Neurosurgical precision at its peak: deep brain stimulation - patient selection strategy and surgical technique – a video article

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Deep Brain Stimulation (DBS) has emerged as a promising therapeutic approach for various neurological disorders. This video article elucidates the intricacies of DBS surgery and patient selection criteria. The article comprehensively discusses the indications for DBS across diverse conditions, including Parkinson's disease, primary generalized dystonia, essential tremor, obsessive-compulsive disorder, Tourette's syndrome, drug-resistant major depression, drug-resistant epilepsy, minimally conscious state, and certain addictive disorders. The article outlines the meticulous patient selection process for Parkinson's disease DBS, emphasizing both inclusion and exclusion criteria to ensure optimal outcomes and patient safety. The surgical procedure is meticulously detailed, encompassing the pre-operative planning phase involving Magnetic Resonance Imaging (MRI) and stereotactic coordinate determination. The step-by-step surgical process is elucidated, from frame application and Computed Tomography (CT) fusion to electrode implantation and confirmation of placement. Post-operative management, including programming of the Implantable Pulse Generator (IPG) and addressing complications, is also discussed. By providing insights into the surgical nuances of DBS and patient selection criteria, this video article serves as a valuable resource for neurosurgeons and healthcare professionals involved in the management of neurological disorders amenable to DBS therapy.

Keywords: deep brain stimulation, stimulation, pulse generator, functional, neurosurgery

Introduction

Deep Brain Stimulation (DBS) is a high frequency, pulsatile, monopolar/bipolar electrical stimulation through a stereotactically placed electrode into a target nucleus which can be activated and deactivated with an external magnet. Its exact physiology is unknown, but higher frequencies mimic cellular ablation and not stimulation.

Indications for DBS

- Parkinson's disease
  - STN/Gpi
- Primary generalized dystonia
  - Gpi
- Essential tremor
  - Vim
- Obsessive compulsive disorder
  - ALIC/BNST
- Tourette's syndrome
  - Gpi
- Drug-resistant major depression
  - ALIC
- Drug-resistant epilepsy
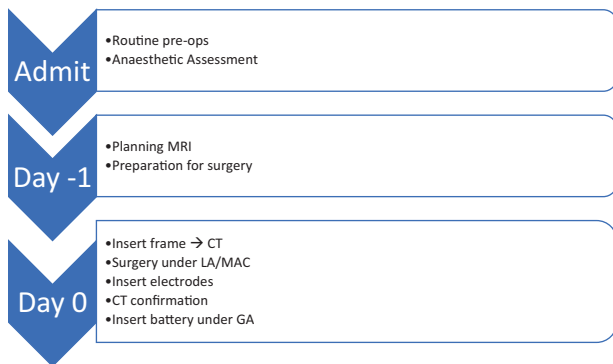 - ANT/CM
- Minimally conscious state

- Alcohol or other addictions
- Post-traumatic stress disorder

Patient selection criteria for Parkinson's disease DBS

- **Inclusion criteria**

    - Diagnosis of PD
    - Response to levodopa
    - UPDRS
    - Dopa challenge testing
    - Dyskinesias and motor fluctuations

- **Exclusion criteria**

    - Severe brain atrophy or Ischaemia
    - Impulse control disorders
    - Major depression
    - Dementia
    - Advanced age
    - Anesthetic risk/bleeding risk

The patient and family members should be educated about having realistic expectations since they may fail to appreciate any improvement if expectations from surgery are too high.

Surgery process flow

Admit
- Routine pre-ops
- Anaesthetic Assessment

Day -1
- Planning MRI
- Preparation for surgery

Day 0
- Insert frame → CT
- Surgery under LA/MAC
- Insert electrodes
- CT confirmation
- Insert battery under GA

Planning MRI is done a day or two prior to the date of surgery. It is ideally done under general anesthesia in order to minimize movement artifacts in the MRI and thereby improve accuracy of identifying the target (**Figure 1**).

Typical stereotactic coordinates for common DBS targets

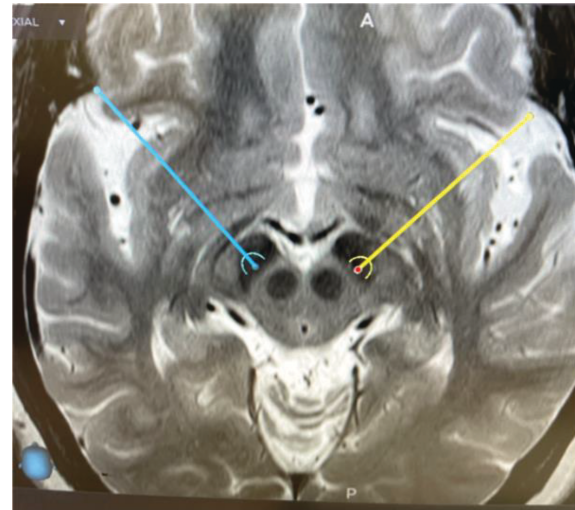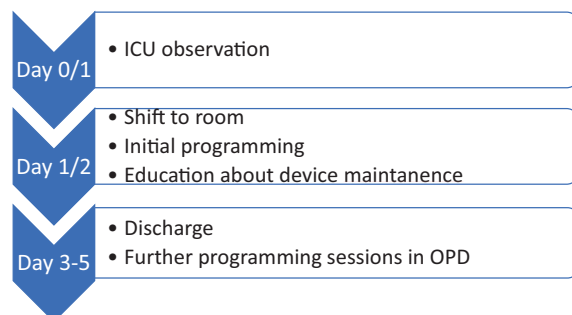|	X (mm)	Y	Z
STN	12	2 mm behind MCP	4 mm inferior
Vim	14	6 mm anterior to PC	At AC-PC plane
Gpi	20–22	2 mm anterior to MCP	4–6 mm inferior

FIGURE 1 | Axial T2W MRI image showing the planned target into both the subthalamic nuclei.

On the day of surgery, the stereotactic frame's base ring is applied under local anesthesia and the patient undergoes CT with the indicator box on. This CT image is fused with the previously done MRI and the stereotactic co-ordinates are calculated.

In the OT, the frame is assembled, burrhole is made on one side (usually the more affected side) and the micro electrode recorder's Ben-Gun array is set up and as many MER tracts are studied as required. Once satisfactory MER recordings of the STN are obtained, macrostimulation is done to get an idea of the best clinical effect and side effect profile. Based on this information the final DBS electrode is implanted and secured with an electrode securing device that also closed the burrhole site. The same process is repeated on the opposite side and thereafter a repeat CT is done to confirm the position of the electrode.

Following this, the IPG is implanted under general anesthesia using extension cables. I prefer a subcutaneous pocket in the left infraclavicular region for my IPG's.

Post-operative course

Day 0/1
- ICU observation

Day 1/2
- Shift to room
- Initial programming
- Education about device maintanence

Day 3-5
- Discharge
- Further programming sessions in OPD

Usual settings at the initiation of programming

- Select the contact
- Usually monopolar
- Freq 130 Hz
- PW 60
- Amplitude is the one variable that is usually increased gradually as per the symptomatic response.

Complications of surgery

- Life threatening <0.5%
    - Major bleeding
    - Risk to life

- Stimulation related 3–10%- usually reversible with change of the contact or programming settings.
- Infection 2–3%- sometimes necessitates implant exit.