG, and connect to the analog inputs 1 and 2 on TDT RZ2 BioAmp Processor.
   4. Place TDT PZ5 amplifier on floor or on O-arm at bedside near patient's head.
   5. BNI surgical staff to setup video camera in OR for recording patient’s movements
   6. Give only one of each sterile material listed in 4a to nurse in OR. Hold second set of sterile materials as backup, so that they are not opened unnecessarily.
7. **Placement of micro-electrode and micro-ECoG grid and connection to PZ5 amplifier**
   1. The neurosurgeon connects the FHC microelectrode to the cable connector. three connections: electrode, reference, and ground).
   2. DB25 connector for the FHC microelectrode is passed out of sterile field and connected to PZ5 amplifier port 1.
   3. The neurosurgeon places the PMT micro-ECoG epicortically in the caudal direction as close to the arm representation of primary motor cortex as possible.
   4. The neurosurgeon slides the pig-tail connector of the PMT micro-ECoG grid into the GateLock connector and closes clamp.
   5. DB25 connector for the micro-ECoG grid is passed out of sterile field and connected to PZ5 amplifier port 2.
   6. The neurosurgeon attaches the ground to the head frame
   7. Ground cable is passed out of the sterile field and connected to the PZ5 amplifier
8. **Recording the electrophysiological signals**
   1. Start recording neural data from microelectrode and micro-ECoG.
   2. Advance the FHC microelectrode to target.
   3. Wait for five minutes to allow for the tissue and electrode interface to stabilize.
   4. Isolate an action potential with acceptable signal to noise ratio (peak-to-peak/RMS).
   5. Note depth of electrode (above target)
   6. Perform 180 second baseline recording (total number of action potentials, firing rate).
9. **DBS stimulation**
   1. Stimulation parameters
      1. Current controlled (impedance calculation)
      2. No ramp
      3. Contact 1 as Anode, Contact 2 as Cathode
      4. Uniphase pulse shape
      5. Interphase delay 0 microseconds
      6. Pulse width 90 microseconds
      7. Pulse amplitude as effective for tremor reduction at 140 Hertz
   2. Confirm stimulation parameters with Medtronic representative
   3. Measure impedance on DBS electrodes prior to any stimulation
   4. Establish pulse amplitude in milliamps at 140 Hz that effectively reduces tremor (quantify tremor reduction) and then use this amplitude for all subsequent stimulations
   5. Pulse frequency sequence: 140 Hertz, 30 Hertz, 250 Hertz, 70 Hertz
   6. Perform pulse trains (10 cycles of 10 seconds of stimulation ON and 10 seconds of stimulation OFF, 50% duty cycle) for each simulation frequency.
   7. Use stopwatch timer to keep track of ON and OFF duration.
   8. Use counter to keep track of the 10 ON/OFF cycles performed.
   9. Patient tremor task/monitoring (at rest, postural) during all stimulation.
   10. Measure impedances on all DBS electrodes post all experiments.
10. **Removing the Connectors and archiving patient data**
    1. Remove the connections to the PMT micro-ECoG grid. Switch off the TDT system.
    2. Leave the PMT micro-ECoG grid in place until after the CT scan, then the surgeon removes it from the cortex…. (When to exactly remove?)
    3. Save the patient recording on the TDT recording system.
    4. Research recordings are finished, and the surgery proceeds.
    5. Collect imaging and anesthesia record
    6. Retrieve & Deliver for sterilization:
       1. Cable connector with active head-stage for FHC microelectrode
       2. GateLock cable connector with active head-stage for micro-ECoG
       3. Ground cable
11. **Troubleshooting**
    1. Ground & References
    2. Anesthesia level
    3. Battery level of PZ5
    4. Cart & TDT settings