**Phrenic Nerve Stimulation in a Patient with a Dorsal Column Stimulator**

Emily L. Walker, M.D., Daniel D. DuBose, M.D., Garrett K. Wright, M.D., Christopher J. Burnett, M.D.

**Abstract**

We present a case of a 76-year-old female who developed recurrent left-sided muscles spasms resembling hiccups after permanent dorsal column stimulator (DCS) implantation. The patient had a cardiac resynchronization device with defibrillating capabilities (CRT-D) in place which was interrogated before and after the permanent DCS placement, with no interference reported. Due to the timing of the event with the placement of the DCS, it was presumed that the spasms were related to the DCS implantation and removal of the DCS was considered. However, further evaluation from cardiology revealed that a lead from her CRT-D was most likely stimulating the phrenic nerve and causing diaphragmatic contractions. The patient was sent to the electrophysiology clinic where the voltage on her left ventricular lead was reduced and her symptoms resolved completely. Due to the time, risks and expense of placing a DCS, it is imperative to consider all other possible causes of diaphragmatic contractions prior to removing a DCS system.

**Introduction**

We describe a patient who developed persistent hiccups immediately after dorsal column stimulator implantation. After further investigation, it was determined that the cause of her symptoms was a lead from her cardiac resynchronization device with defibrillating capabilities stimulating the phrenic nerve and resulting in diaphragmatic contractions.

**Case Report**

A 76-year-old female presented to our pain clinic for evaluation after permanent dorsal column stimulator (DCS) placement. She complained of recurrent muscle spasms across her left upper abdomen that she described as a hiccup, which began several hours after her DCS was placed. Her DCS was turned off and she was started on metaxalone. Despite this, two weeks after surgery she was still having persistent left sided-diaphragmatic contractions.

The patient had undergone a successful trial with the Nevro system one month prior and she did not experience diaphragmatic contractions at that time. Of note, the patient had a cardiac resynchronization therapy device with defibrillating capabilities (CRT-D) in place. Her CRT-D was interrogated before and after the trial with no interference reported.

Placement of the permanent DCS was uneventful. Epidural access was obtained at T12-L1, and the generator was placed in the right gluteal region. The placement of her DCS was completed with lead tips at the bottom of the eighth thoracic vertebrae on the left and the top of the eighth thoracic vertebrae on the right. The patient received monitored anesthesia care and sedation, and she recovered from her anesthetic without any adverse events. Her CRT-D was again interrogated before and after the permanent DCS placement with no interference reported.

The patient’s DCS trial had been successful with no untoward side effects. However, due to the temporal relationship of the DCS placement and the onset of the diaphragmatic contractions, it was presumed that the spasms were related to the DCS implantation and removal of the DCS was considered. Since a lead from the CRT-D can rarely lead to phrenic nerve stimulation with resultant diaphragmatic contractions resembling hiccups, an additional interrogation of the device was planned. The patient was sent to the electrophysiology clinic where the voltage on her left ventricular lead was reduced and her diaphragmatic symptoms resolved completely.

**Discussion**

The temporal relationship of the onset of our patient’s symptoms with the permanent DCS implant led us to consider the DCS as the cause of her left-sided diaphragmatic contractions. To our knowledge, there are no reports in the literature of a DCS causing diaphragmatic contractions; however, epidural manipulation in the form of injection of medications has been implicated in persistent hiccups by an undetermined mechanism (1). Our patient also had a cardiac resynchronization therapy device (CRT-D) in place and left phrenic nerve stimulation (PNS) is a well-known complication of these devices (2,3). The left ventricular lead is placed in the coronary sinus and its proximity to the phrenic nerve creates a potential for nerve stimulation resulting in diaphragmatic contractions. PNS occurs in 33-37% of patients with CRT-D, and is a limiting factor when implanting left ventricular leads from coronary veins (4). Toggweiler et. al. describe a case study that illustrates that a simple non-invasive test of acoustic cardiography can be applied during biventricular pacemaker implantation to ensure that the pacemaker settings are not leading to PNS (5). Some studies suggest that reducing left ventricular bipolar electrode spacing may significantly increase the PNS threshold (6). Additionally, a new quadripolar electrode left ventricular lead may provide more programming options to manage PNS (7). The elevated pacing thresholds and PNS sometimes seen with CRT-D may require that the coronary sinus lead be repositioned or the voltage reduced. In the case of our patient, the electrophysiology team was able to reduce the voltage in the left ventricular lead and her symptoms resolved completely.

There has also been concern historically regarding the combination of spinal cord stimulators and cardiac permanent pacemakers due to the possibility of false inhibition of the permanent pacemaker. Our patient underwent interrogation of her CRT-D before and after placement of the DCS with no signs of interference, and there are case reports in the literature describing the safe use of a DCS in patients with a permanent cardiac pacemaker (8). Ekre et. al. describe a study where 18 patients were tested to see if a spinal cord stimulator and permanent pacemaker could be safely combined. Their pacemaker settings were temporarily modified to increase the probability of interference, while the spinal cord stimulator intensity was increased to the maximum level tolerated. No patients displayed signs of inhibition during the tests and this study suggested that bipolar spinal cord stimulators and permanent pacemakers could be used together safely; however, individual testing is mandatory in each patient (9).

**Conclusion**

When implanting a DCS, it is important to be knowledgeable about other electronic devices the patient has. It is important to always consider these other devices and potential interactions if a patient develops unusual complications after DCS implantation. The pacemaker device company and electrophysiology team may be valuable resources in the setting of a coexisting pacemaker or CRT-D and DCS. It is unclear why this patient’s CRT-D had previously not produced PNS, but did following insertion of the DCS. They are likely unrelated events, however the possibility of the DCS causing a change in thresholds of the CRT-D cannot be ruled out. Ultimately, due to the time, risks and expense of placing a DCS, it is imperative to specifically consider a patient’s CRT-D as the cause of diaphragmatic contractions prior to removing a DCS, even when the temporal relationship of the DCS and onset of new symptoms may suggest otherwise.

**References**

1. McAllister RK, McDavid AJ, Meyer TA, Bittenbinder TM. Recurrent persistent hiccups after epidural steroid injection and analgesia with bupivacaine. Anesth Analg. 2005;100:1834–6.
2. Doguet F, Honoré C, Godin B, Anselme F. Isolation of the phrenic nerve to suppress diaphragmatic contraction induced by cardiac resynchronization. J Cardiovasc Electrophys 2012;23(7):778-80.
3. Hjortshøj S, Heath F, Haugland M, Eschen O, Thøgersen AM, Riahi S, Toft E, Struijk JJ. Long pacing pulses reduce phrenic nerve stimulation in left ventricular pacing. J Cardiovasc Electrophys 2014;25(5):485-90.
4. Biffi M, Zanon F, Bertaglia E, Padeletti L, Varbaro A, De Santo T, Boriani G, Yang Z. Short-spaced dipole for managing phrenic nerve stimulation in patients with CRT: the “Phrenic nerve mapping and stimulation EP” catheter study. Heart Rhythm 2013;10(1):39-45.
5. Toggweiler S, Kobza R, Roos M, Erne P. Visualizing pacemaker-induced phrenic nerve stimulation with acoustic cardiography. Pacing Clin Electrophysiol 2007;30(6):806-7.
6. Biffi M, Foerster L, Eastman W, Eggen M, Grenz NA, Sommer J, De Santo T, Haddad T, Varbaro A, Yang Z. Effect of bipolar electrode spacing on phrenic nerve stimulation and left ventricular pacing thresholds: an acute canine study. Circ Arrhythm Electrophysiol 2012;5(4):815-20.
7. Sperzel J, Dänschel W, Gutleben KJ, Kranig W, Mortensen P, Connelly D, Trappe HJ, Seidl K, Duray G, Pieske B, Stockinger J, Boriani G, Jung W, Schilling R, Saberi L, Hallier B, Simon M, Rinaldi CA. First prospective, multi-centre clinical experience with a novel left ventricular quadripolar lead. Eurospace 2012;14(3):365-72.
8. Kosharskyy B, Rozen D. Feasibility of spinal cord stimulation in a patient with a cardiac pacemaker. Pain Physician 2006;9(3):249-51.
9. Ekre O, Börjesson M, Edvardsson N, Eliasson T, Mannheimer C. Feasibility of spinal cord stimulation in angina pectoris in patients with chronic pacemaker treatment for cardiac arrhythmias. Pacing Clin Electrophysiol 2003;26(11):2134-41.