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Letter: Evaluation and Surgical Treatment of Functional Neurosurgery Patients With Implanted Deep Brain Stimulation and Vagus Nerve Stimulation Pulse Generators During the COVID-19 Pandemic

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Letter: Evaluation and Surgical Treatment of Functional Neurosurgery Patients With Implanted Deep Brain Stimulation and Vagus Nerve Stimulation Pulse Generators During the COVID-19 Pandemic

To the Editor:

The COVID-19 pandemic has necessitated a response that has involved postponement of nonemergent and nonurgent surgeries. A team of practitioners have developed a guidance document, which has been determined to be appropriate for the treatment of patients at our respective institutions and subspecialties. We think it is important to share these guidelines because they may be useful for other practitioners. They are in no way intended to suggest that all recommendations are appropriate to another medical center's particular situation, which is determined by local policies, resource availability, and pandemic penetrance and response measures.

GENERAL CONSIDERATIONS

Reason for This Guidance

- The COVID-19 pandemic has imposed the need to both limit the exposure of vulnerable patients to the virus, and the need to manage critical hospital resources.[1]
- Most centers are limiting access to surgical procedures except for emergent and urgent situations.[2]
- These measures pose unique challenges to the management of functional neurosurgery patients with implanted pulse generators.
- Guidance is needed to aid decision-making, which is specific to individual diagnostic and treatment categories.

Classification of Surgical Cases

We use the following definitions, as per the American College of Surgeons[2]:

- Emergent: needs to be completed immediately due to threatening loss of life.
- Urgent: needs to be completed within 24 h.
- Time-sensitive: needs to be completed within 4 wk.
- Elective: can be postponed for >4 wk.

Categories of Neurosurgical Issues That May Arise During Pandemic Measures

New Deep Brain Stimulation (DBS) Implantation

- Except in very rare circumstances, implantation of new DBS leads is considered an elective procedure and will not be performed in most centers while pandemic measures are in place.
- As COVID-19-related restrictions are lifted at the end of the pandemic, new DBS implantations should be considered in patients who are at relatively lower risk for COVID-19 disease and have debilitating signs. These would ideally be done under local anesthesia, and intraoperative testing, as needed, would be performed without device manufacturer representatives, to minimize exposure and resource utilization.

Internal Pulse Generator (IPG) Depletion

- Battery indicator usually means there are a few weeks of electrical charge remaining.[3]
  - If there is >4 wk until the end of service (EOS), then IPG replacement is categorized as elective.
  - If there is <4 wk until EOS, then IPG replacement is categorized as time-sensitive.
  - IPG replacement can progress from elective to time-sensitive, or from time-sensitive to urgent, the latter depending on patient-specific factors.
- Battery status can in many cases be tracked via telemedicine using patient programmers.
- Emergence of clinical symptoms can be a harbinger of impending battery depletion.[3]
- As a general rule, when battery life is <4 wk and replacement is considered time-sensitive, the IPG should be replaced prior to EOS. However, mitigating COVID-19 system-wide related pandemic measures must be considered in making a final determination.

Hardware Infection

- A superficial infection can be treated conservatively with oral antibiotics.
- The presence and severity of infection or skin erosion may be initially assessed with telemedicine and through emailing (serial) photos, but also may warrant an urgent clinic visit.
- An aggressive or progressive infection requires urgent explantation and intravenous (IV) antibiotics to avoid potentially life-threatening spread to the central nervous system and other organ systems.[4,5]
- Hardware infections (except superficial infections) are considered either time-sensitive or urgent depending on severity.

Hardware Malfunction

- A limited check of the electrical system may be conducted remotely.
- Categorization of hardware malfunction is either elective, time-sensitive, or urgent: This categorization and associated

treatment will depend on the risk of therapy disruption (see below).
- In urgent cases (see below), an in-person visit may be necessary to localize the problem and perform ancillary tests (eg, X-ray for lead breakage).

Surgical Procedure Considerations

- IPG replacement and other DBS-related procedures (eg, troubleshooting a hardware-related issue; acute implantation of DBS) may be performed under local rather than generalized anesthesia (as is often done) to reduce respiratory droplet spread, preserve hospital resources, and shorten a patient's postanesthesia recovery.
- Performing these procedures at outpatient surgical centers should be considered if available.
  Surgeons should prepare to perform intraoperative testing in the absence of a representative from the device manufacturer, to limit exposure to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus.

DBS FOR MOVEMENT DISORDERS RECOMMENDATIONS

Most movement disorder patients treated with DBS are at a higher risk for becoming critically ill if infected with COVID-19. Accordingly, they should not be seen in clinic for the management of their DBS treatment unless urgent.

- DBS battery depletion can, in some cases, result in life-threatening clinical deterioration necessitating emergent intervention. The risk of such emergencies due to disruption of DBS therapy should be assessed for all patients.
- Patients known to be at risk for developing life-threatening symptoms from DBS therapy interruption include those with (Table):
  - Parkinson's disease with bilateral subthalamic nucleus (STN) DBS and additional risk factors (see below) who may experience DBS-withdrawal syndrome[6-9]:
    - The actual risk is difficult to assess. However, it was reported that of 15 patients who had forced DBS cessation due to infection, 3 patients developed malignant withdrawal, of whom 2 died. Thus, the risk appears to be significant.[9]
  - Parkinson's disease with unilateral STN DBS or uni- or bilateral globus pallidus interna (GPi) DBS: The risk for these patients is not known, with the absence of published reports documenting DBS-withdrawal syndrome.
  - Generalized dystonia who may experience dystonic storm (status dystonicus).[10-14]
  - At this time, there is no evidence that other groups of patients are at risk for life-threatening symptoms from DBS cessation, but this could change with the course of time.
  - Though not life-threatening per se, severe symptoms upon DBS cessation due to battery depletion[15] should be evaluated for urgent surgery on a case-by-case basis, and in an effort to minimize hospitalizations or evaluations in the emergency department.

Battery and Impedance Check to Determine Risk for DBS-Withdrawal Syndrome and Dystonic Storm

Determine the hardware (Medtronic, Abbott, Boston Scientific)

- Boston Scientific:
  - Nonrechargeable IPGs: Clinicians should rely on device indicators of Elective Replacement Indicator (ERI).
    - Have the patient check their battery and make note in the medical record.
    - Ask the patient to check battery every 3 to 6 mo while pandemic measures are in place.
    - As per the Vercise™ PC Information for Prescribers manual: "When the implanted non-rechargeable stimulator is nearing end of its battery life, it enters the Elective Replacement mode."[16]
      - "The Elective Replacement Indicator (ERI) will appear on the Remote Control and Clinician Programmer." Patients should be advised to contact their physician. Batteries in "ERI mode will have a minimum of 4 weeks between entering ERI mode and reaching End of Battery Life."[16]
    - "When the stimulator battery is fully depleted, the EOS indicator will be displayed on the remote control."[16]
  - Rechargeable IPGs:
    - Battery life is estimated at 15 yr. Based on when this system became available, there is at present low risk that it will reach EOS during pandemic measures.
- Abbott:
  - Nonrechargeable IPGs only: Clinicians should rely on device indicators of ERI.
    - Have the patient check their battery and make note in the medical record.
    - Ask the patient to check battery every 3 to 6 mo while pandemic measures are in place.
    - For the Abbott system, the Yellow Replacement indicator will appear when battery is at 2.73 V (estimated time to EOs, based on recent usage, is 3 to 6 mo; see the Abbott Clinician Manual for an IPG longevity calculator).

TABLE. Recommendations for IPG Replacement Triage During Pandemic Measures

Consequence of DBS therapy cessation	Patient characteristics	Recommended scheduling priority
At risk for life-threatening symptoms	Parkinson's disease with STN DBS and withdrawal risk factors[a]; generalized dystonia	Time-sensitive or urgent (if IPG depleted)
Severe symptoms, not requiring hospitalization	Nongeneralized dystonias; advanced Parkinson's disease with meaningful DBS benefit; severe essential tremor without a caregiver to assist with activities of daily living	Elective or time-sensitive (if IPG depleted)
Mild to moderate symptoms	Most essential tremor; Parkinson's disease and dystonia with mild to moderate DBS benefit	Elective

[a]Long-standing DBS (>5 yr), advanced disease (>15 yr), and low dopaminergic medications.[7]

- Medtronic:
  - Rechargeable IPGs: Low risk due to 15-yr battery life.
  - Nonrechargeable IPGs:
    - Have the patient check their battery.
    - Ask the patient to check battery every month and at each telehealth or phone visit while pandemic measures are in place. Make note of the charge in the medical record.
    - For the Medtronic Activa system, ERI will appear when battery is at 2.6 V, and EOS will occur at 2.2 V (depending on the impedances and the DBS settings, estimated time to EOS is 8 to 10 wk after ERI warning first appears).
    - Patients with older systems (Soletra, Kinetra) may be at elevated risk to have battery depletion due to the age of their system.

Patients With Parkinson's Disease: Determine the Risk of DBS-Withdrawal Syndrome

- GPi (unilateral or bilateral): DBS-withdrawal in patients with GPi DBS has not been reported to date, so the risk is not known.
- Unilateral STN: DBS-withdrawal in patients with unilateral STN DBS has not been reported to date, so the risk is not known.
- Bilateral STN: These patients are at risk for DBS-withdrawal.[7-9] Additional risk factors are as follows[7]:
  i. Long duration of DBS therapy (>5 yr);
  ii. Long disease duration (>15 yr);
  iii. Significant reduction in dopaminergic medication with DBS therapy;
  iv. Advanced symptoms at the time of the initial surgery;
  v. Early age at the disease onset.

For patients at high risk for DBS-withdrawal, note the battery charge and check battery monthly (see above). In these patients, the IPG should be replaced if at all possible.

Patients With Generalized Dystonia (Both Genetic/Idopathic and Acquired) May Be at Risk for a Dystonic Storm When DBS Stimulation is Disrupted (Unilateral and Bilateral)[11-13]

Note the battery charge and check battery monthly (see above). In these patients, the IPG should be replaced if at all possible.

Warn the patient about a very rare side effect of status dystonicus (persistent severe spasms with difficulty in breathing/swallowing, metabolic dysfunction, pain),[12] and that if stimulation stops, they may need some oral medications (see below).

Treatment of Patients With IPGs Nearing Depletion That Cannot Be Replaced Due to Pandemic Restrictions

If the neurostimulator (IPG) cannot be replaced prior to depletion, a telemedicine or phone consultation for patients can be useful.

- Parkinson's disease:
  - Medication can be optimized, eg, increase dopaminergic medication dose or decrease the time interval between dosages, over days/weeks. This is especially applicable for patients whose medications have been significantly decreased; this is often the case in patients with bilateral STN DBS but can occur in other patients as well.
  - An attempt can be made to decrease DBS stimulation amplitude to extend battery life and to lessen symptoms at the time of complete battery cessation, while optimizing medications.
  - For patients with STN DBS who are on minimal levodopa and who are at risk for DBS-withdrawal syndrome, the reintroduction of levodopa over days or weeks in association with decreasing DBS stimulation parameters may—though not formally tested—re-establish dopamine transmission in the basal ganglia and reduce the risk of DBS-withdrawal syndrome.
  - Make sure the patient has 3-mo supplies of the increased medication regimen.

- Dystonia: Dystonia patients may consider reinstitution of oral medications in order to minimize dystonia symptoms (benzodiazepines, anticholinergics). Simultaneously, an attempt can be made to decrease DBS amplitude as much as tolerated. Generalized dystonia patients should be warned about the possibility of continuous severe dystonic spasms, which may require hospitalization and urgent IPG replacement.
- Essential tremor: Patients can be advised to turn the DBS off during night and as needed during daytime in order to save IPG charge prior to complete depletion. Reinstitution of oral medications may also reduce symptoms.

Impedance Check to Determine Integrity of the System if Patients Present With Sudden Changes in Therapy Effectiveness

The DBS provider can perform a limited impedance interrogation with patient programmer (see manufacturers' Patient Programmer manuals). This requires multiple steps for the patient to perform and data may be difficult to interpret, so not recommended to do routinely via telemedicine. It may be helpful to indicate (or rule out) lead/wire breakage.

- Medtronic system will indicate wire break but will not specify which contact, and will not indicate short circuit.
- Abbott system will indicate any increased/decreased impedance, even if the system is fully functional.
- Boston Scientific system will provide detailed impedance for each contact.

Change contact if possible. If no other contact can be used, determine the risk for DBS-withdrawal syndrome and dystonic storm (see above). While pandemic measures are in place, indication for urgent DBS revision is when patients present with DBS-withdrawal or dystonic storm and should be considered in patients at high risk for these serious outcomes.

Adjustment of DBS Settings and Medication

Offer patient follow-up with telemedicine or phone while pandemic measures are in place.

DBS AND VAGAL NERVE STIMULATION (VNS) FOR EPILEPSY RECOMMENDATIONS

DBS and VNS are used to provide palliative reduction in seizure frequency in patients with drug-resistant epilepsy. During the COVID-19 pandemic, the management of the treatment with these devices needs to be balanced with the risk of exposure to patients and healthcare providers as well as available resources.

- Changes to programming will be deferred except in the setting of severe stimulation related side effects or significant increase in seizures.
- It is recommended that the treating clinician evaluate the need for in-person reprogramming on a case-by-case basis.
- Utilizing device features such as autotitration for VNS devices and program sets for DBS patients may reduce the need for in-person visits.

Device depletion has been reported to be associated with increase in seizures in some patients,[17,18] but there are no reports of status epilepticus or sudden unexpected death in epilepsy (SUDEP). There are also no reports of status epilepticus or SUDEP associated with VNS battery depletion.

Battery and Impedance Checks to Determine Risk of Impending IPG Depletion

See the DBS for Movement Disorders Recommendations section above.

For Patients in Need of IPG Replacement

Recommendation:

- IPG replacement should be performed as an elective procedure in the absence of reports of status epilepticus with depletion.
- Increased numbers of generalized seizures or recurrent seizure-related injuries could increase the patient to time-sensitive or urgent status.
- Daily antiseizure medications can be optimized and patients can be given a home rescue medication to take in the event of worsening seizure severity or frequency.
- It may be possible to adjust parameters to temporarily preserve battery; for example, most patients with DBS for epilepsy are being stimulated in cycling mode, so on-time relative to off-time can be decreased.

DBS FOR TOURETTE SYNDROME

- Patients with Tourette syndrome with head snapping tics or moderate to severe self-injurious behavior require time-sensitive and possibly urgent IPG replacement depending on symptom severity.
- Those with severe tics and/or self-injurious behavior will likely experience increased disability but may not require hospitalization. Replacement is time-sensitive.
- Patients with mild symptoms or mild to moderate DBS benefit can undergo replacement on an elective basis.

DBS FOR NEUROPSYCHIATRIC DISORDERS

Obsessive compulsive disorder patients may experience worsening neuropsychiatric symptoms and suicidal ideation with DBS cessation.[19] There are no published reports of completed suicides due to abrupt acute therapy cessation.

- IPG replacement for patients with obsessive-compulsive disorder (OCD) and impending battery depletion is elective or time-sensitive depending on the remaining battery life.
- Severe worsening of symptoms may render IPG replacement urgent.

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