Aqueduct Stent Placement: Indications, Technique, and Clinical Experience

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■ OBJECTIVE: **Complicated hydrocephalus, such as trapped fourth ventricle, is challenging. Aqueduct stent placement is a possible alternative to the conventional multiple shunts approach. This article discusses the indications, techniques, and clinical experiences of aqueduct stent placement.**

■ METHODS: **We retrospectively analyzed a series of 10 consecutive patients with hydrocephalus and had aqueduct stent placement between February 2009 and May 2014. The clinical and imaging data were collected and the indications, technique, and clinical experience of aqueduct stent placement were analyzed and discussed.**

■ RESULTS: **Among the 10 patients (mean age, 38 years; range, 5 months—69 years), 8 patients harbored an obstructive hydrocephalus caused by aqueductal obstruction. The underlying pathology consisted of intraventricular tumor in 3 patients, intraventricular cysticercosis in 2, and membranous or inflammatory obstruction in 3 patients. Two patients presented with trapped fourth ventricle, which resulted from Dandy-Walker malformation and shunt placement, respectively. Aqueduct stents were placed endoscopically in 8 patients, whereas the other 2 were placed microscopically. There were no deaths due to aqueduct stent placement. Postoperatively, all of the patients showed improvement or resolution of their symptoms. After an average follow-up period of 27 months (range, 1—51 months), recurrence of aqueductal obstruction has not been observed. In 1 patient, there was a complication of transient oculomotor paralysis after aqueduct stent placement. A stent migration was observed in 1 patient after remaining stable for 4 years.**

■ CONCLUSIONS: **Aqueduct stent placement is technically feasible and can be useful in selected patients either with endoscopy or open surgery.**

INTRODUCTION

With the development of neuroendoscopic technology, endoscopic third ventriculostomy (ETV) has become the standard procedure for the management of obstructive hydrocephalus caused by aqueductal stenosis. This procedure, as well as shunt, is regarded as an effective weapon to treat hydrocephalus by surgeons. However, these 2 procedures are not omnipotent for all kind of hydrocephalus (3, 8, 14). First, for patients who suffer an obstructive hydrocephalus, certain anatomic variations of the floor of the third ventricle will make it not feasible to perform an ETV. Even after ETV is successfully performed, the stoma of the ETV can be blocked by tumors or inflammatory hyperplasia of the membranes, and cause the failure of ETV. Second, for patients who suffer from a trapped fourth ventricle (TFV), ETV, or a supratentorial shunt can only treat the supratentorial hydrocephalus, leaving the TFV unsolved. In these situations, the aqueduct stent placement (ASP) seems to be helpful, as aqueductoplasty alone is regarded as unable to solve the problem because of its high risk of failure (4, 7, 11, 14). During the past decades, variations of this procedure for the treatment of aqueductal stenosis, TFV, and related disturbances of the

Key words
- Aqueduct stent placement
- Aqueductal stenosis
- Cerebrospinal fluid
- Third ventriculostomy
- Trapped fourth ventricle

Abbreviations and Acronyms
ASP: Aqueduct stent placement
CSF: Cerebrospinal fluid
DWM: Dandy-Walker malformation
ETV: Endoscopic third ventriculostomy
HC: Head circumference
MRI: Magnetic resonance imaging
TFV: Trapped fourth ventricle

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cerebrospinal fluid (CSF) circulation have been reported (2, 4, 5, 12, 14, 15, 17, 18). Nevertheless, to our knowledge, detailed reports aimed at ASP are still lacking in the literature, and the indications for ASP are still controversial. Therefore we present our experience with ASP, focusing on indications, techniques, and clinical experience.

METHODS

Patients

More than 700 patients suffering from hydrocephalus were treated at our department between February 2009 and May 2014. Among them, 10 cases had ASP. We retrospectively analyzed the clinical features, intraoperative findings, and clinical outcome of all these 10 patients to determine the indications for the ASP. Magnetic resonance imaging (MRI) was approved by the Medical Science Ethics Committee of the Chinese PLA General Hospital. Our institute's ethical committee approved the procedure, and all patients gave signed informed consent to this procedure and to offer clinical data for our analysis.

Surgical Technique

The aqueduct stents were placed with either of 2 approaches. In 2 patients, craniotomies and open surgery for tumor resection were performed. In these two patients, the aqueduct stents were placed during open surgery under the microscope. In all of the other 8 cases, an endoscopic approach was used and the aqueduct stents were placed through the endoscope. All procedures were performed under general anesthesia.

Endoscopic Approach

In general, the patients were placed supine and the head was placed in a horseshoe-shaped headrest. The best trajectory was planned according to the preoperative MRI or with neuronavigation guidance (VectorVision Compact, BrainLab, Feldkirchen, Germany). A 3-cm linear skin incision was then made, and a frontal burr hole was placed accordingly just behind the hairline for cosmetic reasons. A cruciate dural incision was made. The lateral ventricle was cannulated with a peer-away sheath. A 6-mm diameter rigid lens (LOTTA, Karl Storz, Tuttlingen, Germany) was then inserted. The endoscope is advanced through the foramen of Monro into the third ventricle. The floor of the third ventricle was identified and the obstructed aqueduct inlet was inspected with the aid of 30-degree diagnostic optics. The membrane occluding the inlet of the aqueduct can be easily perforated with the aid of the small tip of a 3Fr Fogarty balloon catheter, which was softly inserted into the aqueduct. If the membranous obstruction was located distally and could not be visualized with the rigid scopes, a 2.5-mm steerable fiberscope (FlexScope, Karl Storz, Tuttlingen, Germany) was introduced. In addition the flexible scope was also used to check aqueductal patency and inspect the cavity of the fourth ventricle. After that, the rigid endoscope was reinserted into the lateral ventricle and a multiperforated ventricular catheter tip was inserted with grasping forceps through the working channel of the rigid endoscope (LOTTA, Karl Storz) without a rigid stylet. Because the catheter is very soft, it can be easily pushed sliding down through the aqueduct. Hence, there will be no problem with the insertion angle of the stent. We usually measure on the MRI console the distance from the inferior medullary velum to intraventricular landmarks (e.g., the foramen of Monro on the same side or interthalamic adhesion). The ventricular part of a shunt catheter was then cut according to the distance measured, followed by making several small side holes on the proximal part (Figure 1). The catheter was advanced to the desired distance into the fourth ventricle, with the proximal end of the catheter left at the specific intraventricular landmarks, which were decided on the MRI. The catheter was left in place and the endoscope was then withdrawn while looking for active bleeding and checking the surface of the catheter to ensure the presence of side holes into the third or lateral ventricle. The burr hole was packed with gelatin sponge. To prevent subgaleal CSF accumulation and fistula, the galea should be tightly sutured. The operation was performed under continuous irrigation with 36°C Ringer's solution to maintain a clear view and achieve hemostasis.

Open Surgery

In 2 patients with big tumors (1 glioma, 1 yolk sac tumor) located in the third ventricle, craniotomy and open surgery had to be performed. After maximal tumor resection, a multiperforated ventricular catheter was inserted microscopically with grasping forceps into the aqueduct after its exposure. The catheter was advanced into the fourth ventricle to the adequate distance measured preoperatively on MRI. Side holes of the catheter at the third and lateral ventricle were confirmed with the microscope. An intraoperative MRI study was routinely performed to verify the position of the stent.

Outcome Assessment

All patients underwent routine MRI scans before and after surgery to verify the position of the catheter and the ventricular morphology. Patients enrolled in the present study were followed-up at 1, 3, and 6-month intervals and by a routine 1-year interval afterward. Clinical and imaging findings were evaluated and recorded.

RESULTS

A summary of the 10 patients who underwent ASP is listed in Table 1. The mean age of the patients was 38 years (range, 5 months—69 years). The mean follow-up period was 27 months (range, 1—51 months). There were 4 female patients and 6 male patients. Eight patients harbored an obstructive hydrocephalus caused by aqueductal obstruction. The underlying pathology consisted of intraventricular tumors in 3 cases (pilocytic astrocytoma, craniopharyngioma, and germ cell tumor [yolk sac tumor], respectively), intraventricular cysticercosis in 2 cases, and membranous or inflammatory obstruction in 3 cases. Two patients presented with a TFV resulting from a Dandy-Walker malformation (DWM) and postinfectious hydrocephalus, respectively. Difficult anatomic variation of the floor of the third ventricle was identified in 2 patients, including a thickened floor of the third ventricle and an extremely narrow space between the basilar artery and the dorsum sellae, making it unfeasible for a successful ETV. Two patients had shunts previously. Two patients had a history of failure of ETV. The main presenting symptoms were headache (40%; 4/10 cases), nausea and