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Case Report

Maladjustment of Pressure Settings of Programmable Shunt Valves by Weak Magnetic Fields – A Case Report

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Abstract

Introduction: Hydrocephalus is caused by the progressive accumulation of cerebral spinal fluid (CSF) within the intracranial space. Resulting in an abnormal expansion of cerebral ventricles and, consequently, in brain damage. The standard treatment of hydrocephalus in children and adults is implantation of a shunt valve (i.e. Codman-Hakim shunt valve from Johnson & Johnson). This study shows easy maladjustment of a Codman-Hakim programmable valve even with magnetic field strengths as they occur in daily life.

Methods and Materials: The Codman-Hakim valve is a programmable CSF shunt valve with an opening pressure between 30 and 200 mm H_2O. 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. The spring is attached to a spiral cam. If the pressure difference across the valve exceeds a preset pressure adjustment, the ball rises from the seat and vents CSF. To provide a larger valve orifice, the ball moves further away from the seat once the flow rate through the valve increases

Findings and Outlook: Electromagnetic locking mechanism of common hospital doors employs magnetic field amplitudes strong enough to unintentionally change the patient's shunt settings We experimentally verified that even weak (5-25 mT) magnetic fields can lead to significant changes in the spiral cam setting of Codman-Hakim shunt valves weak magnetic fields of up to 25 mT suggest that shunt valve might even interfere with household objects when brought in close proximity (i.e. refrigerator magnets) Our everyday life involves electronic and technological advances, the number of potentially interfering devices is likely to increase systematic characterization of various shunt valves with respect to everyday's objects might be of significant importance to prevent 'artificially' created psychiatric symptomatic.

Keywords: *Codman-Hakim programmable shunt valves, Maladjustment, Case report, Hydrocephalus*

Introduction

Hydrocephalus is caused by a progressive accumulation of cerebral spinal fluid (CSF) within the intracranial space resulting in an abnormal expansion of cerebral ventricles and, consequently, in brain damage.

Implantation of ventriculo-peritoneal shunts (VP-shunts) is the standard treatment of hydrocephalus in children and adults. Most of the currently used shunt systems involve a valve to control pressure and drain CSF if needed [1-3].

In the last few years, malfunctions of programmable VP-shunts have been reported in cases in which patients have encountered powerful electromagnetic fields, e. g. Magnetic Resonance Imaging (MRI) [4,5]. However, the effects of small magnetic fields on VP-shunts are not well known.

In this study we present a case from Forensic Psychiatry in which pressure settings of an implanted Codman-Hakim programmable valve were changed when using electromagnetically controlled doors in a hospital ward.

Case Report

The patient is a 53-year-old man with a triventricular hydrocephalus due to cerebri stenosis of aqueductus, diagnosed in January 2013 – randomly discovered via MRI because of a newly developed insecure gait without Hakim's triad. Also, an increasing psychomotoric slowdown and affective flattening were described. A treatment with a left ventriculoperitoneal programmable Codman Hakim valve and a Miethke-shunt-assistant was selected.

The pressure of the Codman-Hakim programmable valve was preset at 60 mm H_2O, since the patient developed hygroma as a sign of overdrainage in June 2018.

In September 2018 the patient's behavior was slightly changing. He showed an increasing affective flattening and modifications in psychopathology like repellent behavior. Often a loss of motivation and discouraged answering were recognized.

In skull x-ray a change in preset pressure from 60 to 50 mm H_2O was recognized. In consideration of observed ventricle range, previous patient history of overdrainage and maladjusted pressure setting of 50 mm H_2O, the valve pressure was changed to 40 mm H_2O. One day after changing the pressure setting, the patient felt better and the described symptoms became less.

In mid-January the same symptoms recurred. Skull x-ray revealed a pressure setting of 50 instead of the preset 40 mm H_2O and excluded a shunt disconnection. Again, maladjustments in the pressure setting were thought to have caused behavioral changes, and the valve pressure was subsequently reprogrammed to 40 mm H_2O. Again, the patient improved clinically. Due to the rigorous absence of mobile phones or any other external electromagnetic equipment, the valve's pressure setting had to be changed by some device present in Forensic Psychiatry – the magnetically closure assistance of the doors.

Methods

The Codman Hakim valve (Codman, Johnson & Johnson Company) is a programmable CSF shunt with an opening pressure between 30 and 200 mm H_2O. The valve relies on a special ball-in-cone system. A spherical ruby ball is biased against a conical valve seat by a stainless-steel spring. Atop the spring sits a rotating spiral cam that contains a stepper motor. 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 much above the predefined popping pressure.

To adjust a particular opening pressure an external handheld programming device is placed over the valve and the four programmer's coils enclose the spiral cam centrically (Figure 1). Generating an electrically induced alternating magnetic field only few magnets are attracted by one coil or another. By switching on and off the electric current the spiral cam rotates step by step. This enables setting the opening pressure non-invasively within 18 steps with a range of 10 mm H_2O each.

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 (Figure 2).

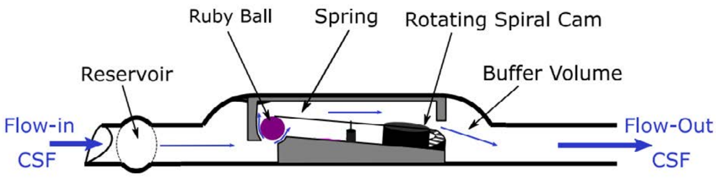

Figure 1: Sketch of a Codman-Hakim shunt valve.

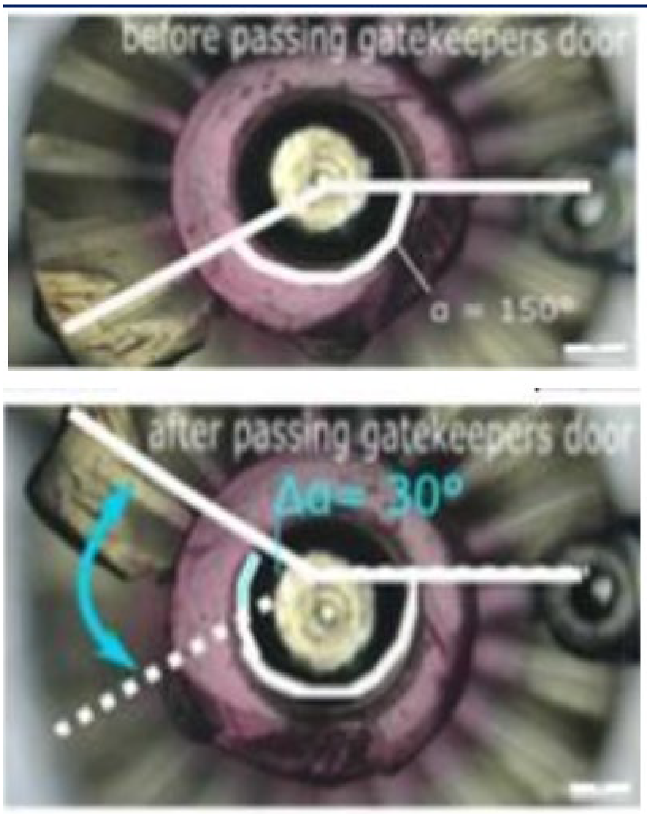

Figure 1: Sketch of a Codman-Hakim shunt valve.

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. 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 [6,7]

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