

Maladjustment of Pressure Settings of a Codman-Hakim Programmable Shunt Valve by Electromagnetic Door Locks – A Case Report

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ABSTRACT

Maladjustments and failures of programmable ventriculo-peritoneal shunts have been reported in patients encountering powerful electromagnetic fields, e. g. MRI.

By the means of the case this study shows an easy maladjustment of a Codman-Hakim programmable valve also by small magnetic fields from everyday hospital life.

We describe the case of a 53year old man treated for hydrocephalus with a programmable Codman-Hakim shunt valve. During his hospitalization in Forensic Psychiatry the patient's valve pressure setting changed randomly during despite frequent reprogramming and surveillance.

We found that the electromagnetic locking mechanism of common hospital doors had a strong enough magnetic field to unintentionally change the patient's shunt setting.

We assume that already weak magnetic fields (<100 mT) may change the pressure settings of Codman-Hakim shunt valves.

Patients should be informed and pay attention of using small magnetic devices, like rod magnets or mobile phones.

Keywords: case report, magnetic field, Codman-Hakim programmable shunt valve, maladjustment.

INTRODUCTION

Hydrocephalus is caused by the progressive accumulation of cerebral spinal fluid (CSF) within the intracranial space, resulting in the abnormal expansion of cerebral ventricles and, consequently, in brain damage [2, 5]. The standard treatment of hydrocephalus in children and adults implantation of a VP shunt. Most of the currently used shunt systems involve a valve to control pressure and drain CSF if necessary [5]. In the past few years, malfunction of programmable VP shunts has been reported in patients encountering powerful electromagnetic fields such as generated by magnetic resonance imaging (MRI) [1, 3]. However, little is known about the effect of weak magnetic fields on VP shunts.

In this study, we present a patient from Forensic Psychiatry who had the pressure settings of an implanted Codman-Hakim programmable shunt valve changed when walking through an electromagnetically controlled doorway on a hospital ward.

The Codman-Hakim valve (Codman, Johnson & Johnson Company) is a programmable CSF shunt with an opening pressure between 30 and 200 mm H₂O. The valve relies on a special ball-in-cone system. A spherical ruby ball is pressed against a conical valve seat by a stainless-steel spring. Atop the spring sits a rotating spiral cam that contains a stepper motor surrounded by 10 magnets in antiparallel orientation [6, 7]. If the pressure difference across the valve exceeds a predefined popping pressure, the ball rises from the seat to vent CSF. To provide a larger valve orifice, the ball moves further away from the seat if the flow rate through the valve increases. Therefore, the pressure drop across the orifice never rises significantly above the predefined popping pressure. To adjust a particular opening pressure, an external handheld programming device is placed over the valve, so that the 4 programmer's coils centrally

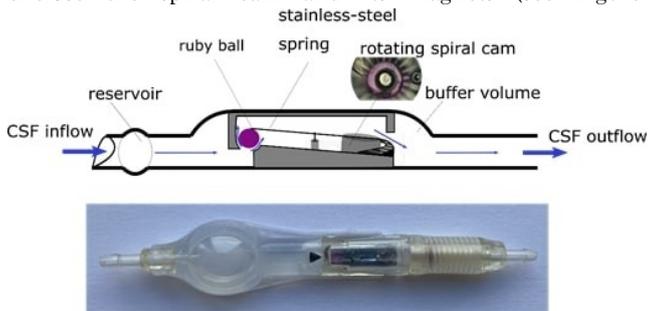
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enclose the spiral cam and its magnets (see Figure 1).



Generating an electrically induced alternating magnetic field, only a few magnets are attracted by one coil or another. Switching the electric current on and off results in the step-by-step rotation of the spiral cam, which enables the non-invasive adjustment of the opening pressure to 18 different range settings with a pressure difference of 10 mm H₂O each.

NARRATIVE

The 53-year-old man presented with triventricular hydrocephalus due to aqueductal stenosis. The diagnosis had been randomly discovered by means of a magnet resonance imaging (MRI) scan that was carried out because of a gait disorder in January 2013. Hakim triad was not present but increasing psycho-motoric slowdown and affective flattening. The patient was treated with a left ventriculo-peritoneal Codman-Hakim programmable shunt valve and a Miethke shunt-assistant.

Because of the presence of hygroma as a sign of overdrainage in June 2018, pressure of the Codman-Hakim shunt valve was initially set to 60 mm H₂O. In September 2018, the patient's behavior slightly changed again to increased affective flattening, modifications in psychopathology such as repellent behavior, frequent loss of motivation, and discouraged answering. An X-ray of the head showed a changed preset valve pressure of 50 instead of 60 mm H₂O.

In consideration of the ventricle range, the patient history, and the altered pressure setting of 50 mm H₂O, valve pressure was further lowered to 40 mm H₂O. After adjustment of the pressure setting, the patient felt better, and the negative symptoms had decreased. In mid-January 2019, the same symptoms recurred. A further X-ray of the head showed a pressure setting of 50 instead of the preset 40 mm H₂O. Disconnection of the shunt was excluded. Maladjustment of the pressure setting was again thought to be the cause of the patient's changes in behavior. Valve pressure was subsequently reset to 40 mm H₂O, resulting in the clinical improvement of the patient. Because of the strict absence of mobile phones or any other external electromagnetic equipment on the forensic psychiatric ward, it was concluded that the valve's altered pressure setting must have been caused by some other device present on the ward. Thus, the electromagnetic door locks of the hospital ward were suspected as the cause of the changed pressure settings.

PATIENT PERSPECTIVE

For security reasons it was not possible to change the doors from an electromagnetic locking mechanism to manually closing doors. To avoid a constant and dangerously unpredictable changing of the pressure setting and enable the patient to participate in therapy in different parts of the Forensic building, we decided to replace the existing shunt with a Codman Hakim valve with a stable pressure of 40 mm H₂O in May 2019. Approximately one month after implantation, the patient was psycho-pathologically stable and could be transferred to a different ward, preparing him for an eventual release out of Forensic Psychiatry.

DISCUSSION

Treatment of hydrocephalus with a shunt system bears several risks such as infections or the obstruction of single shunt components. Another serious impediment is alteration of the pressure settings. According to the manufacturer, exposure to an external magnetic field of up to 3 T—such as generated during MRI—will neither destroy the Codman-Hakim shunt valve nor is it likely to cause any unwanted changes in the valve position. Nevertheless, verification is recommended.

Furthermore, maladjustments of pressure settings are possible in external magnetic fields of at least 80 mT and occur adjacent to the shunt valve.

In addition to the described case, our internal testing in Forensic Psychiatry showed also changes of valve's pressure settings. To evaluate interactions between the Codman Hakim valve and the doors, a field experiment was conducted. A similar, unused Codman Hakim shunt valve was held up at patient's face level while walking through different doors in the hospital ward. Before and after passing a door, the angle of the spiral cam was measured using an optical microscope. Before and after the walk through a doorway, the angle of the spiral cam was measured with an optical microscope.

Measurements of the valve's position before and after passing the gatekeepers door. The spiral cam was rotated 30° clockwise.

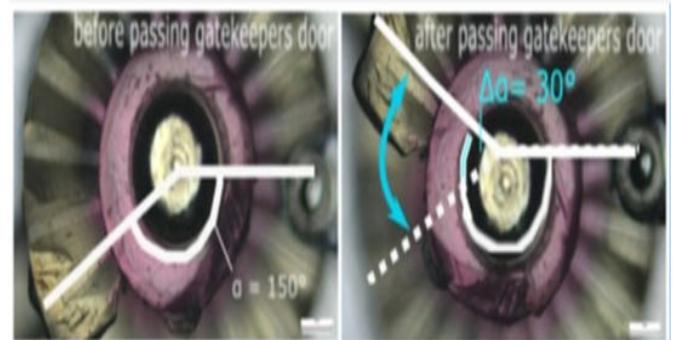


Figure 2: shows a maladjustment of 30 degrees clockwise after passing through the gatekeepers door.

Maladjustments of pressure settings are possible in external magnetic fields of at least 80 mT and occur adjacent to the

shunt valve. Common items such as headphones, earphones, and specific mobile phones operating at levels of 140 to 340 mT may already be the cause of alterations of valve settings [4].

CONCLUSION

The described case and our internal testing suggest that even weak magnetic fields below 80 mT may lead to significant changes in the cam setting of Codman-Hakim shunt valves. Therefore, even common household items may interfere with Codman-Hakim shunt valves. In fact, any item that creates a magnetic field with a corresponding trajectory of movement, even devices in the healthcare environment, could potentially influence pressure settings. Because our everyday life involves more and more electronic and technological advances, the number of potentially interfering devices is very likely to increase. Both low-intensity and strong magnetic fields carry the risk of interacting with the pressure settings of shunt valves, a problem that both patients and medical professionals should be made aware of.

Even though the validation and reproducibility of our tests may have been somewhat limited, our results underline the fragility of Codman-Hakim shunt valves against even the weakest magnetic fields and pave the way for safe medical devices.

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