Programmable shunt valve affected by exposure to a tablet computer

Laboratory investigation

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Object. The authors investigated the effect of a tablet computer on performance-level settings of a programmable shunt valve.

Methods. Magnetic field strength near the tablet computer with and without a cover was recorded at distances between 0 and 100 mm. Programmable valves were exposed to the tablet device at distances of less than 1 cm, 1–2.5 cm, 2.5–5 cm, 5–10 cm, and greater than 10 cm. For each distance tested, the valves were exposed 100 times to the tablet with the cover, resulting in 500 total valve exposures. The tablet alone, without the cover, was also tested at distances of less than 1 cm for 30 valve exposures. Changes in valve performance-level settings were recorded.

Results. The maximum recorded magnetic flux density of a tablet with a cover was 17.0 mT, and the maximum recorded magnetic flux density of the tablet alone was 7.6 mT. In 100 exposures at distances between 0 and 1 cm, 58% of valves had different settings following exposure. At distances greater than 1 cm but less than 2.5 cm, 5% of valves in 100 exposures had setting changes. Only a single setting change was noted in 100 exposures at distances greater than 2.5 cm but less than 5 cm. No setting changes were noted at distances greater than 5 cm, including 100 exposures between 5 and 10 cm, and 100 exposures of more than 10 cm. For the 30 valve exposures to the tablet without a cover, 20 valve performance-level changes (67%) were noted.

Conclusions. Based on these results, exposure to tablet devices may alter programmable shunt valve settings. (http://thejns.org/doi/abs/10.3171/2012.3.PEDS1211)

Key Words • hydrocephalus • programmable shunt valve • complications • tablet computer • magnetic flux density

Magnetically programmable shunt valve settings may be affected by magnetic fields. Normally, external magnetic programming tools can change valve settings by interacting with a magnetic rotor inside the valve. There have been multiple reports of environmental magnetic field exposures changing adjustable valve settings. In addition to the well-known effect of MRI magnets on programmable valve settings, lower-intensity magnetic fields induced by magnetic toys, televisions, and speakers have been reported.1–3,6,7 Studies evaluating the in vivo settings of programmable valves have also reported spontaneous valve setting changes.4 The Apple iPad 2 (Apple, Inc.) has several magnets built into the tablet device itself, as does the iPad 2 Smart Cover (Apple, Inc.), which, although sold separately, is the most frequently used cover for the iPad device. The purpose of this study was to determine the effect of this best-selling tablet computer4 on magnetically programmable shunt valves.

Illustrative Case

The authors implanted a programmable shunt valve in a 4-month-old girl with hydrocephalus. Three weeks following initial implantation, the patient presented with symptoms of shunt malfunction. At the time of that presentation, the valve was investigated and found to be at a higher performance level than the initial setting. The patient’s mother reported that she had held a tablet computer (the Apple iPad 2) while holding the infant. No other significant environmental exposures to magnetic sources could be identified. The valve was reprogrammed back to the original performance level and the patient’s symptoms improved.

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Programmable shunt valve affected by a tablet computer

Methods

We measured magnetic field strength (magnetic flux density) near 32-GB iPad 2 devices using a magnetometer (THM 7025 3-axis Hall Magnetometer, Metrolab Instruments SA). The area of the tablet with the highest magnetic field strength was tested in 3 different devices. In every case, the highest magnetic field was recorded in proximity to an area along the upper left perimeter of the device. This area was labeled on the tablet. Throughout the trials, distances were calculated based on this location (Fig. 1). Magnetic field strength near the tablet was recorded at distances between 0 mm (contact of the device to the magnetometer) and 100 mm. Magnetic fields were recorded for the tablet with and without the cover in place.

Ten programmable shunt valves were tested (Strata Valve, Medtronic, Inc.). Two valves were set to 5 different performance levels (0.5, 1.0, 1.5, 2.0, and 2.5), and the setting was confirmed using the Strata investigative device. The valves were positioned on a flat surface at least 150 mm from other valves throughout testing. Valves were exposed to the tablet device at distances of less than 1 cm, 1–2.5 cm, 2.5–5 cm, 5–10 cm, and greater than 10 cm. The shortest distances reflect distance between the valve and the tablet computer positioned parallel, one over the other. Each exposure lasted 10 seconds. Following exposure, the valve setting was investigated and the performance level was recorded. For each distance tested, the valves were exposed 100 times to a tablet with a cover, resulting in 500 total valve exposures. Trials with the cover were performed with the cover in the closed position. The tablet alone, without a cover, was also tested at distances less than 1 cm for 30 valve exposures. The tablet was turned on during each trial and was in wireless internet mode.

Results

The magnetic flux density of the tablet with a cover was 17.0 mT at 0 mm and decreased with increasing distance as the inverse of the distance squared (Fig. 2). The magnetic flux density decreased to less than 10 mT at a distance of 3 mm and to less than 5 mT at a distance of 11 mm. The maximum recorded magnetic flux density of the tablet alone (without cover) was 7.6 mT and decreased to less than 5 mT at a distance of 2 mm (Fig. 2).

Changes in valve performance-level settings were commonly noted at very short distances between valves and the tablet with a cover (Fig. 3). In 100 exposures at distances between 0 and 1 cm, 58% of valves had different settings following exposure. At distances greater than 1 cm but less than 2.5 cm, 5% of valves changed in 100 exposures. Only a single change was noted in 100 exposures at distances greater than 2.5 cm but less than 5 cm. No changes were noted at distances greater than 5 cm, including 100 exposures between 5 cm and 10 cm, and 100 exposures greater than 10 cm. Finally, for the 30 valve exposures to the tablet without the cover, 20 valve performance-level changes (67%) were noted at the shortest distance tested (< 1 cm).

In all trials, we found 64 cases of change in shunt performance level following exposure to a tablet device with or without a cover. There were 11 changes at a performance level of 0.5, 10 changes at a performance level of 1.0, 11 changes at the 1.5 level, 8 changes at the 2.0 level, and 24 changes at the 2.5 level. There were changes to different performance levels as well as changes to a setting in between 2 performance levels. All tested valves changed, but no significant difference between individual valves was noted.

Discussion

Environmental factors such as magnetic forces may...
alter programmable shunt valve settings. The Apple iPad 2 has several magnets built into the tablet device itself, as does the Smart Cover. Although sold separately, the Smart Cover is the most frequently used cover for the iPad 2 device. The original iPad does not contain magnets for the cover attachment, and these results do not apply to the original iPad without integrated magnets. We found that exposure to iPad 2 devices may alter programmable shunt valve settings.

While our data do not support any significant interaction between the tablet computer and the programmable shunt valve at distances greater than several centimeters, patients and their caregivers should be warned of the potential for this interaction when the iPad 2 is in very close proximity to the programmatically programmable shunt valve. With proper precautions to keep a tablet device away from close proximity to the valve, the continued use of these devices, even in the general vicinity of patients with programmable shunt valves, appears to be safe. Finally, it should be noted that magnetic field strength of the iPad 2 is within the range of other household magnets. General precautions taken with the iPad 2 should reflect common precautions taken with other household magnets.

There are several limitations to our analysis. First, these magnetic exposure trials were conducted in conditions than could be expected clinically. No attempt was made to place a tissue layer between the tablet and shunt valve. Thick layers of scalp and other tissue will increase the distance between the magnetic source and the valve and thus should have a protective effect against changes in valve performance levels. Multiple valves were tested at once. Due to our concern that each valve could impart a magnetic field on other valves, the valves were tested and found to have a small magnetic field up to a distance of 50 mm. Valves were positioned at least 150 mm from other valves during the testing. Finally, in some cases, the change in performance level resulted in a setting between 2 performance levels. When this is the case, the valve will perform at the higher of the 2 performance levels. If the setting changed to a performance-level setting between the proper level and the level directly below it, it is possible that the valve would continue to function at the proper level. Therefore, we acknowledge the likelihood that at least some of the changes in performance level that were observed would not have resulted in a clinically relevant change for a patient.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Maher, Selzer. Acquisition of data: Strahle, Selzer. Analysis and interpretation of data: Maher, Strahle, Garton. Drafting the article: Maher, Strahle. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Maher. Statistical analysis: Strahle. Study supervision: Maher, Muraszko, Garton.

Acknowledgment

The authors wish to thank Holly Wagner for providing editorial assistance.

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