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Technical note

Persistent hydrocephalus due to postural activation of a ventricular shunt anti-gravity device

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ABSTRACT

The ever present need to balance over drainage with under drainage in hydrocephalus has required innovations including adjustable valves with antigravity devices. These are activated in the vertical position to prevent siphoning. We describe a group of bedridden patients who presented with unexplained under drainage caused by activation of antigravity shunt components produced by peculiar head/body position.

Retrospective single centre case series of hydrocephalus patients, treated with ventriculo-peritoneal (VP) shunt insertion between April 2014 – February 2016. These patients presented with clinical and radiological under drainage syndrome. Medical notes were reviewed for clinical picture and outcome. Radiological studies were reviewed assessing shunt placement and ventricular size.

Seven patients presented with clinical and radiological under drainage syndrome. A consistent posturing of long term hyper-flexion of the neck whilst lying supine was observed. All patients had similar shunt construct (adjustable Miethke ProGAV valve and shunt assistant anti-gravity component). In each of those patients a hypothesis was formulated that neck flexion was activating the shunt assistance anti-gravity component in supine position. Five patients underwent shunt revision surgery removing the shunt assistant device from the cranium and adding an anti-gravity component to the shunt system at the chest. One had the shunt assistant completely removed and one patient was managed conservatively with mobilisation. All patients had clinical and radiological improvement.

Antigravity shunt components implanted cranially in bedridden hydrocephalus patients will produce underdrainage due to head flexion induced anti-gravity device activation. In these patients, anti-gravity devices should be placed at the chest. Alternatively, special nursing attention should be paid to head-trunk angle.

1. Introduction

Cerebrospinal fluid diversion with a ventriculo-peritoneal (VP) shunt is the mainstay of treatment for hydrocephalus. Over-drainage and under-drainage are common complications associated with VP shunts, being observed in around 30% and 10% of postoperative cases respectively [1]. When VP shunts are open, pressures exerted from vertical positions may become unphysiologically negative [2,3]. Posture-related over-drainage occurs in 10–12% of patients after VP shunt, resulting in headache, hygroma and subdural haemorrhage [3–6]. In order to prevent over-drainage, innovations have developed to integrate anti-gravity (also known as anti-siphon or shunt assistant) devices with adjustable valves.

ProGAV (programmable gravitational valves [Miethke GMBH & Co KG]) systems are routinely used at the authors centre and have demonstrated good outcomes in preventing overdrainage [7]. Such valves can be adjusted to drain 0–20 cm of water and have anti-gravity device, the shunt assistant (Miethke GMBH & Co KG). The shunt assistant has a ball-in-cone unit that regulates outflow when supine, and a gravitational unit (weighted tantalum ball), that adds additional outflow resistance when the patient is upright.

In this series we aimed to report our experiences with an anti-gravity device associated complication of under-drainage due to abnormal posturing in bedridden patients.

2. Methods and materials

A single centre case series of patients with under-drainage despite having a VP shunt, referred to the hydrocephalus service

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Table 1
Patient characteristics and intervention.

Patient	Age	Gender	Indication for shunt	Co-morbidities	Valve type [setting cmH_20]	Acute Symptoms	Intervention [setting cmH_20]
A	55	M	Hydrocephalus secondary to tumour	Hypothyroidism, psoriatic arthritis, osteroporosis and asthma	ProGAV (5) Shunt assistant	Reduced mobility and confusion	Removal of shunt assistant
B	32	M	Hydrocephalus secondary to tumour	Neurofibromatosis type II, tectal plate astrocytoma and seizures	ProGAV (5) Shunt assistant	Worsening headache	Removal of shunt assistant and ProGAV Insertion of ProSA (20) in chest wall
C	36	M	Hydrocephalus secondary to ventriculitis	Clival chordoma resection complicated by ventriculitis and later, hydrocephalus and seizures. Ventilator associated pneumonia	ProGAV (5) Shunt assistant	Reduced consciousness and mobility	Removal of shunt assistant Insertion of ProSA (20) in chest wall
D	69	F	Hydrocephalus secondary to tumour	Cervical spine meningioma	ProGAV (5) Shunt assistant	Headache, reduced mobility and confusion	Removal of shunt assistant Insertion of ProSA (20) in chest wall
E	83	F	Hydrocephalus secondary aSAH	Left para-opthalmic aneurysm rupture, treated with coil embolisation	ProGAV (5) Shunt assistant	Disorientation	Removal of shunt assistant Insertion of ProSA (20) in chest wall
F	51	F	Hydrocephalus secondary neurosarcoid	Sarcoidosis, sagittal sinus thrombosis, osteoporosis and vertebral wedge fractures	ProGAV2 (5) Shunt assistant	Reduced consciousness and mobility	Relocation of shunt assistant to chest wall
G	23	M	Hydrocephalus secondary to tumour	Stable tectal plate germinoma treated with craniospinal radiotherapy	ProGAV2 (5) Shunt assistant	Increasing confusion and tiredness	Reposition patient to avoid neck flexion whilst lying flat

from April 2014 to February 2016. Documentation and recognition of their abnormal posturing was prospectively recorded. Inclusion criteria for the series required a clinical and radiological evidence of under-drainage, the presence of a VP shunt and a characteristic supine (with head-up) posturing.

Demographic details, medical history and interventions were reviewed from clinical and operative records. Clinical symptoms of persistent hydrocephalus (including reduced consciousness and confusion, nausea and vomiting and headache) were documented.

Outcome measures included resolution of clinical features of hydrocephalus and radiological improvement on CT (reported by a neuroradiologist), length of stay following intervention and complications. Data was collected prospectively and analysed retrospectively from the initial presentation date to the patient's last follow-up.

3. Results

3.1. Patients

Seven patients (A-G) (three females and four males) with persistent hydrocephalus were referred or re-investigated for possible VP shunt malfunction. Mean age was 49.8 ± 21.3 (range 23–83) years (mean ± SD) (Table 1). All patients were bedridden. Three patients had a VP shunt for hydrocephalus secondary to a tumour, 2 secondary to infection or inflammation, 1 secondary to aneurysmal subarachnoid haemorrhage and 1 primary obstructive hydrocephalus. All seven had multiple co-morbidities resulting in their increased recumbency (Table 1). At the point investigation for persistent hydrocephalus, the VP shunt had been in-situ for a mean 19.29 days (range 3–54 days). The valve setting, construct and shunt type was homogenous amongst the group, with all 7 patients having a Sprung reservoir in-situ (Miethke GMBH & Co KG) with a ProGAV (0–20/5) or ProGAV2® (0–20/5) (Miethke GMBH & Co KG) set at 5 cmH_20 with a distal anti-gravity component.

The seven patients presented with clinical and radiological under drainage syndrome (Table 1). The natural history demonstrated two groups of patients. The first group (A,D,E,F and G) had a VP shunt insertion within two weeks, yet their hydrocephalus persisted. The second group (B and C) had a clinical improvement after their VP shunt, followed by a deterioration and return of their hydrocephalus after a recent period of increased recumbency.

All the patients had been noted to have a particular posturing in bed, with their head up (elevated on pillows). The rationale for this particular posture was either due to respiratory disease (A,C), tracheostomy care (C), musculoskeletal pain (A,F), neurological disease with reduced mobility (B, C, D and E) and patient choice (G) when lying in bed. This abnormal posturing (or 'pseudovertical' position) was exacerbated by confusion in patients A, D and G (Fig. 1 lateral skull radiograph demonstrates this posture).

Bloods tests confirmed that no additional infections or new diseases were responsible for the global clinical decline (from the patient's pre-shunt baseline disease). CSF (sent routinely during VP shunt insertion) confirmed no co-existing ventriculitis. Patients had radiographs of the lateral skull, an anterior-posterior (AP) chest, and lateral and AP abdominal images to ensure no disconnection or kinking in the shunt tubing (Fig. 1A). The skull radiograph also confirmed correct orientation (Frankfurt plane) of the shunt assistant (as incorrect placement during insertion may potentially affect its function) [8]. Axial CT head imaging confirmed the presence of enlarged ventricles and ruled out retraction or poor placement of the ventricular catheter (Fig. 2).