Bedside Iohexol Ventriculography for Patients with Obstructive Colloid Cysts: A Protocol to Identify Auto-Fenestration of the Septum Pellucidum

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■ OBJECTIVE: **Patients with hydrocephalus secondary to third ventricular colloid cysts can require bilateral external ventricular drain (EVD) placement while awaiting surgery. However, some patients could develop auto-fenestration of the septum pellucidum (AFSP) and only require 1 EVD. We evaluated our experience with bedside iohexol ventriculography and staged EVD placement for patients with obstructive hydrocephalus.**

■ METHODS: **We retrospectively identified 34 patients who had been treated for third ventricular colloid cysts (2013–2016). The preoperative and postoperative data, including age, sex, colloid cyst size, preoperative hydrocephalus, preoperative EVD placement, preoperative iohexol ventriculography, operative approach, intraoperative findings, and postoperative ventriculoperitoneal shunt requirements, were reviewed.**

■ RESULTS: **Hydrocephalus was found in 23 patients (68%) on initial presentation. Nine patients (26%) had EVDs placed before surgery. Six patients (18%) underwent iohexol ventriculography after insertion of a right-sided EVD. Five patients (15%) demonstrated no evidence of ventricular communication. Four patients (67%) required left-sided EVD placement. One patient (17%) had robust communication between the lateral ventricles after intraventricular iohexol injection, which was managed with a single EVD. AFSP was observed during surgical resection of this patient's colloid cyst. One other patient who did not undergo preoperative EVD placement was noted to have AFSP intraoperatively, resulting in 2 of 34 patients (6%) with AFSP in our series.**

■ CONCLUSIONS: **A subset of patients with obstruction at the foramina of Monro can develop AFSP. Iohexol ventriculography after unilateral EVD placement allows clinicians to assess for the presence of AFSP and identify patients who can be treated with a single EVD before surgery.**

INTRODUCTION

Colloid cysts are benign brain tumors that represent 0.2%–2% of all intracranial neoplasms. These rare lesions arise from ectopic endodermal elements that aberrantly migrate into the velum interpositum during the development of the fetal central nervous system.[1] Most colloid cysts arise within the anterosuperior portion of the third ventricle and are attached to the choroid plexus on the ventricular roof at the foramen of Monro.[2] Additionally, despite their rarity, these lesions represent 15%–20% of all intraventricular masses.[2,3] Overall, colloid cysts are estimated to have a prevalence of 1 in 8500 persons and an annual incidence of 3.2/1,000,000 persons.[2]

Owing to their location adjacent to the foramina of Monro, colloid cysts will occasionally obstruct the outflow of cerebrospinal fluid from the lateral ventricles, thus causing obstructive hydrocephalus. Because colloid cysts grow slowly, obstructive hydrocephalus typically develops over a long period. However, a small subset of patients with colloid cysts will present with acute,

Key words
- Auto-fenestration
- Colloid cyst
- External ventricular drain
- Hydrocephalus
- Intraventricular
- Iohexol
- Septum pellucidum
- Ventriculography

Abbreviations and Acronyms
AFSP: Auto-fenestration of the septum pellucidum
CT: Computed tomography
EVD: External ventricular drain
MRI: Magnetic resonance imaging

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decompensated hydrocephalus. Several mechanisms have been proposed to explain this presentation, including rapid cyst growth, cyst apoplexy, cyst rupture, and traumatic cyst displacement.[1,3,4] Regardless of the mechanism of onset, the risk of acute deterioration from a symptomatic colloid cyst has been estimated to be 6%–45%, with some studies demonstrating a mortality rate of ≤12% among patients presenting with symptomatic colloid cysts.[4] In this clinical scenario, patients will often require emergent external ventricular drain (EVD) placement before undergoing definitive surgical management. Given that obstruction of both lateral ventricles is often present, bilateral ventriculostomies are commonly required.[3,5-7]

Chronic ventricular obstruction can lead to auto-fenestration of the septum pellucidum (AFSP),[8,9] and this has been anecdotally observed in the surgical treatment of intraventricular lesions, in particular, colloid cysts.[9,10] However, the incidence of AFSP has not been well documented in the reported neurosurgical literature.

At our institution, we implemented a protocol using iohexol ventriculography after unilateral EVD placement for patients presenting with acute obstructive hydrocephalus and imaging findings that demonstrate a colloid cyst. We sought to determine the incidence of AFSP in these patients in an attempt to spare them bilateral EVD placement and the potential for EVD-related morbidity. We have described our experience with this protocol and how it has affected our treatment of these patients.

METHODS

Patient Population

The institutional review board of Barrow Neurological Institute at St. Joseph's Hospital and Medical Center (Phoenix, Arizona, USA) approved the present study. Informed consent was not required, and the investigators were kept unaware of the subjects' personal health information. We performed a retrospective review of the electronic medical records to identify patients who had undergone surgical management of colloid cysts at our institution from June 26, 2013, to December 9, 2016.

Data Collection

The preoperative and postoperative data, including age, sex, colloid cyst size, presence of preoperative hydrocephalus, preoperative EVD placement, preoperative iohexol ventriculography, operative approach, intraoperative findings, and postoperative ventriculoperitoneal shunt requirements, were reviewed. T1-weighted, T2-weighted, and fluid-attenuated inversion recovery sequence magnetic resonance imaging (MRI) studies were additionally reviewed to determine whether AFSP was detectable and present on the MRI studies.

Bedside Iohexol Ventriculography Protocol

At the discretion of the attending physician, those patients presenting with ventriculomegaly of both lateral ventricles secondary to third ventricular colloid cysts underwent iohexol ventriculography after placement of a right frontal EVD. We injected 5–10 mL of 300 mg/mL of iohexol contrast (Omnipaque, GE Healthcare, Little Chalfont, UK) into the right lateral ventricle at the bedside. Axial computed tomography (CT) imaging was obtained immediately after iohexol injection. The presence or absence of iohexol contrast in the left lateral ventricle was used to evaluate whether the lateral ventricles were in communication. If the lateral ventricles were found to be in communication, contralateral EVD placement was not performed. Otherwise, a second, left-sided EVD was inserted at the patient's bedside. If a second EVD was inserted, the patients underwent a second head CT scan to confirm placement. All patients subsequently underwent endoscopic or open surgical resection of their colloid cysts.

RESULTS

From June 26, 2013, to December 9, 2016, 34 patients were identified as having undergone resection of a colloid cyst at our institution (**Table 1**). These 34 patients included 21 males (62%) and 13 females (38%), ranging in age from 16 to 69 years (mean ± standard deviation, 42.3 ± 13.2) at surgery.

All patients were found to have colloid cysts of the anterosuperior third ventricle at presentation. The colloid cyst size in the axial plane on radiographic imaging ranged from 0.5 to 3.0 cm. Hydrocephalus on initial presentation was found in 23 of the 34 patients (68%). MRI failed to reveal AFSP in any of the patients included in the present series. Of the 34 patients, 18 (53%) had been admitted electively for surgery and 16 (47%) had presented acutely as emergency department admissions or transfers and underwent surgery during the same hospital admission. Nine patients (26%) had EVDs placed before surgery to treat hydrocephalus.

Six patients (18%) had undergone iohexol ventriculography after undergoing placement of a right frontal EVD. Of these 6 patients, 1 (17%) was found to have communication between the lateral ventricles and was treated with the existing right-sided EVD only. The remaining 5 patients (83%) demonstrated no communication between the lateral ventricles. Four of these patients underwent contralateral (left-sided) EVD placement in addition to the first EVD. In 1 patient (patient 19), placement of the first EVD was complicated by intraparenchymal hemorrhage, which precipitated emergent surgical clot evacuation and removal of the colloid cyst.

Three patients (patients 4, 10, and 28) had undergone placement of a right frontal EVD only without a subsequent iohexol study or contralateral, left-sided EVD placement. The decision to forego ventriculography for these patients was at the discretion of the attending surgeon. No patients who had undergone iohexol ventriculography had experienced any adverse effects related to the delay in the placement of a second EVD.

After initial stabilization, all the patients had undergone surgical resection of their colloid cyst. Of the 34 patients, 13 (38%) had undergone endoscopic surgical resection, and 21 (62%) had undergone open surgical resection via the interhemispheric transcallosal or transcortical approach. After surgical resection, 11 patients were left with EVDs, 7 of which were placed preoperatively and 4 were placed intraoperatively. All patients had undergone follow-up imaging after surgery. Two patients required ventriculoperitoneal shunt placement before discharge.

Case Description

Case 1. Patient 15 was a 32-year-old woman who had presented with 1 week of headaches and was found to have significant hydrocephalus secondary to a colloid cyst. MRI sequences, including T1-weighted, T2-weighted, and fluid-attenuated

Table 1. Patient Demographics, Disease Characteristics, and Surgical Outcomes

					Preoperative					Postoperative	
Patient	Sex	Age (Years)	Admission Status	Colloid Cyst Size (cm)	HCP	EVD	Iohexol Ventriculography*	AFSP Visible on MRI	Approach	EVD	VPS
1	M	49	Elective	1.0 × 0.9	Yes	No	No	No	Endoscopic	No	No
2	M	16	Elective	0.7	No	No	No	No	Open, IHTC	No	No
3	M	49	Elective	1.7	Yes	No	No	No	Open, IHTC	Yes	No
4	M	42	Emergent	1.2 × 1.4	Yes	Yes; right	No	No	Endoscopic	No	No
5	M	32	Emergent	1.3 × 1.4	Yes	No	No	No	Open, IHTC	No	No
6	M	44	Elective	1.0 × 0.7	No	No	No	No	Endoscopic	No	No
7	F	31	Elective	0.8	No	No	No	No	Endoscopic	No	No
8	F	36	Elective	0.56	No	No	No	No	Open, IHTC	No	No
9	M	38	Elective	1.3 × 1.3 × 1.7	Yes	No	No	No	Open, IHTC	No	No
10	F	24	Emergent	1.5 × 1.2	Yes	Yes; right	No	No	Endoscopic	Yes	No
11	M	49	Elective	1.2	No	No	No	No	Open, IHTC	No	No
12	F	48	Elective	0.6	Yes	Shunts	No	No	Open, IHTC	No	No
13	F	49	Elective	0.6 × 1.0	No	No	No	No	Open, IHTC	No	No
14	M	57	Emergent	0.7	Yes	No	No	No	Open, IHTC	No	Yes
15	F	32	Emergent	1.1	Yes	Yes; BL	Yes; no communication	No	Endoscopic	Yes; left	No
16	M	36	Elective	0.5	No	No	No	No	Open, IHTC	No	No
17	M	57	Emergent	1.2 × 0.9	Yes	Yes; BL	Yes; no communication	No	Endoscopic	Yes; BL	No
18	M	24	Elective	0.6 × 0.6	No	No	No	No	Open, IHTC	No	No
19	M	59	Emergent	1.9 × 1.9	Yes	Yes; right	Yes; no communication	No	Open, transcortical	Yes	Yes
20	M	69	Emergent	2	Yes	Yes; BL	Yes; no communication	No	Open, IHTC	No	No
21†	F	49	Emergent	0.8	Yes	No	No	No	Endoscopic	Yes	No
22	F	56	Emergent	1.7 × 1.5 × 1.6	Yes	Yes; BL	Yes; no communication	No	Open, IHTC	Yes; left	No
23	M	49	Elective	1.5 × 1.4	Yes	No	No	No	Endoscopic	No	No
24	M	44	Elective	1.3 × 1.2 × 1.2	No	No	No	No	Open, IHTC	No	No
25	F	28	Elective	0.7	Yes	No	No	No	Endoscopic	No	No
26	M	54	Elective	1.2 × 1.1	Yes	No	No	No	Endoscopic	Yes	No
27	F	54	Elective	1.1	Yes	No	No	No	Open, IHTC	No	No
28	F	30	Emergent	0.9 × 0.8 × 0.7	Yes	Yes; right	No	No	Open, IHTC	Yes; right	No
29	M	42	Emergent	2.2 × 3.0 × 2.8	Yes	No	No	No	Open, IHTC	No	No
30	F	57	Elective	1.3 × 1.1	No	No	No	No	Open, IHTC	No	No
31	M	40	Emergent	1.2 × 0.8	Yes	No	No	No	Open, IHTC	Yes; right	No
32†	M	61	Emergent	1.6 × 1.8	Yes	Yes; right	Yes; communication	No	Endoscopic	Yes	No
33	M	35	Emergent	1.3 × 1.3	No	No	No	No	Open, IHTC	No	No
34	F	44	Emergent	0.8 × 0.5	Yes	No	No	No	Endoscopic	No	No

HCP, hydrocephalus; EVD, external ventricular drain; AFSP, auto-fenestration of the septum pellucidum; MRI, magnetic resonance imaging; VPS, ventriculoperitoneal shunt; M, male; IHTC, interhemispheric transcallosal; F, female; BL, bilateral.

*Iohexol ventriculography administered after unilateral EVD placement at the discretion of the attending physician.

†ASFP found during surgery.

inversion recovery sequences, showed no evidence of AFSP. The patient underwent an iohexol-dye study after placement of a right-sided EVD, which demonstrated no evidence of communication between the lateral ventricles (Figure 1). A left-sided EVD was subsequently placed in the intensive care unit before surgical resection. Both EVDs were opened at 15 cm above the tragus. The patient's intracranial pressure was constant at about 10 cm H_2O, and the catheters were noted to drain 3–8 mL/hour before surgery. The patient was taken to the operating room on hospital day 3 for right frontal endoscopic resection. Gross total resection was achieved.

Case 2. Patient 32 was a 61-year-old man with no significant medical history. He had initially presented to the emergency department with 2 months of increasing confusion and dysequilibrium. An MRI study obtained in the emergency department demonstrated a 1.6 × 1.8-cm colloid cyst of the third ventricle with marked hydrocephalus involving only the lateral ventricles and no evidence of AFSP. Iohexol ventriculography was performed after insertion of a right-sided EVD and demonstrated clear communication of dye between the lateral ventricles (Figure 2). The decision was subsequently made not to place a left-sided EVD. The initial EVD was left open to drain at 20 cm above the tragus. The patient's intracranial pressure ranged from 1 to 18 cm H_2O, and the catheter was noted to drain 0–6 mL/hour before surgery. The patient underwent right-sided endoscopic resection on hospital day 1. AFSP was readily visualized (Video 1). Gross total resection was achieved.

Video available at www.sciencedirect.com

DISCUSSION

Depending on the natural history of their specific lesion, patients with colloid cysts of the third ventricle can present with a variety of symptoms, ranging from mild headaches to severe hydrocephalus leading to cerebral herniation and, ultimately, death.[3,4] It is believed that the natural history of a colloid cyst can progress down 1 of several paths, depending on patient age, cyst composition, and the rate of cyst growth. Older patients with smaller colloid cysts will often be asymptomatic because of the preserved patency of the ventricular system and a slower rate of cyst growth. Younger patients with larger cysts and accompanying ventriculomegaly will be more likely to experience symptoms related to obstructive hydrocephalus. Depending on the rate of progression, 12%–85% of patients with colloid cysts will eventually develop symptomatic hydrocephalus and require surgical intervention.[1]

We have described a method using iohexol ventriculography to determine the presence or absence of communication between the ventricles. This information was subsequently used to determine which patients with obstructive hydrocephalus due to third ventricular colloid cysts would receive bilateral EVDs. We have described 1 case in our series in which 1 patient with severe, symptomatic hydrocephalus secondary to a colloid cyst obstructing the foramina of Monro bilaterally was stabilized with a single EVD after radiographic evidence was obtained showing communication between the lateral ventricles—a finding that was subsequently confirmed during endoscopic surgery, with the demonstration of AFSP. Whether patients without communication between the ventricles required both left and right drains is not clear. None of the patients without the test experienced decompensation. We have reported our experience primarily to document the incidence of communication between the lateral ventricles and the use of iohexol dye as a method to establish this communication preoperatively.

It is common practice to place bilateral EVDs in patients with third ventricular colloid cysts who present with symptomatic hydrocephalus to simultaneously decompress the left and right lateral ventricles.[6] Each EVD placement, although useful in the acute setting to reduce intracranial pressure, is not an entirely benign procedure. A number of complications have been associated with the insertion of an EVD, including catheter misplacement, infection, hemorrhage, obstruction, and malfunction requiring replacement.[8,11] One report estimated an overall complication rate of 26% after EVD placement in pediatric patients,[8] and EVD placement in adults has been associated with a risk of ≤22% of ventriculitis and meningitis, and about a 5% overall risk of hemorrhagic complications.[12,13] Although no studies, to the best of our knowledge, have specifically investigated the additional complication rate associated with the placement of bilateral EVDs, avoiding a second procedure could be beneficial in terms of reducing complications and improving patient outcomes. As we have demonstrated in the present case series, select patients with colloid cysts and AFSP can be stabilized with only a single EVD owing to communication between the lateral ventricles.

AFSP, known to occur as a result of severe or prolonged hydrocephalus, has been specifically noted in cases of hydrocephalus secondary to intraventricular hemorrhage and severe ventriculitis.[9] In these cases, the increased pressure in the lateral ventricles frays and eventually disintegrates the 2 leaves of the septum pellucidum, thus transforming the left and right lateral ventricles into a single, communicating cavity.[10,14] It has been reported that this communication can occasionally be visualized directly on non–contrast-enhanced CT.[10] However, we have not found this method to be reliable, and we were unable to identify ventricular communications using standard head CT scans in our series, either prospectively or retrospectively. In the present series, we have shown that iohexol ventriculography is capable of demonstrating AFSP that might otherwise be undetectable on preoperative imaging studies.

We believe that the use of iohexol ventriculography in patients with third ventricular colloid cysts is both safe and effective. In the present series, no direct or indirect adverse effects occurred in any of the 6 patients who had undergone the procedure. Although this protocol might subject some patients to an additional CT scan of the head, we propose that the benefits of avoiding placement of a second EVD outweigh the risks of additional radiation exposure.

Future studies might consider investigating the correlation between radiographically observed communication between the lateral ventricles and intraoperatively observed AFSP. A better understanding of this relationship would further validate the ability of iohexol ventriculography to identify septal perforations. Furthermore, our study focused on the single entity of colloid cysts. However, fenestration of the septum pellucidum can also occur with other causes of obstructive hydrocephalus, and this protocol can be used to assess for ventricular communication with

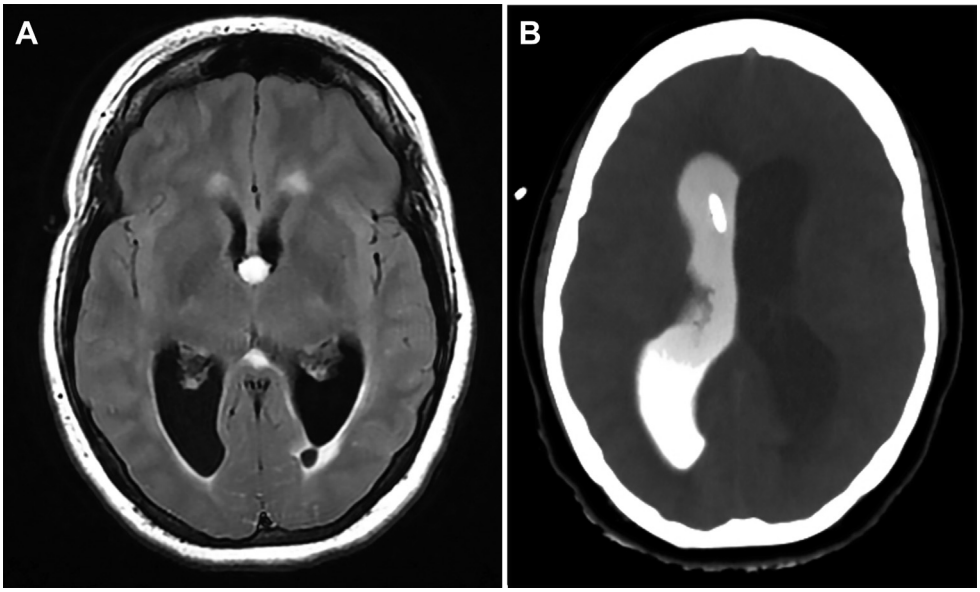

Figure 1. Case 1. (**A**) Axial T2-weighted fluid-attenuated inversion recovery sequence magnetic resonance image demonstrating bilateral ventriculomegaly with an obstructive colloid cyst at the foramen of Monro. (**B**) Axial head computed tomography scan after the iohexol dye study; note the clear lack of communication between the lateral ventricles. Used with permission from Barrow Neurological Institute, Phoenix, Arizona, USA.

other underlying pathologic entities. Finally, investigators in future studies might consider obtaining more detailed MRI scans through the septum pellucidum, such as constructive interference in steady-state or fast imaging using steady-state acquisition sequences, to determine whether these imaging modalities are capable of detecting AFSP before surgical intervention.

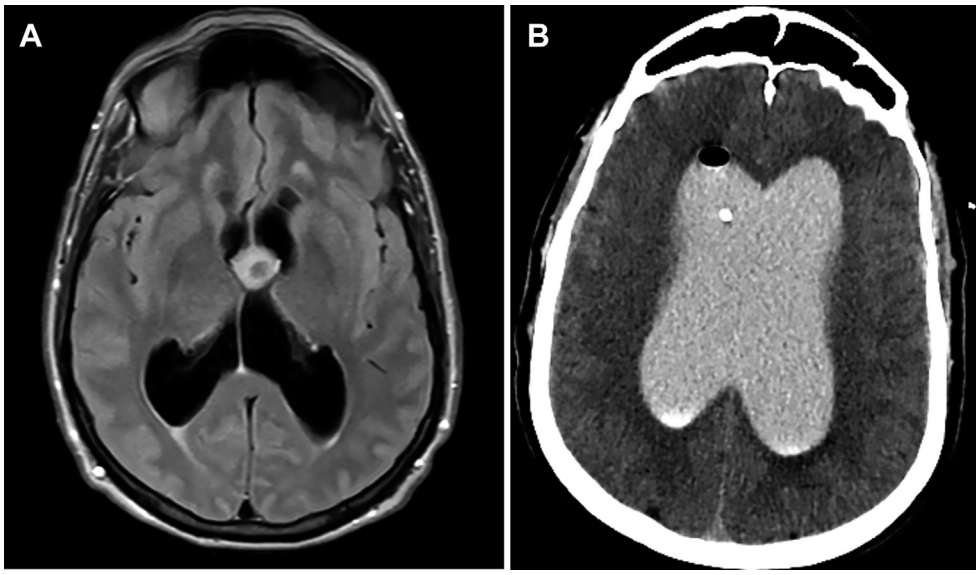

Figure 2. Case 2. (**A**) Axial fluid-attenuated inversion recovery sequence magnetic resonance image demonstrating bilateral ventriculomegaly with an obstructive colloid cyst at the foramen of Monro. (**B**) Axial head computed tomography scan after the iohexol dye study; note the clear communication of dye between the lateral ventricles. Used with permission from Barrow Neurological Institute, Phoenix, Arizona, USA.

Study Limitations

Although the present study represents our institutional experience with colloid cysts during the course of 45 months, the number of patients was limited owing to the relatively rare nature of colloid cysts. Additionally, not all patients with hydrocephalus had undergone EVD placement before surgery, and not all of those who had had EVDs placed underwent iohexol ventriculography. A larger sample examining the iohexol ventriculography protocol might provide more insight into the true incidence of AFSP in this population of patients. Despite these limitations, we believe that the use of iohexol ventriculography offers a safe and effective method of determining the necessity of bilateral EVD placement in patients with third ventricular colloid cysts.

CONCLUSIONS

A subset of patients with colloid cysts presenting with ventricular obstruction at the foramen of Monro can develop AFSP (2 of 34 patients [6%] in the present series). In our experience, the use of iohexol ventriculography after unilateral EVD placement allows clinicians to assess for the presence of lateral ventricle communication and to identify patients who can be treated with a single EVD before surgery. This technique reduces potential EVD-related complications in this patient population.

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