Ventriculoperitoneal Shunt Alone Does Not Guarantee Spinal Cord Protection After Complex Aortic Aneurysm Repair

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Introduction: Spinal cord ischaemia (SCI) is a devastating complication of the treatment of thoraco-abdominal aneurysms. Peri-operative cerebrospinal fluid (CSF) drainage, typically using a spinal catheter, is a possible preventive measure. There are no reports or guidelines on peri-operative CSF drainage for this indication in patients with a ventriculoperitoneal (VP) shunt.

Report: A single case of a patient suffering SCI after fenestrated endovascular aortic repair for the treatment of a pararenal aneurysm after previous open repair of an infrarenal aortic aneurysm is presented. Despite the presence of a patent VP shunt, elevated CSF pressures were observed after placement of a CSF drain.

Discussion: A VP shunt with a gravitational component may drain insufficiently in bedridden patients who often lie with their head tilted on a cushion. In this position, both the differential pressure component and the gravitational component become active, thereby increasing the overall resistance to CSF outflow, hence increasing intracranial and intraspinal pressure. VP shunts with gravitational components should be managed with caution in the setting of prophylactic or therapeutic drainage of CSF to prevent SCI in extensive aortic repair. For reliable CSF pressure monitoring or active drainage in case of symptoms, the insertion of a spinal drain is indicated.

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INTRODUCTION

Spinal cord ischaemia (SCI) is a devastating complication after extensive open or endovascular aortic repair.1,2 Although the possible risk of complications related to cerebrospinal fluid (CSF) drainage should not be minimised,2 current European Society for Vascular Surgery guidelines recommend the use of CSF drainage in the prevention of SCI in patients requiring aortic repair with a high risk of SCI.3 Typical examples are patients who have previously undergone abdominal aortic aneurysm repair, or those in whom extensive aortic repair, covering large aortic segments, is necessary.

No data are available on the role of ventriculoperitoneal (VP) shunts in the prevention of SCI. At first sight, one might expect the presence of a VP shunt to be protective against SCI, by effectively lowering the intraspinal pressure through drainage of CSF, similar to a lumbar drain. At least in the case presented, this has not been shown to be true.

CASE REPORT

A 69 year old man was referred with a 70 mm pararenal aortic aneurysm. Seven years earlier, he underwent open repair of an infrarenal abdominal aneurysm, with aortobifemoral bypass. This time, an endovascular repair was scheduled.

Because of symptoms of normal pressure hydrocephalus (urinary incontinence and lower body parkinsonism), with temporary relief following lumbar puncture, a VP shunt was inserted two months prior to the endovascular repair. An adjustable Miethke proGAV 2.0 (B. Braun, Melsungen AG, Hessen, Germany) valve was used. This specific valve consists of two components: an adjustable differential pressure valve (set at 8 cmH2O), in series with a gravitational valve (fixed pressure at 20 cmH2O). Within days of insertion of the VP shunt, there was a clear improvement in both gait and urinary symptoms.

For the endovascular repair, a custom made stent graft (Cook Medical, Bloomington, IN, USA) with four fenestrations and inverted limb was planned. Because of tortuosity and the presence of wall thrombus, a proximal landing site...
was planned 80 mm above the coeliac trunk. Given the extensive covering of the aorta, the possibility of inserting a spinal catheter immediately before the endovascular procedure was discussed. The neurosurgical advice was that there was no true advantage to do so as the spinal pressure would be <10 cm H2O, which is where the spinal catheter is usually set at, in a patient nursed flat given the presence of the VP shunt. The valve settings were verified pre-operatively. The day before the procedure, no clinical signs were present suggesting a non-functioning VP shunt.

Bilateral femoral cut down was performed under general anaesthesia. The endovascular repair with the custom made stent graft and four fenestrations went well. The proximal landing zone was at the level of the eighth thoracic vertebra; the distal landing zones extended into the limbs of the aortobifemoral graft. No endoleak was seen on the completion angiography. Total procedure time was 252 minutes. During the procedure the mean arterial pressure (MAP) was 84/60 mmHg. Immediately post-operatively, normal strength in the lower limbs was observed (Medical Research Council [MRC] 4 grade 5). However, one hour later, during his stay on the post-operative care unit, there was a rapid deterioration towards complete paralysis of both legs (MRC 0). This partially recovered immediately after raising the MAP (97/50 mmHg) and supplementary concomitant placement of a spinal catheter (MRC 3 left leg, MRC 1–2 right leg). Upon measuring immediately after inserting the spinal catheter, the spinal pressure ranged from 14 to 20 cmH2O. The spinal catheter was left draining for 72 hours, aiming at a spinal pressure between 8 and 10 cm H2O.

After that, the patient made a good but incomplete recovery, and he was able to leave the hospital after 22 days, walking independently with a walking frame.

**DISCUSSION**

Patients with chronic hydrocephalus can be treated with a VP shunt.5,6 These shunts can have a fixed opening or an adjustable variable pressure valve. In adjustable valves the opening pressure can be changed with the help of an external magnetic tool. After re-adjusting they behave like a fixed pressure valve. With the patient changing from a lying to an upright position, there are important differences in the hydrostatic pressure over the valve, as well as in the abdominal pressure, facilitating CSF flow in an upright vs. lying position. To account for this, many current valves consist of two components. In addition to a fixed or differential pressure valve, which opens when the pressure difference between the proximal and distal catheter reaches a certain pressure threshold, they also house a gravitational or membranous component, which gradually compensates for the positive effect of gravity on CSF drainage when the patient is in the upright position. In a gravitational component this is achieved by adding a small ball to the system. In a horizontal position, this ball will be easily pushed away by CSF flow, hence the contribution to the total resistance of the valve will be negligible. As the patient moves towards a vertical position, however, gravity will increasingly pull the ball downwards, increasing the resistance against CSF flow (Fig. 1).

To evaluate for valve malfunctioning, companies provide a system based on an antechamber.7 This is a reservoir that can be incorporated in the valve itself (e.g., Medtronic strata valve [Medtronic, Dublin, Ireland] and Codman Hakim/Certas valve [Integra LifeScience, Plainsboro, NJ, USA]) or it can be available as a connecting piece (MIETHKE; Aesculap, Centre Valley, PA, USA). Transcutaneous puncture can be performed to sample CSF, inject drugs, check the patency of the shunt or to measure intracranial pressure. However, a risk of shunt infection comes with every shunt tap. There is one commercially available system for external monitoring of CSF flow (ShuntCheck; NeuroDx, Yardley, PA, USA).8,9 By externally cooling a proximal part of the shunt with an ice cube the device senses thermal change over the distal part.

In the present patient shunt patency was not verified prior to placement of a spinal drain. Presenting with acute symptoms, continuous pressure monitoring and CSF...
drainage was anticipated, and a spinal drain was placed. Because of the increased risk of infection, continuous drainage or pressure monitoring through the shunt reservoir is not recommended. Nevertheless, it can be done briefly for pressure monitoring.

Importantly, the valve is usually positioned under the scalp; hence, the position of the head rather than that of the body will determine the contribution of the gravitational component. Patients may be positioned flat in bed, but when their head is upright on a pillow, the gravitational component will be partly closed. This was confirmed by \textit{in vitro} and \textit{in vivo} analysis of this type of valve at different inclinations of head and upper body\textsuperscript{5}, and was also demonstrated clinically in 2009\textsuperscript{10}.

Above all, one should realise that the pressures provided by the shunt manufacturers are relative values, and that the “real life” pressure as measured through a spinal catheter will generally exceed this value due to (1) the intra-abdominal pressure not being zero, especially in obese or not fully relaxed patients; (2) the resistance of the tubing used; and (3) the gravitational component virtually never being zero as the head nor the implanted valve are usually perfectly horizontal\textsuperscript{7}.

\textbf{CONCLUSION}

VP shunts, especially those with gravitational components, are not completely reliable for drainage of CSF to prevent and treat SCI after extensive open or endovascular aortic repair. If VP shunts are considered to be the only way of draining CSF, malfunction should be checked preoperatively. If continuous pressure monitoring or drainage is anticipated, placement of a spinal drain vs. continuous drainage through the antechamber is recommended owing to the risk of infection. The head of the patient should be positioned so that the valve is as horizontal as possible and the intra-abdominal pressure should be minimised, facilitating CSF drainage. If valve function cannot be assessed correctly or in case of symptoms (even with correct functioning of the valve) the threshold for spinal drain placement should be low.

\textbf{CONFLICTS OF INTEREST}

None.

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