Journal of Clinical Medicine: Current Research
Volume 2 (2022) 2 Pages

Mini Review | *Open Access*

Multiple Electronic Devices That Utilize Bipolar Leads Are Safe in Pediatrics

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Received: March 15, 2022;
Accepted: March 24, 2022;
Published: March 29, 2022

Citation: Mohammad S. Khan, Christopher Snyder. Multiple Electronic Devices That Utilize Bipolar Leads Are Safe in Pediatrics. J Clin Med Current Res. (2022);2(1): 1-2

Key words: Bipolar, unipolar, leads, pacemaker, pacer, interference, electromagnetic

1. Abstract

Phrenic nerve injury can lead to a disruption of the autonomic nervous system (ANS) resulting in episodes of bradycardic arrest. Implanted diaphragmatic pacing has been used to overcome phrenic nerve paralysis, but these do not change the ANS. Therefore, patients with phrenic nerve paralysis may require the implantation of a permanent cardiac pacemaker (PPM) to overcome bradycardic episodes. Having two electronic devices in the same patient may lead to device-device interaction (DDI). This can result in over-sensing leading to lack of pacing of either device. We present the case of a 17-year-old pediatric male with phrenic nerve injury who required implantation of both diaphragm and cardiac pacemaker. Intra-procedural interrogation of the cardiac pacemaker demonstrated DDI in unipolar mode, but not in bipolar. Thus, we demonstrated the safe utilization of multiple implantable electronic devices *in the pediatric patient* without device-device interaction.

2. Description

Pacemaker technology has been in existence for just over a half-century. The technology was developed to treat bradyarrhythmias and subsequently alternatively purposed for innovations such as the implantable cardioverter-defibrillator (ICD). The first form of an implantable pacemaker consisted of a pulse generator and myocardial electrodes that were implanted by the famous Swedish cardiothoracic surgeon Ake Senning in 1958 [1]. Almost concurrently, in recognizing the prevalence post-operative atrioventricular block (AVB) after ventricular septal defect (VSD) repair, a common complication at that time, cardiologist Seymour Furman developed a transvenous approach for pacing via endocardial leads [2]. These devices were created to serve a single function: pace. This first generation of implantable cardiac pacemakers, however, lacked longevity of the pulse generator and durability of the leads. Over the course of the next several decades, with discovery of newer technologies, the implantable cardiac pacemaker was refined to current day standards of resilience and structural integrity of leads. These pacemakers now served multiple functions, including sensing ones own intrinsic heart rate.

In the pediatric world, transvennous pacemakers were first utilized as early as the 1980s with a good safety profiles [3]. Historically, electrodes utilized in these pacemakers were unipolar and favored over bipolar leads given the better flexibility, smaller dimensions, and durability of unipolar lead. Unipolar leads use a single conductor and generate a broader electrical loop, encompassing a larger area of tissue between the tip lead (cathode) to generator (anode). On the other hand, bipolar leads contain both cathode and anode on the same lead and thus generate a smaller area of electrical loop [4]. Additionally, bipolar leads have far better sensing and pacing capabilities but historically were at increased risk of insulation failure [5]. Modern day bipolar leads encompass a sleeker tip with more flexible material that persistently demonstrate enhanced pacing and sensing thresholds [6].

Soon after the first generation of cardiac pacemakers were implanted, the technology was being envisioned for utilization by other physiologic demands. Reports surfaced in the early 1960's of the successful use of diaphragm pacers in adults with ventilatory deficiency [7]. Over the ensuing decades, this technology was appropriated for use in pediatric patients with either congenital Central Hypoventilation Syndrome or secondary hypoventilation due to cervical spine injury [8]. Phrenic nerve paralysis is a well-known consequence of high cervical spine injury. As such, one can deduce that a patient with this form of trauma will likely utilize, at least temporarily, both cardiac pacing to allow for atrioventricular synchrony in addition to diaphragmatic contraction to facilitate respiratory ventilation. As such, device-device interaction (DDI) was a well-documented phenomenon in the 1980s – 1990s era and was minimized, but not absolutely suppressed, by physical spacing of the unipolar pacing system of the diaphragm and cardiac pacemakers [8]. We can envision how this need for real estate may pose a problem in the pediatric patient.

In the article *Minimizing Device-Device Interactions Using Bipolar Pacemaker Leads in A Pediatric Patient*, published in the journal of *Pediatric Cardiology* on January 13, 2022, we describe the implantation of the Medtronic Assurity MRI™ 1272 single chamber pacemaker in a patient with cervical spinal cord injury. The resulting phrenic nerve paralysis necessitated diaphragmatic pacer implantation (DPM) to facilitate extubation. However, given the patient's symptomatic bradycardia, including two bradycardic arrests, a second electronic device, an intracardiac permanent pacemaker (PPM), was required. With the aforementioned electrical pathways of the unipolar and bipolar leads, we intentionally utilized bipolar leads in our pediatric patient to avoid electrical interference from the DPM. A simple test in unipolar mode demonstrated that DDI does indeed still exist and is problematic for inappropriate sensing and pacing. After PPM implantation and programming in bipolar mode, our patient recovered nicely in the pediatric intensive care unit without further bradycardic events. Upon further device interrogation, there was no evidence of DDI. Our patient went on to successfully transfer to another facility for long-term physical rehabilitation. To date, he has not required modification of his pacemaker leads, nor programming mode of his cardiac pacemaker.

3. Disclosure

The authors have no conflicts of interest.

4. Funding Information

There was no funding provided for this paper.

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