Describe the management of DBS stimulators during non-neurologic surgery

General:

Deep brain stimulation is an effective treatment for Parkinson's disease, and the application has been extended to other disorders such as essential tremor, epilepsy, dystonia, chronic pain, and psychiatric conditions (major depression, anorexia nervosa). The most common DBS hardware has four components: (1) intracranial electrodes surgically implanted into the deep brain (thalamus, subthalamic nucleus, or internal globus palludus) unilaterally or bilaterally; (2) a plastic ring and cap seated onto a burr hole to fix the electrodes to the skull; (3) a single- or dual-channel internal pulse generator (IPG) typically beneath the clavicle level; (4) an extension cable that is tunneled subcutaneously from the cranial area to the chest or abdomen, connecting the DBS electrode(s) to the IPG. The battery lasts between two and five years and has to be replaced together with the pulse generator.

Currently, none of the anaesthetic techniques for neurostimulator implantation has proven to be superior to others, although awake or sedation techniques are popular as they facilitate intraoperative neurological testing. Sedation options include propofol, dexmedetomidine, and opioids.

The surgical procedure is a staged process. The first stage involves mapping of target areas via MRI and placement of intracranial electrodes via burr-hole craniotomy. This step involves a stereotactic frame fixed to the patient's head, and is usually done under local anesthetic and sedation. Clinical testing in an awake patient helps to confirm micro-electrode placement and rapidly detect side effects. A general anesthetic may be required if the patient cannot cooperate with / remain still for the procedure (developmental delay, disinhibited dementia, claustrophobia, previous difficult sedation, etc.). Tools to remove the head-frame for emergency airway access must be available at all times.

The second stage involves implanting and connecting the neurostimulator IPG, which can be completed on the same day or a second stage procedure. The IPG and battery unit are commonly implanted in the chest wall or abdomen under general anesthesia. Postoperative neurological observation is necessary after the first stage of the procedure, regardless of the type of anaesthetic technique utilized, as it is an intracranial operation. This is not as necessary for the second stage of the procedure, if it is carried out as a separate operation. Anti-parkinsonian medications should be recommenced as soon as possible, to avoid deterioration in motor and neurological function.

DBS insertion is generally safe, but some potential complications include intracranial hemorrhage, seizures, stroke, neurologic deficit, venous air embolism, respiratory/airway compromise, hypertension, and post-procedural delirium. Device-related problems include infection, electrode migration, and equipment failure.

The major perioperative anesthetic considerations for patients with an implanted DBS system include the medical indication/condition warranting DBS, the potential for electromagnetic interference (from electrocautery, MRI, etc.), and postoperative evaluation of the patient and the device.

Pre-Operative:

Patients for elective procedures should ideally be seen in a pre-anesthesia clinic, as their specific indication for DBS may warrant special considerations (such as those around Parkinson disease, epilepsy, and dystonia). Specific DBS information to elicit includes the exact model, IPG location, last device check, battery change, and current settings. The severity of symptoms when the device is turned off should be detailed. The physician should know how to use the patient remote programmer to turn the device ON and OFF. In addition, the patient's neurologist or DBS technician can be contacted for any specific considerations or precautions, as well as to interrogate and adjust the DBS settings. A

preoperative CXR can identify the path of the DBS wires to avoid damage during surgeries close to the device site.

Intra-Operative:
In general, the DBS should be turned OFF to minimize electromagnetic interference. Older models should be powered down and will also turn off in response to a magnet. Newer models can be turned off via remote patient handheld programmers. If the patient symptoms are severe, the DBS can be turned off after induction of a general anesthetic – and oral medication supplementation may be required. If a neuraxial or regional anesthetic technique is employed, the patient may require deeper sedation to mitigate severe symptoms. Patients may experience rigidity once the device is switched off, and mechanical ventilation is sometimes necessary in the rare situation where severe rigidity interferes with their ability to breathe. The device should then be turned on before emergence from anesthetic. Specific precautions with electrocautery include preferentially using bipolar cautery with minimum power settings in short intermittent irregular bursts. If unipolar cautery is used, the grounding pad should be placed far away such that the current will not pass through the DBS system.

Post-Operative:
At the end of the procedure, the neurostimulator should be turned on to the original settings. If general anesthesia was administered, the device should be turned on before emergence to avoid symptom recurrence when the patient is awake. A device check should be performed by the relevant DBS physician or technician. A neurologic examination of the patient should also be performed to rule out any adverse event.

Special Considerations:
- ECG: Electrocardiogram recording can be affected by electrical signals generated from the DBS system; however, this interference resolves when the neurostimulator is turned off. When the device is turned off, recurrence of symptoms may introduce movement-related artifacts that preclude optimal ECG recording.
- Defibrillation/Cardioversion: There are no clear guidelines, but DBS should not preclude emergent life-saving defibrillation or cardioversion in critical situations. Pads should be placed as far from the DBS system as possible, and the device should be interrogated after defibrillation.
- MRI: Some neurostimulators are likely MR compatible, as suggested by studies showing the safe use of MRI under specified conditions in patients with an implanted DBS system. The use of MRI is currently contraindicated for Boston Scientific DBS systems but can be performed, if necessary, in patients with Medtronic DBS systems under specified conditions.
    - Neurostimulators should be turned off during imaging, which, in some patients, can lead to recurring symptoms that interfere with adequate image acquisition. In neurostimulator systems with a magnetic switch, the magnetic switch must be turned off and the stimulation amplitude set to 0 V.
    - Other safety precautions include limiting the active scan time, proper patient positioning, and constant communication with the patient to identify early complications. After imaging, the DBS specialist should check the neurostimulator and turn on the device to its original settings.
- Cardiac pacemaker/ICD: Precautions should be taken because of potential interactions between these devices, including inappropriate sensing and response by the cardiac pacemaker, inappropriate sensing of tachyarrhythmia by the ICD resulting in discharges, and inactivation of or adjustment to the neurostimulator settings.
    - To minimize interactions between the cardiac pacemaker and the DBS device, the cardiac pacemaker should be programmed to bipolar sensing mode to avoid oversensing and

inappropriate response. Similarly, use of bipolar sensing electrodes for the ICD system also reduces oversensing.
    - The functioning of the neurostimulator should be checked after the ICD delivers a shock.
    - In order to reduce electromagnetic interference, it is also recommended not to insert the IPGs of the two systems in close proximity.
    - If an external magnet is required intraoperatively to inactivate the defibrillator function of the ICD, precautions should be taken to avoid placing it in close proximity to the DBS device.
    - Detailed cardiac investigations, e.g., Holter monitoring, should be performed whenever adjustments are made to the DBS device settings to ensure consistent functionality of the cardiac pacemaker device.
    - As MRI may be contraindicated in patients with a cardiac pacemaker, stereotactic CT has been used for nuclei mapping as an alternative.
- Electroconvulsive therapy (ECT): ECT is a recognized treatment for severe depression, which can be comorbid in up to 30% of people with Parkinson's disease. Concerns include heat generation from the electrical radiofrequency charge which can damage the electrodes, functional disruption of the DBS system, and electrode displacement from the induced seizure activity. Case reports have shown ECT can be conducted safely in patients with a DBS system.
    - Recommendations include turning off the DBS system before the procedure, placement of ECT electrodes as far as possible from the DBS electrodes, and using the lowest possible energy for seizure induction. The device can then be turned on after ECT has completed, and it should be checked to ensure appropriate function.

Resources

Poon CC & Irwin MG. Anaesthesia for deep brain stimulation and in patients with implanted neurostimulator devices. Br J Anaesth 2009 103: 152–65.

Yeoh TY et al. Anesthesia considerations for patients with an implanted deep brain stimulator undergoing surgery: a review and update. Can J Anesth 2017 64: 308–319.

Lee C. Anaesthetic Management of Deep Brain Stimulators: Insertion & Perioperative Considerations. WFSAHQ 2016 (335).