ORIGINAL

Spinal magnetic resonance imaging artifacts in lumboperitoneal shunt surgery using adjustable valve implantation on the paravertebral spinal muscles

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Abstract : Background : Adjustable shunt valves that have been developed for managing hydrocephalus rely on intrinsically magnetic components ; thus, artifacts with these valves on magnetic resonance imaging (MRI) are inevitable. No studies on valve-induced artifacts in lumboperitoneal shunt (LPS) surgery have been published. Therefore, this study aimed to evaluate valve-induced artifacts in LPS. Methods : We retrospectively reviewed all MRIs obtained between January 2023 and June 2023 in patients with an implanted Codman CERTAS Plus adjustable shunt valve (Integra Life Sciences, Princeton, New Jersey, USA). The valve was placed <1 cm subcutaneously on the paravertebral spinal muscle of the back, with its long axis perpendicular to the body axis. The scans were performed using a Toshiba Medical Systems 1.5 Tesla scanner. The in-plane artifact sizes were assessed as the maximum distance of the artifact from the expected region of the back. Results : All spinal structures or spinal cords can be recognized, even with valve–induced artifacts. The median maximum valve-induced artifact distance on T1-weighted axial imaging was 25.63 mm (mean, 25.98 mm ; range, 22.24–30.94 mm). The median maximum valve-induced artifact distance on T2-weighted axial imaging was 25.56 mm (mean, 26.27 mm ; range, 21.83–29.53 mm). Conclusion : LPS surgery with adjustable valve implantation on paravertebral muscles did not cause valve-induced artifacts in the spine and spinal cord. We considered that LPS could simplify the postoperative care of these patients. J. Med. Invest. 71 : 154-157, February, 2024

Keywords **:** *hydrocephalus, programmable valve, lumboperitoneal shunt, artifact, magnetic resonance imaging*

INTRODUCTION

A multicenter prospective cohort study to assess lumboperitoneal shunt (LPS) implantation in patients with idiopathic normal pressure hydrocephalus (iNPH) in Japan, SINPHONI-2, showed that LPS placement is not statistically inferior to ventriculoperitoneal shunt (VPS) placement in patients with iNPH, and more patients have undergone LPS placement (2, 5). LPS placement is an extracranial procedure that can minimize intracranial complications.

In VPS surgeries, adjustable shunt valves produce large magnetic resonance imaging (MRI) artifacts, which make it difficult to study brain structures (1, 13, 14). It has been reported that VPS valves should be placed on the chest wall to avoid valve-induced artifacts (11).

LPSs are free of postoperative valve-induced artifacts on head MRI because these valves are implanted on the paravertebral spinal muscles. It is common for patients with hydrocephalus to have spinal and spinal cord diseases, and complications of spinal cord tumors (3, 4), spinal stenosis (7), and vertebral compression fractures (10) have been reported. Spine MRI is increasingly being used to assess patients with implanted shunt valves. MRI is commonly used to evaluate nerve and soft tissue structures, such as the spinal canal and neural foramen, and surrounding anatomy. One disadvantage of metal implants is that metal-induced artifacts occur on MRI, resulting in signal loss, the accumulation of artifacts, and geometric distortion. The artifacts on MRI can lead to misdiagnoses, which have serious implications on patient health and outcomes.

To the best of our knowledge, no studies on MRI artifacts in LPS have been published. Therefore, this study aimed to evaluate valve-induced artifacts on MRI in LPS.

MATERIALS AND METHODS

We retrospectively reviewed all MRIs obtained between January 2023 and June 2023 in patients with an implanted Codman CERTAS Plus adjustable shunt valve with SiphonGuard (Integra Life Sciences, Princeton, New Jersey, USA). Shunt valves were implanted for NPH. It had eight power settings (1–8). A metal connector was connected to the spinal side of the shunt valve (Fig. 1A). The valve was placed <1 cm subcutaneously on the paravertebral spinal muscle of the back, with its long axis perpendicular to the body axis. The position of the valve was confirmed by computed tomography (Fig. 1B).

The scans were performed using a Toshiba Medical Systems 1.5 Tesla scanner. The sequences were sagittal T2-weighted (repetition time [TR], 3200/echo time [TE], 120 ; slice thickness, 4 mm ; matrix size, 224 × 400 ; field of view [FOV], 35 × 30 cm), sagittal T1-weighted (TR, 400/TE, 15 ; slice thickness, 4 mm ; slice size, 224 × 384 ; FOV, 35 × 30), axial T2-weighted (TR, 3300/TE, 108 ; slice thickness, 4 mm ; slice size, 256 ×

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256 ; FOV, 18), and axial T1-weighted (TR, 510/TE, 10 ; slice thickness, 4 mm ; slice size, 256 × 288 ; FOV, 18). One sequence could have been included : sagittal short T1 inversion recovery (TR, 4150/TE, 80 ; slice thickness, 4 mm ; matrix size, 224 × 320 ; FOV, 35 × 30 cm). The shunt valves were checked using a shunt tool before and after MRI to confirm that the set pressures were unchanged.

A neurosurgeon assessed the artifacts on the MR images without information on the valve used, as follows : valve-induced artifact diameters were calculated by an observer. The in-plane artifact sizes were assessed as the maximum distance of the artifact from the expected region of the back (Fig. 2). The valve-induced artifacts were measured on axial T1- and T2-weighted images in the slice with the largest artifact (Fig. 2). In this study, we defined the artifact area as the area in which we could not detect spinal structures and spinal cord, among others. Areas that were slightly shaded where the aforementioned structures could be seen were excluded from the artifact area.

RESULTS

We confirmed the clinical findings in five patients (Table 1). The valves were placed <1 cm subcutaneously on the paravertebral muscles of the back. For all valves, the pressure settings were unchanged during examinations. All spinal structures or spinal cords can be recognized, even with valve-induced artifacts. Representative images are shown in Fig. 3.

The median maximum valve-induced artifact distance on T1-weighted axial imaging was 25.63 mm (mean 25.98 mm ; range, 22.24–30.94 mm). The median maximum valve-induced artifact distance on T2-weighted axial imaging was 25.56 mm (mean, 26.27 mm ; range, 21.83–29.53 mm).

Table 1. The clinical findings in the five patients.

Case	Age	Sex	Setting of the valve	Artifact distance on T1WI (mm)	Artifact distance on T2WI (mm)
1	78	Male	4	30.94	29.53
2	89	Male	7	23.91	26.56
3	80	Male	5	27.19	27.07
4	86	Male	3	22.24	21.83
5	73	Male	7	25.63	26.37

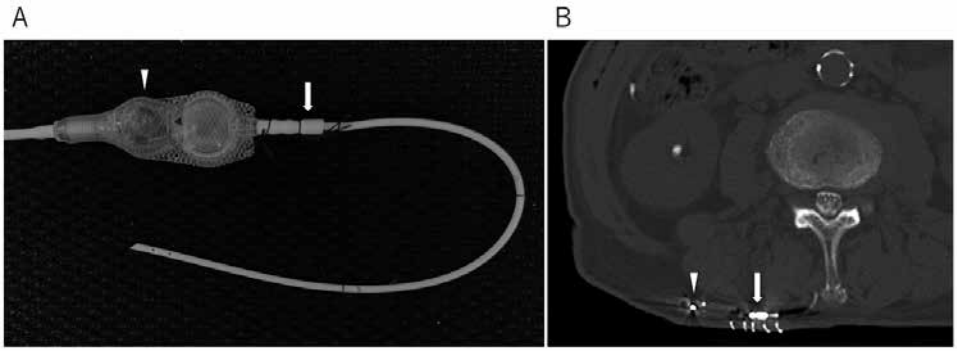

Fig. 1. Photograph (A) and computed tomography (B) show a Codman CERTAS Plus adjustable shunt valve (arrowhead) connected to the spinal side via a metal connector (arrow) implanted <1 cm subcutaneously on the paravertebral muscle of the back, with its long axis perpendicular to the body axis.

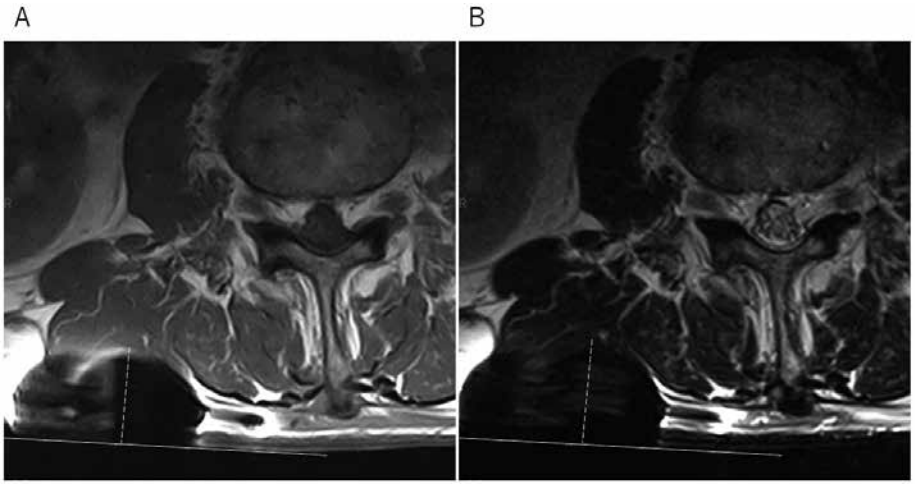

Fig. 2. Spinal artifacts were calculated by measuring the maximum distance perpendicular to the back on T1-weighted images (A) and T2-weighted images (B).

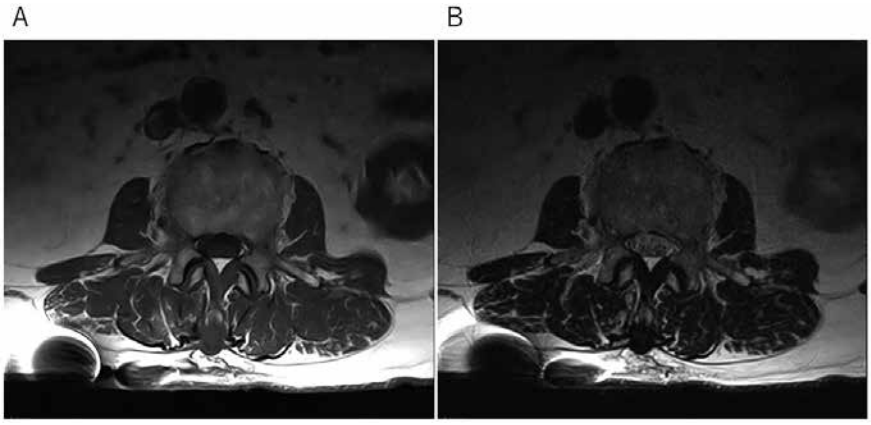

Fig. 3. Representative magnetic resonance images obtained with the CERTAS Plus valve implanted in the paravertebral muscle of the back. The spinal structures or spinal cord can be seen even with valve artifacts on T1-weighted images (A) and T2-weighted images (B).

DISCUSSION

Adjustable shunt devices are also widely used to treat hydrocephalus following subarachnoid hemorrhage or iNPH to avoid overdrainage, mainly due to postoperative improvement in activities of daily living (6).

All these devices contain magnetic components that allow the setting of the valve to be adjusted using an external magnetic adjuster (1, 13, 14). The development of shunt devices with locking systems to eliminate the risk of inadvertent valve setting changes during MRI has facilitated follow-up after device implantation (9).

The permanent magnets used in these devices are now resistant to interference from the 1.5 T magnetic fields used in MRI ; however, artifacts caused by the high magnetic field increase in size and obscure the image and subsequently the diagnosis (1, 9, 13, 14).

MRI is the recommended imaging modality for most spinal pathologies. Patients with instrumentation, such as a shunt valve, may face difficulties when evaluating critical diseases.

In a study, the maximum valve-induced artifact distance in head MRI ranged from 13.7 to 22.7 mm on T1-weighted axial imaging and from 14.0 to 20.7 mm on T2-weighted axial imaging, depending on the valve type and pressure (14), In our study, the maximum valve-induced artifact distance in spine MRI ranged from 22.24 to 30.94 mm on T1-weighted axial imaging and from 21.83 to 29.53 mm on T2-weighted axial imaging. The difference in distance was because of the thickness of the skin on the head and back. The anatomical length of the spinous process, measured from the spinolaminar line to the posterior tip of the spinous process, ranged from 24.86 mm at L5 to 33.96 mm at L3 (8). In our method, the valve placement position is L2–L3 high on the back (12). All spinal structures or spinal cord can be seen, even with valve-induced artifacts.

The main finding of the study was that the use of LPS results in the absence of valve-induced artifact areas in spinal canals and vertebral bodies, which significantly improves the postoperative assessment of anatomical structures using MRI and thus provides a substantial diagnostic benefit.

Some limitations of this study must be acknowledged. First, this study was conducted with a combination of Codman CERTAS Plus adjustable shunt valves and Toshiba Medical Systems 1.5 Tesla scanner ; however, other combinations should be considered. Second, the valves in this study were placed <1 cm subcutaneously on the paravertebral spinal muscle of the back, with its long axis perpendicular to the body axis ; this shunt valve implantation simplifies interference between the magnetic field of the shunt valve and that of the MRI scanner. In the real world, shunt valves may be placed obliquely at various locations on the back. Furthermore, because of time constraints, we obtained images of each patient with each sequence only once ; therefore, the accuracy of the measurements is a concern.

CONCLUSION

Neurosurgeons should consider valve-induced artifacts as an important factor in patients with shunts. In this study, LPS with adjustable valve implantation on the paravertebral muscles did not cause artifacts in the spine and spinal cord. We considered that LPSs could simplify the postoperative care of these patients.

CONFLICTS OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

All procedures in this study were performed in line with the principles of the 1964 Declaration of Helsinki. A series of treatments were performed after obtaining appropriate written informed consent from the patients. Owing to the retrospective and observational nature of the study, the requirement for an additional written consent for inclusion in this study was waived.

DISCLOSURES

The authors report that there are no competing interests to declare.

FUNDING

The authors have no relevant financial or nonfinancial interests to disclose.

AUTHORS' CONTRIBUTIONS

All authors contributed to the conception and design of this study. Preparation of material and data collection were performed by all authors. Data analysis was performed by Tatsuya Tanaka. The first draft of the manuscript was written by Tatsuya Tanaka, and all authors commented on the previous versions of the manuscript. All the authors have read and approved the final version of the manuscript.

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