

Case Report

Maladjustment of programmable ventricular shunt valves by inadvertent exposure to a common hospital device

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Abstract

Background: Programmable ventricular shunt valves are commonly used to treat hydrocephalus. They can be adjusted to allow for varying amounts of cerebrospinal fluid (CSF) flow using an external magnetic programming device, and are susceptible to maladjustment from inadvertent exposure to magnetic fields.

Case Description: We describe the case of a 3-month-old girl treated for hydrocephalus with a programmable Strata™ II valve found at the incorrect setting on multiple occasions during her hospitalization despite frequent reprogramming and surveillance. We found that the Vocera badge, a common hands-free wireless communication system worn by our nursing staff, had a strong enough magnetic field to unintentionally change the shunt setting. The device is worn on the chest bringing it into close proximity to the shunt valve when care providers hold the baby, resulting in the maladjustment.

Conclusion: Some commonly used medical devices have a magnetic field strong enough to alter programmable shunt valve settings. Here, we report that the magnetic field from the Vocera hands-free wireless communication system, combined with the worn position, results in shunt maladjustment for the Strata™ II valve. Healthcare facilities using the Vocera badges need to put protocols in place and properly educate staff members to ensure the safety of patients with Strata™ II valves.

Key Words: Magnetic field, Strata™ programmable shunt, Vocera

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INTRODUCTION

Programmable ventricular shunt valves allow for adjustable control of cerebrospinal fluid (CSF) flow using an external magnetic field. Orientation of valve mechanisms can generally be changed by a rotation that coordinates with the direction that the magnet is turned, modifying the opening pressure or rate of flow through the valve. This re-configuration mechanism allows for unrelated electronic devices with magnetic fields to change valve settings [Table 1].^[2,3,4,11,14] Even

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amusement park rides can cause maladjustment of valves.^[10] Despite these risks, programmable valves, when compared to nonprogrammable shunts, are found to be associated with a significant decrease in complications regarding over or underdrainage, as well as a reduction in overall complications.^[1,13] Regulating the amount of flow is important because, as in the presented case, over-drainage can lead to problems such as subdural bleeds, craniosynostosis, and intracranial hypotension.^[13]

According to the manufacturer, Medtronic, a magnetic field must have a strength of at least 80 gauss (G) and be adjacent to the Strata™ II valve to move its mechanism.^[5] Some authors have found that common items such as headphones, earphones, and certain cellular telephones are sufficient for valve maladjustment at levels of 140 to 340 G.^[8] At very close proximity (i.e. 10 to 50 mm), valves may even be adjusted by values as low as 4 G, which is the field strength found with toy magnets, such as a road roller in Lego™ Duplo sets.^[14] Some concerning items include popular headphone brands, such as Apple earphones and Beats by Dr. Dre, particularly due to their placement in relation to the shunts. Studies have shown that headphones cause changes when placed directly against the valves. Laboratory testing did not demonstrate maladjustment at further distances, but with their gauss level, they have the potential to cause problems at up to 5 mm.^[9] Other common electronic devices with this hazard are smartphones. iPhone 5s at 62 G and Samsung Galaxy S5 at 61 G can produce reversible changes to Strata™ valves and irreversible deviations to Codman Certas Valves.^[6] Lastly, a recent study demonstrated alterations in valve settings by osseointegrated hearing devices due again to their juxtaposition.^[7]

Although patient education is commonly provided about household items with magnetic fields, the risks of commonly used medical devices in the hospital can be overlooked.

CASE REPORT

The patient is a 3-month-old girl born premature at 33 weeks' gestation with accelerated head growth and a bulging fontanelle from post-hemorrhagic hydrocephalus. Treatment with a right frontal ventriculoperitoneal shunt with a programmable Medtronic Strata™ II valve was selected because of extreme ventriculomegaly with a very thin cortical mantle and unpredictable CSF drainage needs. The patient underwent a postoperative magnetic resonance imaging (MRI), which showed decreased ventricular size and confirmed the appropriate function of the shunt. Following imaging, the shunt was programmed to performance level 2.5, and was confirmed to be at this setting seven days later. Three days later, the patient was fussy and feeding poorly. The valve was found to be set at performance level 1.0, and was reprogrammed to 2.5. The

following day, it was again back at 1.0, and an investigation was started to determine the cause of the maladjustment.

Despite a lack of warnings regarding magnetic fields from the manufacturer, we hypothesized that the Vocera badge, a newly instituted device in our facility, might be responsible for the inadvertent valve changes. We found that sweeping a Vocera badge across a packaged Strata™ II valve caused the ball and valve mechanism to spin, changing the performance setting.

Upon further investigation, we learned that the patient's head was brought into an adjacent position to the Vocera badge by nursing staff when held for feedings. This proximity of the valve and badge caused changes to the valve's setting. A policy was instituted prohibiting Vocera badges in the patient's room. Alerts were also placed in the electronic medical system. After institution of the new policy, the patient's shunt setting was correct for the remainder of the hospitalization.

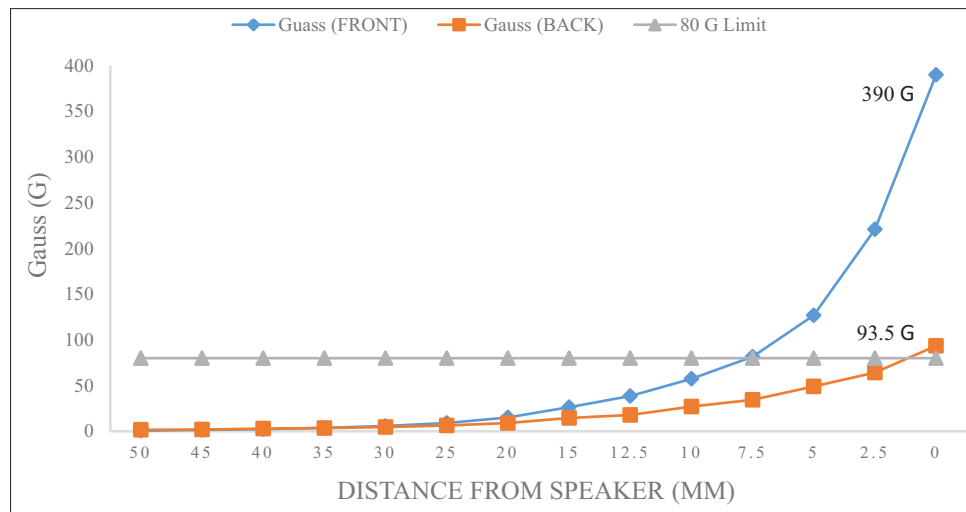
DISCUSSION

Programmable shunt valves allow control of CSF flow, which may be essential to a patient's treatment plan. In this particular case, it was important to regulate the outflow of the shunt to avoid over-drainage and possible collapse of the thin cortical mantle. For this patient and many others, awareness of external objects that may influence these settings is imperative. It is reported that 2% of programmable valve shunt complications are drainage related. As more electronic and technological advances make their way into everyday life, this number may increase.^[13]

Medtronic Inc., the manufacturer of Strata™ valves, reports that 80 G directly adjacent to the valve is necessary for any adjustment to occur.^[5] They state that if something has the ability to lift three paper clips, it creates a strong enough magnetic field leading to adjustment (personal



Figure 1: Vocera badge holding three paper clips



Graph 1: Gauss level of Vocera speaker at various distances Graph Courtesy of Medtronic, Goleta, California

communication). When testing this, we found that the Vocera badge was able to do so [Figure 1].

According to their internal testing, the Vocera badge speaker caused a change when dragged across the valve cassette mechanism where the magnetic rotor resides in the Strata™ valve. Medtronic found that the magnetic field of the Vocera badge was the same when powered on or off, and was the strongest in the center of the speaker. Both the front of the badge (450G) and the back (100G) are strong enough to provoke adjustment [Graph 1]. Medtronic recommends keeping this device 2 inches away from the Strata™ valve (personal communication).

The manufacturer provides educational materials that warn of potential hazards due to the magnetic fields produced by common household items [Table 1]. Medtronic also recommends keeping these items at least 2 inches away for the Strata™ valve.^[5] The valve's external programming device, designed to adjust valve settings, has a field of 3000 G, well above the necessary limit.

Other programmable valves hold similar risks. Manufacturers claim that Codman-Hakim valves require a minimum of 82 G to alter the setting.^[11] Upon investigation, some found that the Codman-Hakim experienced alterations at 150 G and Sophysa valves at 350 G when tested with household electronics.^[8] In another study, it was found that a minimum of 24 G, created by toy magnets, could illicit a change in the Codman-Hakim valve as far as 5 mm away. Finally, the Polaris Sophysa valve, requiring the strongest magnetic force, was altered at 170 G when placed directly against the device.^[14] Strata™ valves have been found to be the most sensitive to alteration when compared to Sophysa and Codman shunts.^[4]

Vocera badges are used commonly in health care settings and produce magnetic fields sufficient to change the Medtronic Strata™ II valve. Vocera badges are hands-free, wearable, lightweight, voice-controlled devices that are

Table 1: Electronic devices found to disrupt shunt programming in the literature

	Gauss at 0 mm to item	Reference
iPad 3 Smart Cover	1200	4
iPad Smart Cover	2060	5
Cell Phone – Clam Shell Type	525	5
Refrigerator Door Magnet	50-340	5, 14
iPhone 5S	62	6
Samsung Galaxy S5	61	6
Cell Phone (S10D, Siemens)	175	8
Apple earbuds	196	9
Beats by Dr. Dre	267	9
Bose Quiet Comfort	240	9
Cathode ray tube television	10	11
Magnetic toys (Lego Duplo)	170	14

utilized to communicate within a network.^[12] They are often attached to clothing or carried on a lanyard by hospital personnel. When caring for infants and children who may be picked up by hospital staff, these communication devices have the potential to interfere with the desired settings due to their proximity.

When discussing these potential risks with Vocera, they released a statement stating the magnetic field was indeed strong enough to influence the programmable valves. They also recommended that the badges not be brought within 2 inches of the valves. Suggestions were made to wear Vocera on the upper arm, close to the clavicle, or removing it from personnel before entering the room to prevent interference.

CONCLUSION

Many household items have been found to interfere with the programmable shunt valves. Anything that creates a strong enough magnetic field could potentially

influence the setting. This includes devices within the healthcare environment that may not be recognized as safety concerns. As more technological devices are made and implemented in hospitals, it should be noted that a potential interference with care of magnetically controlled devices exists. Restriction of Vocera badges in rooms with patients with programmable ventricular valve shunts may be necessary. Further investigation may be needed to discover effects on other medical devices as well.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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