Adjustable differential pressure valve

- Programmable gravitational valves in idiopathic normal pressure hydrocephalus: long-term outcomes after a 3-year follow-up
- Fixed versus Adjustable differential pressure valves in case of idiopathic normal pressure hydrocephalus treated with ventriculoperitoneal shunt. A systematic review and meta-analysis of proportion
- Effect of antisiphon devices on ventriculoperitoneal shunt drainage dynamics in growing children
- A single center experience of adjusting valve pressure ventriculoperitoneal shunts for the treatment of hydrocephalus in infants under 6 months old
- Non-adjustable gravitational valves or adjustable valves in the treatment of hydrocephalus after aneurysmal subarachnoid hemorrhage patients?
- An adjustable gravitational valve for initial VP-shunt treatment in hydrocephalic preterm neonates and infants below 1 year of age
- Multiplex Ventilation: Solutions for Four Main Safety Problems
- Considerations in the Use of Gravitational Valves in the Management of Hydrocephalus. Some Lessons Learned with the Dual-Switch Valve

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Adjustable differential pressure valves in combination with fixed anti-siphon devices are currently a popular combination in counteracting the effects of cerebrospinal fluid overdrainage following implantation of a ventriculoperitoneal shunt system.

Types

CODMAN CERTAS Plus Programmable Valve

Codman Hakim programmable valve

Strata valve 2 from Medtronic

Polaris Valve from Sophysa

Sophy SU8 adjustable valve

ProGAV from Miethke.

Settings

Programmable shunts can be adjusted to optimize CSF diversion in patients with hydrocephalus without the need for re-operation. Currently, all shunts incorporate radiopaque markers so that their setting can be determined on skull X-ray images. The purpose of this study was to evaluate whether the shunt setting could also be determined ex vivo and in vivo using the data from a standard head CT scan since one is nearly always obtained when patients with VP shunts present with new symptoms that could be due to shunt malfunction. Materials and Methods: Four commonly used programmable shunts were attached to a dried skull and scanned using a variety of CT techniques. The shunts imaged were the CertasTM Plus (Codman, Raynham, Massachusetts), Polaris® (Sophysa, Orsay, France), proGAV 2.0® (Braun, Bethlehem, Pennsylvania), and Hakim® (Codman, Raynham, Massachusetts). Each shunt was scanned at two different valve settings using multiple CT techniques: CTDIvol 75, 140kVp, 330mAs, CTDIvol60, 120kVp 390mAs, CTDIvol40, 80kVp with 430mAs, 140kVp with 215mAs. Image reconstruction with and without CT metal suppression software was used for all scans, and the data was reconstructed into volume-rendered images. We enlisted ten observers to review the volume-rendered images only. After a short set of training slides viewed by all observers, they were asked to predict the shunt setting for each valve along with their level of confidence. One clinical case of a patient with a programmable valve was evaluated on a CT scan.

Results: Using the volume-rendered images only, the two shunt settings of the Polaris shunt were correctly predicted by all the observers and in nine of 10 settings for the CertasTM Plus valve. For the Hakim® shunt and the proGAV 2.0® shunt, setting prediction accuracy was 0% and 10%, respectively. In one clinical case, the programmable valve setting could be determined from the CT scan data.

Conclusion: The valve setting of at least two currently available programmable shunts can be determined using volume-rendered images generated from CT data. Reconstructions using metal suppression software were rated as superior and may be necessary for some valve designs [1].

In adjustable or programmable valves, the settings may be changed by external magnetic fields of intensity above 40 mT (exceptions: ProGAV, Polaris, and Certas). Most of the magnetically adjustable valves produce large distortions on MRI studies.

The behavior of a valve revealed during testing is of relevance to the surgeon and may not be adequately described in the manufacturer's product information. The results of shunt testing are helpful in many circumstances, such as the initial choice of shunt and the evaluation of the shunt when its dysfunction is suspected [2].

Electromagnetic fields

All are programmed externally with a magnet, and can potentially be inadvertently reprogrammed by external magnetic fields including those encountered during an MRI (the Polaris valve and the Certas Plus valve are promoted as being less susceptible to inadvertent reprogramming). Therefore, valve settings should be rechecked after an MRI scan performed for any reason, or if there is ever a concern about shunt function. The pressure setting on all of these valves can be checked on a plain x-ray taken perpendicular to the shunt valve. Some can also be checked using a special hand-held compass-like device provided by the manufacturer to most hospitals and clinics that deal with their valves. In all systems on the market, increasing the programmed number results in higher valve opening pressures and therefore less CSF drainage at any given CSF pressure.

All valves, with the exception of the Polaris and ProGAV models, are prone to unintentional reprogramming when exposed to heterogeneous magnetic fields stronger than 40 mT. All valves generated a distortion of the MR image, especially the GE sequences [3].

Transcranial magnetic stimulation (TMS)

Can interfere with programmable shunt valves by inducing unsetting or movement. This finding suggests that great care must be taken if applying TMS in hydrocephalic, shunted patients [4].

Magnetic toys

The magnetic properties of nine toy magnets were examined. To calculate the effect of a single magnet over a distance, the magnetic flux density was directly measured using a calibrated Hall probe at seven different positions between 0 and 120 mm from the magnet. Strata II small (Medtronic Inc.), Codman Hakim (Codman & Shurtleff), and Polaris (Sophysa) programmable valves were then tested to determine the effects of the toy magnets on each valve type.

The maximal flux density of different magnetic toys differed between 17 and 540 mT, inversely proportional to the distance between toy and measurement instrument. Alterations to Strata and Codman valve settings could be effected with all the magnetic toys. The distances that still led to an alteration of the valve settings differed from 10 to 50 mm (Strata), compared with 5 to 30 mm (Codman). Valve settings of Polaris could not be altered by any toy at any distance due to its architecture with two magnets adjusted in opposite directions.

Parents, surgeons, neurologists, pediatric oncologists, and paramedics should be informed about the potential dangers of magnetic toys to prevent unwanted changes to pressure settings [5].

A study examined the flow performance of three DP valves in successive combination with an anti-siphon device in an in vitro shunt laboratory with and without vertical motion.

Methods: We analyzed three DP valves Codman Hakim programmable valve [HM], CODMAN CERTAS Plus Programmable Valve [CP], and Miethke proGAV [PG], in combination with either Codman SiphonGuard [SG] or Miethke ShuntAssistant [SA]), resulting in the evaluation of six different valve combinations. Defined DP conditions between 4 and 40 cm H2O within a simulated shunt system were generated and the specific flow characteristics were measured. In addition, combinations with SA, which is a gravity-dependent valve, were measured in defined spatial positions (90°, 60°). All device combinations were tested during vertical motion with movement frequencies of 2, 3, and 4 Hz.

All valve combinations effectively counteracted the siphon effect in relation to the chosen DP. Angulation-related flow changes were similar in the three combinations of DP valve and SA in the 60° and 90° position. In CP-SA and PG-SA, repeated vertical movement at 2, 3, and 4 Hz led to significant increase in flow, whereas in HM-SA, constant increase was seen at 4 Hz only (flow change at 4Hz, DP 40 cm H2O: PG (opening pressure 4 cm H2O) 90°: 0.95 ml/min, 60°: 0.71 ml/min; HM (opening pressure 4 cm H2O) 90°: 0.66 ml/min, 60°: 0.41 ml/min; CP (PL 2) 90°: 0.94 ml/min, 60°: 0.79 ml/min; $p < 0.01$); however, HM-SA showed relevant motion-induced flow already at low DPs (0.85 ml/min, DP 4 cm H2O). In combinations of DP valve with SG, increase of flow was far less pronounced and even led to significant reduction of flow in certain constellations. Maximum overall flow increase was 0.46 ± 0.04 ml/min with a HM (opening pressure 12 cm H2O) at 2 Hz and a DP of 10 cm H2O, whereas maximum flow decrease was 1.12 ± 0.08 with a PG (opening pressure 4 cm H2O) at 3 Hz and a DP of

10 cmH2O.

In an experimental setup, all valve combinations effectively counteracted the siphon effect in the vertical position according to their added resistance. Motion-induced increased flow was consistently demonstrated in combinations of DP valve and SA. The combination of HM and SA especially showed relevant motion-induced flow already at low DPs. In combinations of DP and SG, the pattern of the motion induced flow was more inconsistent and motion even led to significant flow reduction, predominantly at DPs of 10 and 20 cmH2O [6].

Adjustable differential pressure valve dysfunction

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