Vagal Nerve Stimulator Lead Revision Using Needle-Tip Cautery: Case Series, Literature Review, and Technical Note

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BACKGROUND: **Vagal nerve stimulators (VNs) have been in use in the United States since the 1990s as a palliative treatment option for drug-resistant epilepsy. Over time, the electrode coils wrapped around the vagus nerve become encapsulated by extensive scar tissue, making complete electrode removal challenging. We present a case series of lead revision surgeries with a unique way to remove the scar tissue around the vagus nerve, demonstrating a technique for complete electrode removal.**

METHODS: **This was a case series of 9 consecutive patients who underwent complete removal of an existing VNs electrode using needle tip monopolar electrocautery.**

RESULTS: **Complete removal of the entire VNs electrode array was achieved in all patients with no permanent complications seen at postoperative follow-up at 3 months.**

CONCLUSIONS: **Complete VNs electrode array removal can be safely achieved by using needle tip monopolar electrocautery.**

INTRODUCTION

In 1938 Baily and Bremer described the cortical representation of the vagus nerve and reported alterations in brainwave activity in cats after vagal nerve stimulation (VNS).[1] In recent years, VNS has emerged as a viable surgical option for the treatment of medically refractory epilepsy. The vagal nerve stimulator (VNs) has been used for the treatment of medically refractory epilepsy in Europe since 1994 and in the United States since 1997.[2] Over the years, numerous articles have been published documenting complications and side effects of VNS therapy.[1-13] Removal of the VNs electrode array occasionally is needed when there is a fracture in the array or if the patient is in need of magnetic resonance imaging (MRI) of the body or spine. Removal of the array can be challenging, and we present a series of consecutive patients in whom the electrode array successfully was removed via an ultrasharp needle tip cautery technique.

METHODS

We obtained internal review board approval from the Dartmouth-Hitchcock Medical Center Institutional Review Board (Project number STUDY00030762) and conducted a retrospective review of the neurosurgery database of a single academic center in New Hampshire to obtain a series of consecutive patients who underwent removal of an existing VNs electrode array between 2012 and 2017. No identifiable patient information was collected. No consent was needed, given that the retrospective research involved no more than minimal risk to subjects and data had already been collected as part of the normal clinical process. Charts were reviewed and data were abstracted for patient demographics, indication for removal, and postoperative outcome after surgery and at 3 months after surgery (**Table 1**). One attending physician (D.F.B.) with previous training in the procedure completed procedures in all patients, resolving any potential issues with interoperator variation.

RESULTS

Nine consecutive patients were found, all of whom were treated with this technique by a single surgeon (D.F.B). Six patients were male and 3 patients were female. The mean length of VNS therapy was 11.9 years. Indication for VNs lead removal included

Key words
- Complications
- Cranial nerve stimulator
- Epilepsy
- Needle tip cautery
- Seizure surgery
- Vagus nerve stimulation
- Vagal nerve stimulator

Abbreviations and Acronyms
EC: Electrocautery
MRI: Magnetic resonance imaging
VNs: Vagal nerve stimulator
VNS: Vagal nerve stimulation

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Table 1. Results of MRE, VNs, Fx, and IPG

Case	Reason for VNs	Reason for VNs Removal	Duration of VNs Implant, years	Operative Time, minutes	Postoperative Complications
1	MRE	VNs lead fx	10	130	None
2	MRE secondary to TBI	Need for spine imaging	9	113	None
3	MRE secondary to neonatal herpes encephalitis	VNs lead fx and expired IPG	6	146	None
4	MRE secondary to mitochondrial disorder	VNs lead fx	12	67	None
5	MRE	VNs lead fx	15	120	None
6	MRE secondary to Coffin—Lowry syndrome	VNs lead fx	14	140	Mild hoarseness that resolved
7	MRE	VNs lead fx	11	146	Hoarseness that resolved
8	MRE	VNs lead fx	16	144	Hoarseness, dysphagia; significant delayed improvement
9	MRE secondary to neonatal meningitis	No need for VNs and expired IPG	14	67	None

MRE, medication-refractory epilepsy; VNs, vagal nerve stimulator; fx, fracture; IPG, implantable pulse generator; TBI, traumatic brain injury.

lead fracture with elevated impedance (7 of 9 patients, 77.8%), no need for VNs (1 of 9 patients, 11.1%), and need for spine imaging (1 of 9 patients, 11.1%). All 9 patients had successful complete removal of the VNs electrode array. Seven of 9 patients (77.8%) had immediate successful reimplantation of a new electrode array because of lead fracture. One patient (11.1%) had dysphagia immediately after surgery that resolved before discharge. On initial follow-up visit, 3 patients (33.3%) had hoarseness, and 6 patients (66.6%) had no complications. At the 3-month follow-up, the hoarseness in the 3 patients had significantly improved, with only 1 patient believing he had continued mild hoarseness to his voice. No patient had swallowing difficulties, and there were no perioperative infections. The same technique of ultra-sharp needle tip monopolar electrocautery (EC; Colorado Needle from Stryker, Kalamazoo, Michigan, USA) was used for every patient in this series. Mean surgery time was 119.2 minutes, with a range of 67—146 minutes (Table 1).

CASE SERIES

Case 1

A 25-year-old man was diagnosed with seizures at 10 years of age and ultimately was refractory to antiepileptic medications, requiring VNs placement. He presented with 2 months of a shock-like neck pain when he extended his neck to the right. The VNs was interrogated while he was looking straight ahead and with his head turned in both directions. The VNs had increased impedances with his head turned to the right, and normal impedance with his head looking forward and looking towards the left. The patient was taken to the operating room for complete VNs removal and replacement via Colorado Needle monopolar cautery (Stryker). He tolerated surgery well and had his VNs turned on 2 weeks after surgery. At the 3-month postoperative visit, he had a functioning VNs without new problems or deficits. No new speech or swallowing problems were observed.

Case 2

A 13-year-old female patient with a history of traumatic brain injury as an infant had subsequent development of hydrocephalus requiring shunting and seizures that became refractory to antiepileptic medications. She underwent VNs implantation in 2004 and underwent functional hemispherectomy in 2011, with good effect on seizure control. In January 2013, the patient developed worsening paraplegia in the setting of an inactive VNs. To obtain MR imaging of the spine the patient's entire VNs system was explanted via the Colorado Needle (Stryker) in January 2013. She experienced no operative complications from this, and MRI of the spine revealed a new holocord syrinx. At 3-month postoperative follow-up, she was neurologically stable with well-healing incisions. No new speech or swallowing problems were observed.

Case 3

A 14-year-old male patient with a history of neonatal herpes encephalitis developed medically refractory seizures requiring corpus callosotomy followed by VNs implantation. Nine years later, the patient presented to clinic with a several months history of increasing nighttime seizures, and VNs battery was found to be expired. A week later, the patient was taken to the operating room, where the VNs lead was noted to be fractured, prompting revision of the entire VNs via the Colorado Needle (Stryker). The entire device was removed, and a new device and electrode array was placed. At the 3-month postoperative visit, he was doing well without new deficit and with well-healing incisions. No new speech or swallowing problems were observed.

Case 4

A 19-year-old male patient with mitochondrial complex 5 deficiency causing early onset of medically refractory seizures underwent an implant of a VNs device at age 9. Six years later, the patient presented in status epilepticus and was found to have high impedance on interrogation of his VNs. He was taken to the