


NEURO GADGETS AND
NON-NEUROLOGIC
SURGERY

MINNESOTA SOCIETY OF ANESTHESIOLOGISTS
NOVEMBER 2021

Tasha L. Welch, MD
Assistant Professor
Department of Anesthesiology and Perioperative Medicine
Mayo Clinic
Rochester, MN



1

Disclosures

- Relevant Financial Relationships:
None

©2021 Mayo Foundation for Medical Education and Research | slide-2

2

LEARNING OBJECTIVES

- Explain types and indications of neuromodulators
- Describe the peri-procedural management of patients with deep brain stimulators undergoing non-neurologic surgery
- Describe the peri-procedural management of patients with vagal nerve stimulators undergoing non-neurologic surgery

©2021 Mayo Foundation for Medical Education and Research | slide-3

3

NEUROMODULATORS

ADVANCING TECHNOLOGY

- Technologic advancements in neuromodulation have provided the ability to treat an unprecedented number of patients
- Invasive and non-invasive techniques of electrical stimulation
- Stimulation technologies are evolving toward closed-loop therapeutic control systems
 - Goal to deliver stimulation with higher spatial resolution
 - Provide continuous customized neuromodulation for optimal clinical outcomes

©2021 Mayo Foundation for Medical Education and Research | slide-4

4

Neurostimulation Devices for the Treatment of Neurologic Disorders

Christine A. Edwards, MS; Abbas Kouzani, PhD; Kendall H. Lee, MD, PhD; and Erika K. Ross, MS, PhD

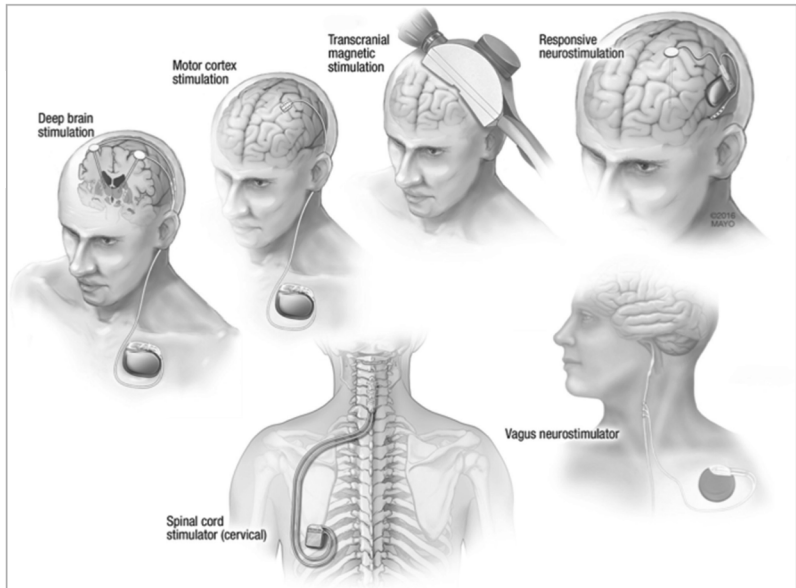


FIGURE 1. Neuromodulation devices for the treatment of neurologic disorders. Schematic summarizing common neuromodulation devices and stimulation targets in the central and peripheral nervous systems.

Mayo Clin Proc. ■ September 2017;92(9):1427-1444 ■ <http://dx.doi.org/10.1016/j.mayocp.2017.05.00>
www.mayoclinicproceedings.org ■ © 2017 Mayo Foundation for Medical Education and Research

5



NEURO GADGETS IN THE OPERATING ROOM

- Implantable electronic devices are vulnerable to external electrical currents and magnetic fields
- Modern operating rooms have an abundance of electrical devices and equipment that can interfere with such devices
- As the number of approved indications for implantable devices increases, we will be seeing more patients with these devices
- Understanding these devices and the peri-procedural implications is critical for the safety of our patients

<https://www.teepublic.com/kids-t-shirt/1924683-inspector-gadget>
 Accessed 2/7/19

6

DEEP BRAIN STIMULATORS

7

DEEP BRAIN STIMULATORS

- Minimally invasive targeted neurosurgical intervention
- Enables structures deep within the brain to be stimulated electrically by an implanted pulse generator

©2021 Mayo Foundation for Medical Education and Research | slide-8

8

DEEP BRAIN STIMULATION

INDICATIONS

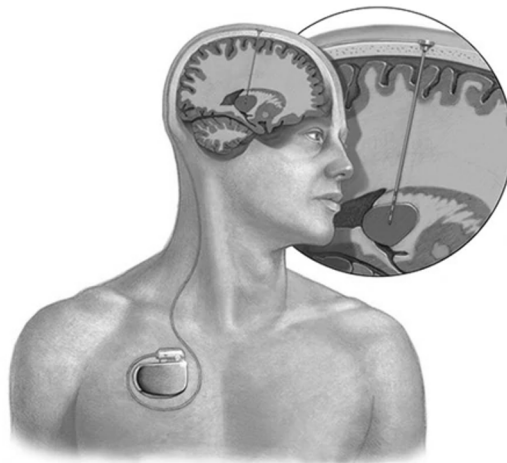
- Movement disorders
 - Parkinson's Disease
 - Essential tremor
- Drug resistant focal epilepsy
- Other possible disorders
 - Obsessive compulsive disorder
 - Dystonia
 - Depression
 - Anorexia
 - Tourette's
 - Chronic pain
 - Alzheimer's disease

©2021 Mayo Foundation for Medical Education and Research | slide-9

9

DEEP BRAIN STIMULATOR

COMPONENTS



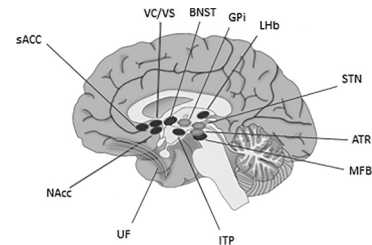
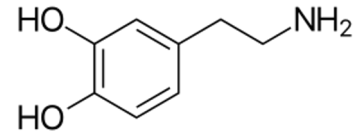
© MAYO FOUNDATION FOR MEDICAL EDUCATION AND RESEARCH. ALL RIGHTS RESERVED.

10

DEEP BRAIN STIMULATOR

TARGETS/HOW IT WORKS

- Depends on the indication for treatment
- Movement disorders
 - Mimics the inhibitory effect of dopamine from the substantia nigra, which has been lost
 - Frequent targets include the thalamus, globus palladium and subthalamic nuclei
- Epilepsy
 - Stimulation disrupts circuitry/neuronal activity
 - Anterior and centromediam thalamic nuclei, subthalamic nucleus, caudate, hippocampus, and the cerebellum



https://en.wikipedia.org/wiki/Dopamine_agonist

https://ars.els-cdn.com/content/image/1-s2.0-S0166432818307344-gr1_lrg.jpg
Behavioural Brain Research, Vol. 359, Feb 1 2019, 266-273.

©2021 Mayo Foundation for Medical Education and Research | slide-11

11

DEEP BRAIN STIMULATOR

PREOPERATIVE CONSIDERATIONS

- Know the indication for DBS treatment
- Ask the patient for DBS information
 - DBS model, pulse generator location, last check, battery status
 - Current settings, programmability and any device complications
- Know severity of symptoms when device is turned off
- Learn to use the programmer to turn device ON and OFF

©2021 Mayo Foundation for Medical Education and Research | slide-12

12

DEEP BRAIN STIMULATOR INTRAOPERATIVE CONSIDERATIONS

- Turn DBS off to minimize electromagnetic interference
 - Consider turning off after induction of anesthesia if symptoms are severe
- May require deeper sedation during regional anesthesia if symptoms are severe
- Turn DBS on prior to reversal of anesthesia and emergence
- *Some newer models may remain on during the procedure – if electrocautery is not utilized

©2021 Mayo Foundation for Medical Education and Research | slide-13

13

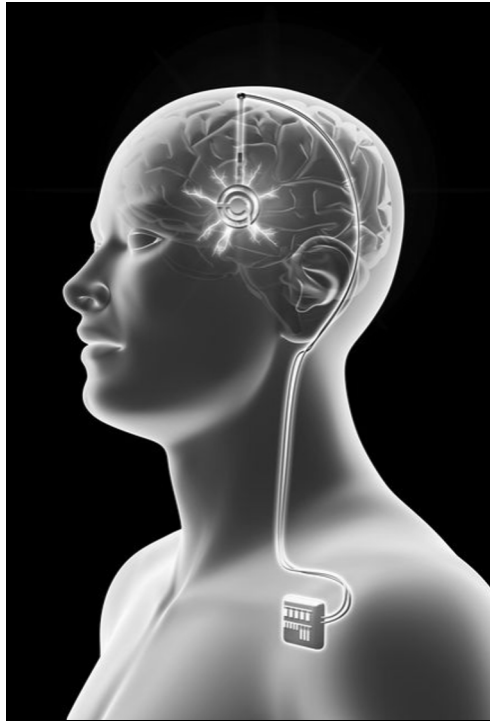


DBS INTRAOPERATIVE CONSIDERATIONS

- Potential for DBS system to interact with multiple medical devices in the operating room
 - Diathermy
 - Electrocautery
 - Peripheral nerve stimulator
 - Cardiac defibrillator
 - Therapeutic ultrasound
 - Laser equipment

©2021 Mayo Foundation for Medical Education and Research | slide-14

14



DEEP BRAIN STIMULATOR INTRAOPERATIVE CONSIDERATIONS

- Electromagnetic interference can affect the function of the DBS
 - Direct damage to the implantable pulse generator (IPG)
 - suppressed or increased stimulation or complete cessation of output
- Induced current can pass through the IPG along the conducting wires
 - Lead to heat generation at the tip of the DBS electrodes
 - Damage to brain tissue in proximity of the electrodes

<https://spectrum.ieee.org/the-human-os/biomedical/devices/how-brain-pacemakers-treat-parkinsons-disease>

15

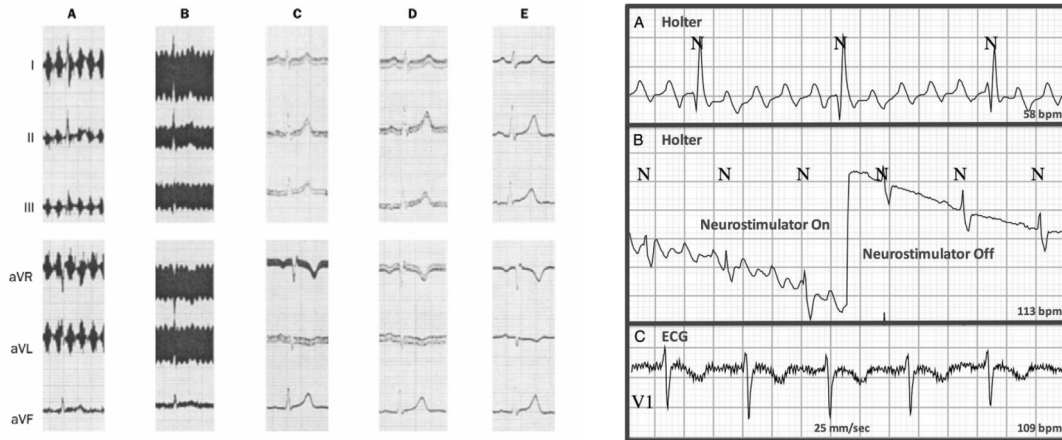
DEEP BRAIN STIMULATOR INTRAOPERATIVE CONSIDERATIONS

- Use bipolar cautery at minimal power necessary
- Avoid monopolar cautery
 - If necessary, place the ground pad as far from system as possible and so that current does not flow through the DBS system
- Case report of a patient with DBS reported a shocking sensation when exposed to monopolar cautery during a dermatologic procedure
- For emergency surgery when programmer not available, proceed with precautions for electrocautery

Voutsalath MA, Bichakjian CK et al. Electrosurgery and implantable electronic devices: Review and implications for office-based procedures. *Dermatol Surg* 2011; 37:889-899.

16

DEEP BRAIN STIMULATOR ECG INTERFERENCE



Kooger BL, Jaspers, GJ et al. Deep brain stimulator-induced flutter-like artefact on Holter recording. Eur Heart J. 2017 Jan 1;38(1):61
 Martin WA, Camenzind E, Burkhard PR. ECG Artifact due to deep brain stimulation. Lancet 2003, 361:1431

©2021 Mayo Foundation for Medical Education and Research | slide-17

17

DEEP BRAIN STIMULATOR CASE REPORT

- Patient with bilateral DBS for Parkinson's disease underwent a laparoscopic cholecystectomy under GA
- During reversal of anesthesia the patient did not arouse and entropy levels remained low despite an end-tidal desflurane concentration of 0.4% (MAC 0.1)
- The DBS was reactivated and there was a sudden increase in entropy values and spontaneous eye opening



FIGURE 1. Figure showing sudden increase in entropy values coinciding with turning on the deep brain stimulation pulse generator (white block arrow). The end-tidal desflurane concentration and minimum alveolar concentration were both low (white box), indicating minimal residual effect of the volatile anesthetic.

Singh M, Venkatraghavan L. Cortical arousal with deep brain stimulation after general anesthesia for laparoscopic cholecystectomy. J Neurosurg Anesthesiol 2016

©2021 Mayo Foundation for Medical Education and Research | slide-18

18

DEEP BRAIN STIMULATOR POSTOPERATIVE CONSIDERATIONS

- Neurologic examination to rule out adverse events related to device interaction
- DBS device check by relevant device representative or DBS physician

©2021 Mayo Foundation for Medical Education and Research | slide-19

19

DEEP BRAIN STIMULATOR REGIONAL ANESTHESIA



<https://emedicine.medscape.com/article/2000865-technique>

- Device deactivation may make performing regional anesthesia more challenging
- Sedation may help minimize symptoms and facilitate the procedure
- Peripheral nerve stimulation has been reported for brachial plexus blocks
 - Ensure electrical stimulation does not pass through the DBS system
 - Puncture site should not be in proximity to wires of the DBS
- Ultrasound guidance
 - Do not place ultrasound transducer directly over the device

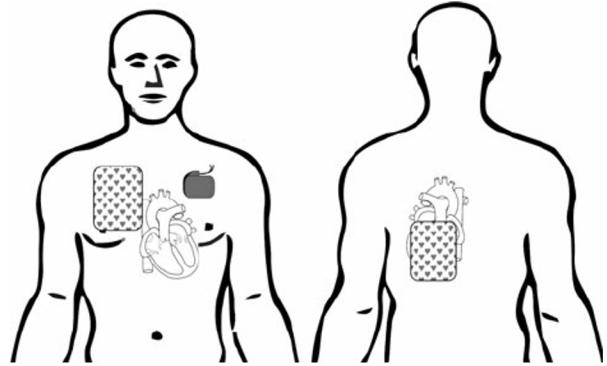
©2021 Mayo Foundation for Medical Education and Research | slide-20

20

DEEP BRAIN STIMULATOR SPECIAL SITUATION

Cardiac Defibrillation

- Lifesaving defibrillation or synchronized cardioversion should not be withheld
- Use lowest clinically appropriate output setting
- Position paddles as far from neurostimulator as possible
- Position paddles perpendicular to the DBS system
- Check the device after shock delivery



https://www.researchgate.net/figure/Placement-of-transcutaneous-pads-to-facilitate-intraoperative-external-pacing_fig1_271661859

©2021 Mayo Foundation for Medical Education and Research | slide-21

21

VAGAL NERVE STIMULATORS

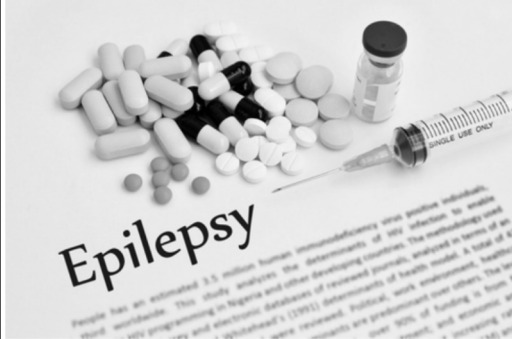


<https://health.howstuffworks.com/mental-health/depression/facts/vagus-nerve-stimulation-for-depression.htm>

©2021 Mayo Foundation for Medical Education and Research | slide-22

22

VAGAL NERVE STIMULATOR INDICATIONS



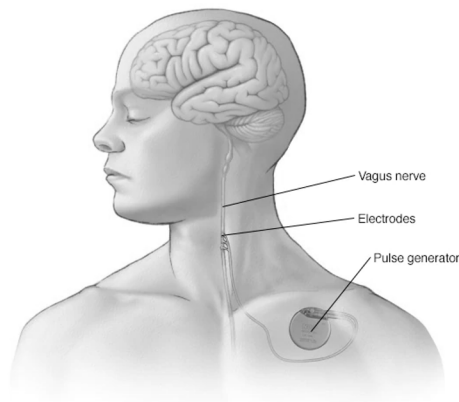
- Adjunct therapy for medically refractory epilepsy and major depression
- Additional indications are under investigation

<http://epilepsyu.com/tag/epilepsy-medications/>
 Accessed 2/10/19

©2021 Mayo Foundation for Medical Education and Research | slide-23

23

VAGAL NERVE STIMULATOR COMPONENTS



© MAYO FOUNDATION FOR MEDICAL EDUCATION AND RESEARCH. ALL RIGHTS RESERVED.

©2021 Mayo Foundation for Medical Education and Research | slide-24

24

VAGAL NERVE STIMULATOR DETAILS

- The pulse generator delivers an electrical stimulation burst based on programmer parameters
- VNS does not monitor central nervous system electrical or peripheral muscle activity
- Does not respond to potential seizure activity
- Noninvasively programmed via an externally placed programming wand and software on a standard computer
- Radiofrequency signals are used to communicate with the implanted VNS generator/stimulator



<https://neuronewsinternational.com/fda-approves-sentiva-device-treatment-epilepsy/>

©2021 Mayo Foundation for Medical Education and Research | slide-25

25

VAGAL NERVE STIMULATOR HOW IT WORKS

- The mechanism of action is not completely understood
- It is believed that VNS electrical stimulation creates action potentials within the cervical vagus nerve that modulate cerebral neuronal excitability
- This effect may be through induction or inhibition of electrical signals by altering neuronal electrical or chemical properties

©2021 Mayo Foundation for Medical Education and Research | slide-26

26

VAGAL NERVE STIMULATOR INTRAOPERATIVE CONSIDERATIONS

- VNS does not need to be deactivated or inhibited during surgery
- Electrocautery
 - Can damage the generator
 - Bipolar cautery preferred
 - Position grounding pads to prevent current flow through the system and as far away from the VNS generator as possible
- Correct functioning of the VNS may need to be confirmed after the procedure

©2021 Mayo Foundation for Medical Education and Research | slide-27

27

VAGAL NERVE STIMULATOR SPECIAL CONSIDERATIONS

- External defibrillation and electrical cardioversion may damage generator circuitry
 - Use lowest appropriate energy
 - Place defibrillation pads as far from generator and implanted lead as possible
 - Confirm correct functioning of VNS after defibrillation

©2021 Mayo Foundation for Medical Education and Research | slide-28

28

VAGAL NERVE STIMULATOR SPECIAL CONSIDERATIONS

- Chronic vagal nerve stimulation can cause significant respiratory side effects
 - Consistent decreases in air flow sleep
 - Laryngeal dysfunction can occur
 - VNS may worsen OSA during stimulation intervals
 - Respiratory effort is preserved
 - Respiratory events resolved with CPAP
 - Obvious perioperative considerations here

Banzett RB, Guz A, Paydarfar D, et al. Cardiorespiratory variables and sensation of the left vagus in patients with epilepsy. *Epilepsy Res* 1999;35:1-11.

©2021 Mayo Foundation for Medical Education and Research | slide-29

29

Case of Vagal Nerve Stimulator–Induced Stridor After Anterior Cervical Discectomy and Fusion–Induced Vocal Cord Paralysis

David Horvat¹, John Lovell¹, Jason Boulter², Abraham Sabersky², Joseph Brown¹

*Citation: World Neurosurg. (2020) 134:76-78.
<https://doi.org/10.1016/j.wneu.2019.10.132>*

- 56-year-old woman with a left sided VNS underwent an anterior C7-T2 cervical discectomy and fusion via a right sided approach
- Developed stridor on POD 1 that progressed over a 3-week period
- Presented to ED 3 weeks post op with worsening stridor
- ENT evaluation = right sided vocal cord paralysis + left vocal cord paresis with minimal motion → glottic narrowing
- Neurology evaluation noted correlation of the stridor with VNS stimulation intervals
- VNS was turned off and the patient was initiated on additional antiepileptic medication therapy

©2021 Mayo Foundation for Medical Education and Research | slide-30

30

Effects of vagus nerve stimulation on respiration during sleep

A pilot study

B.A. Malow, MD, MS; J. Edwards, MD; M. Marzec, BS; O. Sagher, MD; and G. Fromes, MS, RN
NEUROLOGY 2000;55:1450-1454

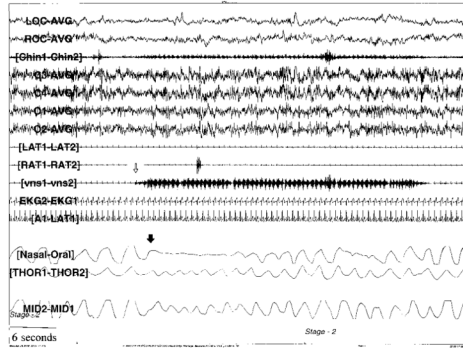


Figure 1. One-minute epoch shows obstructive apnea (solid arrow) recorded at 1.5 mA, 30 Hz, on-time/off-time of 30 s/5 min, and 500 μ s. The onset of the vagus nerve stimulation signal is indicated by the open arrow.

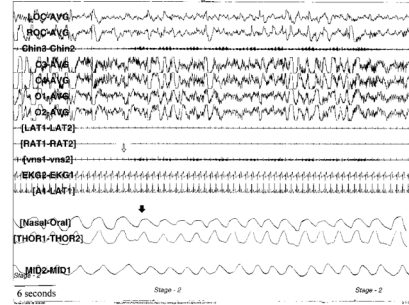


Figure 2. One-minute epoch shows mild decrease in airflow and effort (solid arrow) recorded at 1.5 mA, 20 Hz, on-time/off-time of 30 s/5 min, and 500 μ s. The onset of the vagus nerve stimulation signal is indicated by the open arrow. There is no arousal from sleep or 4% or greater oxygen desaturation with this event and it was therefore not scored as a hypopnea.

©2021 Mayo Foundation for Medical Education and Research | slide-31

31

Effects of vagus nerve stimulation on respiration during sleep

A pilot study

B.A. Malow, MD, MS; J. Edwards, MD; M. Marzec, BS; O. Sagher, MD; and G. Fromes, MS, RN

Table 2 Follow-up studies in Patient 1 to compare proportion of respiratory events (apneas or hypopneas) during 30-second epochs of VNS activation and nonactivation at varying stimulus frequencies

| Condition (stimulus frequency) | Total sleep time, min | No. of events/no. of epochs of sleep sampled with VNS activation | No. of events/no. of epochs of sleep sampled without VNS activation | p Value, Fisher's exact test* |
|--------------------------------|-----------------------|--|---|-------------------------------|
| Night 1, Hz | | | | |
| 30 | 118 | 23/22 | 16/213 | <0.0001 |
| 20 | 66 | 2/11 | 4/121 | 0.08 |
| 10 | 60 | 1/8 | 11/101 | 0.62 |
| Night 2, Hz | | | | |
| 30 | 53 | 10/11 | 0/95 | <0.0001 |
| 20 | 133 | 22/29 | 28/236 | <0.0001 |
| 10 | 146 | 9/33 | 57/258 | 0.32 |

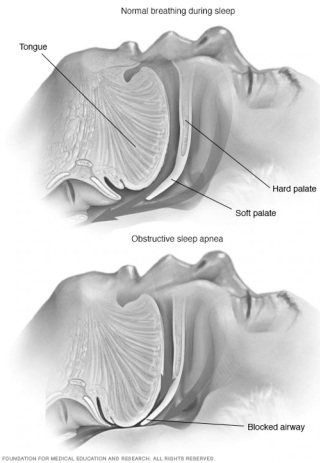
* Comparing proportion of respiratory events during vagus nerve stimulation (VNS) activation and nonactivation for each condition.

©2021 Mayo Foundation for Medical Education and Research | slide-32

32

VAGAL NERVE STIMULATOR PERIPROCEDURAL RECOMMENDATIONS

- Minimize postoperative respiratory complication risks
 - Non-opiate analgesic regimens such as NSAIDs
 - Supplemental O2 with close monitoring
 - CPAP available if patient has OSA



<https://www.mayoclinic.org/diseases-conditions/obstructive-sleep-apnea/symptoms-causes/syc-20352090>

©2021 Mayo Foundation for Medical Education and Research | slide-33

33

VAGAL NERVE STIMULATOR FUTURE ROLES

- Initially approved for treatment of refractory epilepsy
- Subsequent approval for the adjunctive treatment of depression
 - Patients with VNS for epilepsy showed signs of elevated mood
- Obesity
 - Effects of vagal afferents on multiple aspects of satiety and eating behavior
- Neuropsychiatric disorders (OCD, panic disorder, PTSD) are under investigation
- Treatment of pain syndromes

©2021 Mayo Foundation for Medical Education and Research | slide-34

34

NEUROMODULATION DEVICES SUMMARY

- Advances in neuromodulation techniques are leading to increasing number of patients with neurostimulators
- We are likely to encounter an increasing number of patients with neuromodulating devices for non-neurologic surgery
- Knowing the appropriate peri-operative care for these patients is essential for patient safety
- Deep brain stimulators
 - Turn off the DBS system prior to surgery (especially if using any cautery)
 - Bipolar cautery
- Vagal nerve stimulators
 - Do not adjust for non-neurologic surgery
 - Bipolar cautery
 - May have worsening of sleep apnea in post-operative period

©2021 Mayo Foundation for Medical Education and Research | slide-35

35

REFERENCES

- Banzett RB, Guz A, Paydarfar D, et al. Cardiorespiratory variables and sensation of the left vagus in patients with epilepsy. *Epilepsy Res* 1999;35:1-11
- Edwards CA, Kouzani A, Lee K, Ross EK. Neurostimulation Devices for the Treatment of Neurologic Disorders. *Mayo Clin Proc.* September 2017;92(9):1427-144
- Hatton KW, McLarney TJ, Pittman T, and Fahy BG. Vagal Nerve Stimulation: Overview and Implications for Anesthesiologists. *Anesth Analg* 2006;103:1241-9
- Horvat D, Lovell J, Boulter J, et al. Case of vagal nerve stimulator induced stridor after anterior cervical discectomy and fusion – induced vocal cord paralysis. 2020. *World Neurosurg* 134:76-78
- Kooger BL, Jaspers, GJ et al. Deep brain stimulator-induced flutter-like artefact on Holter recording. *Eur Heart J.* 2017 Jan 1;38(1):61
- Malow BA, Edwards J, et al. Effects of vagus nerve stimulation on respiration during sleep. A pilot study. *Neurology* 2000;55: 1450-1454
- Martin WA, Camenzind E, Burkhard PR. ECG artifact due to deep brain stimulation. *The Lancet.* 2003 Apr 26;361:1431
- Singh M, Venkatraghavan L. Cortical arousal with deep brain stimulation after general anesthesia for laparoscopic cholecystectomy. *J Neurosurg Anesthesiol* 2016
- Venkatraghavan L, Chinnapa V, et al. Non-cardiac implantable electrical devices: brief review and implications for anesthesiologists. *Can J Anesthes* 2009;56:320-326
- Voutsalath MA, Bichakjian CK et al. Electrosurgery and implantable electronic devices: Review and implications for office-based procedures. *Dermatol Surg* 2011; 37:889-899
- Yeoh TY, Manninen P, et al. Anesthesia considerations for patients with an implanted deep brain stimulator. *Can J Anesthe* 2017; 64:308-319

©2021 Mayo Foundation for Medical Education and Research | slide-36

36

QUESTIONS & ANSWERS

©2021 Mayo Foundation for Medical Education and Research | slide-37