



## Endoscopic Route for Excision of Intraventricular Neurocysticercosis: Light at the End of the Tunnel

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■ **BACKGROUND:** Poor sanitation, poor hygiene, and archaic cooking practices have led to neurocysticercosis (NCC) being endemic in India. Apart from a cortical location that leads to seizures, intraventricular NCC can present with hydrocephalus and sudden deterioration in sensorium. Consequently, endoscopic excision plays an important role in its treatment because a dilated ventricle offers a minimally invasive and less traumatic route to the pathology.

■ **METHODS:** All endoscopically excised intraventricular NCC cases operated were retrospectively analyzed from 2014 to 2017, discussing surgical nuances and post-operative outcome.

■ **RESULTS:** Twelve such cases were found (mean age,  $21.9 \pm 8.36$  years; 9 men and 3 women). The mean follow-up period was  $21.17 \pm 13.96$  months (range, 2–40 months). The most common site was the aqueduct and fourth ventricle.

■ **CONCLUSIONS:** An endoscopic approach is a feasible and safe tool for treating this disease. Technical nuances such as entry point and trajectory of endoscope need to be kept in mind while operating.

### INTRODUCTION

Neurocysticercosis (NCC) is one of the most common parasitic infestations of the central nervous system and a common cause of epilepsy in the Indian subcontinent, affecting nearly 1.2 million population.<sup>1</sup> It accounts for 2.5% of all

intracranial space-occupying lesions. Among these, the intraventricular location is reported to be between 7% and 60%.<sup>2</sup> Compared with parenchymal NCCs, intraventricular cysts carry a poor outcome.<sup>3</sup> The need for postoperative antihelminthics, steroids, and antiepileptics in intraventricular neurocysticercosis (IVN) still remains debatable. IVN has an additional risk of ependymitis, especially in patients whom anthelmintic drugs are prescribed before surgery, and intermittent hydrocephalus, which is fatal at times.<sup>4,5</sup>

Current standard of care for IVN is emergency cerebrospinal fluid diversion with or without microsurgical cyst excision, either via transcortical or transcallosal corridors. These approaches risk damaging the eloquent areas and causing functional deficits. With the expanding horizon of neuroendoscopy, endoscopic excision with septostomy or third ventriculostomy is on the rise. Despite a learning curve, the surgical satisfaction is immense and it avoids the use of shunt hardware. In this series, we discuss our experience and surgical outcome in patients with IVN.

### MATERIALS AND METHODS

#### Study Design

All patients with IVN, managed endoscopically in our department, between January 2014 and December 2017, were included in our study. We collected data on demographic profile, symptomatology, location, size, type of cyst, surgical findings, and post-operative complications. Hospital case records, outpatient files, and the hospital information system were the primary sources of our data collection. Radiologic assessment consisted of computed tomography scan and magnetic resonance imaging (MRI) of the brain. Individual consent from all patients for publication of clinical details was given, and the study was approved by the institute's ethics board.

#### Key words

- Endoscopy
- Intraventricular cyst
- Neurocysticercosis

#### Abbreviations and Acronyms

- IVN:** Intraventricular neurocysticercosis
- MRI:** Magnetic resonance imaging
- NCC:** Neurocysticercosis

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**Table 1.** Demographic Profile and Clinical Features of the Patients (N = 12)

Characteristic	Value
Age (years), mean $\pm$ SD, median (range), IQR	21.9 $\pm$ 8.36, 22 (11–35), 15
Sex, male/female	9 (75)/3 (25%)
Location	
Third ventricle	1
Fourth ventricle isolated	5
Fourth ventricle and parenchymal both	2
Lateral ventricle isolated	3
Both lateral and third ventricle	1
Clinical presentation at time of admission	
Headache	12
Seizure (generalized tonic-clonic)	1
Vomiting	12
Progressive vision loss with blurring	6
Papilledema	6
Diplopia	1
Vertigo	1
Gait ataxia	4
Hemiparesis	0
GCS score at time of admission	
Fully conscious and oriented (15/15)	11
<15	1
Investigation	
TLC >11,000	2
Mean neutrophil count in DLC	65
Mean lymphocyte count in DLC	30
Pleocytosis in cerebrospinal fluid study (out of 3)	1
Radiologic details	
Scolex seen	9
Ependymal enhancement	3
Albendazole started before admission	6
Excision	
Complete	11
Partial	1
Technique to pull cyst	
Using infant feeding tube and negative suction	8
Forceps application along with negative suction	4
Postoperative complications	
Continues	

**Table 1.** Continued

Characteristic	Value
Ventriculoperitoneal CSF diversion	2
Transient ptosis	1
Wound bulge	2
Follow-up (months), mean $\pm$ SD, median (range), IQR	21.17 $\pm$ 13.9, 22.5 (2–40), 29
Values are number of patients or as otherwise indicated. IQR, interquartile range; GCS, Glasgow Coma Scale; CSF, cerebrospinal fluid; TLC, total leukocyte count; DLC, differential leukocyte count.	

### Surgical Procedure

The entry point was guided by preoperative radiology highlighting the status of frontal horn dilation and the position of the foramen of Monro. The standard 3-cm lateral to midline and 1-cm anterior to coronal suture for third ventricle visualization and 4- to 5-cm anterior to coronal suture for fourth ventricle visualization was made (**Supplementary Figure S1**).

We used a neuronavigation system (StealthStation [Medtronic, Louisville, USA]) for making a burr hole just prior to surgery after registration of the patient's head. The Karl Storz (Tuttlingen, Germany) rigid neuroendoscope system was used in all of our cases. In lateral ventricular NCC, once the scope enters inside, the cyst was visualized and removed using grasping forceps, taking care not to rupture the cyst. In third ventricular NCC, the cyst was removed via a transforaminal (foramen of Monro) approach. In fourth ventricular NCC, the cyst was removed via a transforaminal-transaqueductal approach. A 6-French infant feeding tube was used for applying negative suction for pulling the parasitic cyst.

**Pulling and Rotatory Movement of the Catheter.** Once the cyst wall was in contact with the catheter, it was rotated 180° clockwise and counterclockwise under 2 mL syringe suction, so as to allow the cyst to be partially sucked into the lumen of the catheter. After this, the catheter was pulled slowly, to allow the cyst to be dislocated and delivered. The idea is to minimize traction over ventricle walls and vasculature.

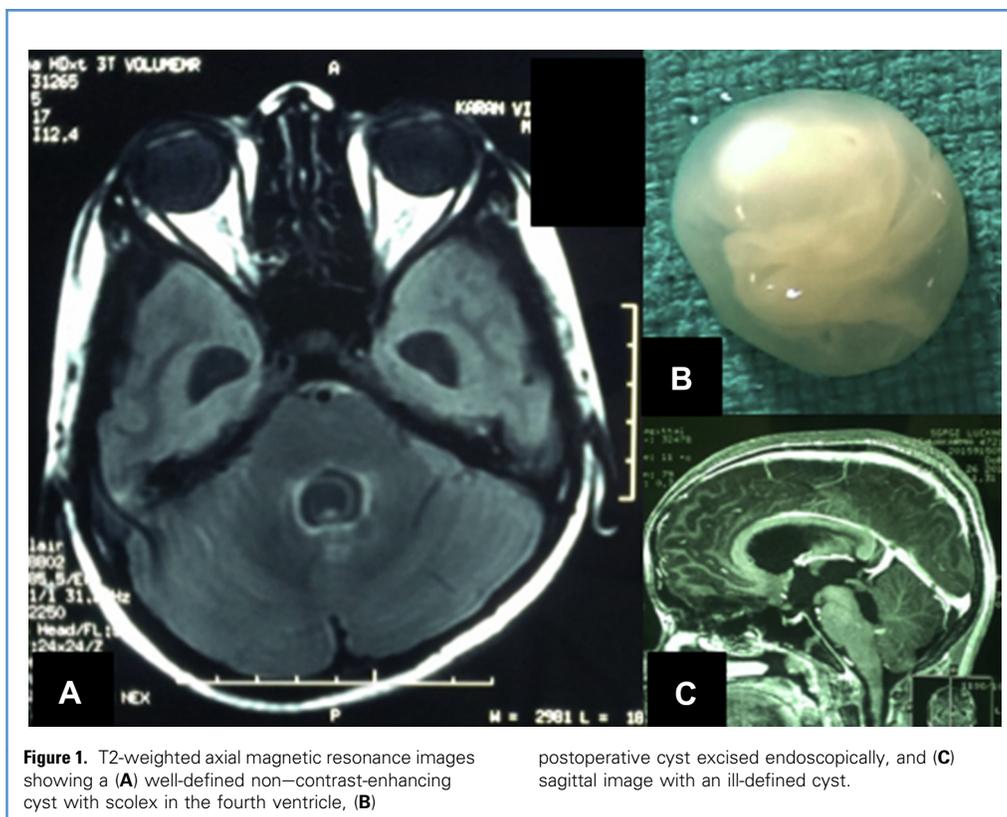
**Postoperative Care.** Anthelmintic drugs were continued in the postoperative period. MRI was repeated 6 weeks later, after which the drugs were stopped. Patients with history of seizures were continued on antiepileptic drugs, whereas those not having any such history were advised to stop after 7 days postsurgery. Follow-up was advised after every 6 months with a repeat MRI after 1 year of surgery.

## RESULTS

### Demographic Profile

A total of 12 patients (9 men and 3 women) admitted for IVN were retrospectively analyzed in our study (**Table 1**).

The age of patients ranged from 11 to 35 years with mean age of 21.9  $\pm$  8.36 years. Most of the patients (n = 10; 83%) belong to the lower middle class, with 9 (75%) living in the Western Uttar Pradesh region with a high prevalence of the *Taenia solium* parasite.



**Figure 1.** T2-weighted axial magnetic resonance images showing a (A) well-defined non-contrast-enhancing cyst with scolex in the fourth ventricle, (B)

postoperative cyst excised endoscopically, and (C) sagittal image with an ill-defined cyst.

### Clinical Presentation

The most common presentation was headache (100%), followed by painless progressive loss of vision (50%) because of secondary optic atrophy. Four patients (33.3%) had difficulty in walking (in form of gait ataxia), 1 patient had vertigo, 1 patient had diplopia, and 1 patient presented with generalized tonic-clonic seizure. Among the patients presenting with gait ataxia, all 4 had cysts located in the fourth ventricle. The fundus examination revealed presence of papilledema in 6 patients (50%). The most common site of IVN in our series was the fourth ventricle (58%).

### Investigation

Brain MRI with contrast enhancement and cerebrospinal fluid flow studies were done in all cases. However, the scolex could be visualized in only 9 patients (75%). Ependymal enhancement (basal exudates and enhancing ventricular lining) was seen in 5 patients (41.6%). The cyst was hypointense on T1-weighted image in 11 patients and hyperintense on T2-weighted image and fluid-attenuated sequences in 12 patients.

In addition, blood counts were analyzed for an infective trend. The mean total leucocyte count at admission was  $9141.66 \pm 2352.8$  cells/dL, with 2 patients having counts of  $>11,000$  cells/dL. The mean differential neutrophil count was  $65 \pm 9.1$  per 100 cells, and the mean differential lymphocyte count was  $30 \pm 6.6$  per 100 cells. Serologic study was not done in our patients.

### Medical Management

With our institution being a tertiary care center, 7 patients (58.3%) were already taking oral albendazole. All cases were continued on oral albendazole 15 mg/kg/d for 6 weeks in the postoperative period.

### Surgical Management

Endoscopic excision of the cyst was performed in all cases as described, with endoscopic third ventriculostomy done additionally in all cases and septostomy done in 3 cases (Video 1). External ventricular drainage was left in 2 patients, which was taken out after 24 hours. The cyst was removed completely in 11 patients and partially in 1 patient. Adhesions were present in 5 patients. Among these, 2 had cyst rupture, without sequelae. In cases with cyst rupture, the ventricle was thoroughly irrigated with warm saline until the run-off was clear.

### Complications and Follow-Up

The mean follow-up period was  $21.17 \pm 13.96$  months (range, 2–40 months). Three cases needed ventriculoperitoneal shunt for hydrocephalus. None of the cases had cerebrospinal fluid leak; however, 2 cases had wound bulge without sequelae. Both of these patients were managed conservatively with compression dressings and acetazolamide. One patient had complete bilateral ptosis in the immediate postoperative period, probably because of



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**Table 2.** Review of All Published Series Where Fourth Ventricular Neurocysticercosis Is Managed Endoscopically

Study	Primary Location of Cyst in Ventricle (Lateral/Third/Fourth)	Surgical Corridor Taken (Transaqueductal/Transcortical/Transforaminal)	Number of Cases	Complications
Jensen and Post, 2016 <sup>3</sup>	Anterior third ventricle	Transcortical-trans-foramen of Monro	2	No
Goel et al., 2007 <sup>8</sup>	Fourth ventricle (n = 14)/lateral ventricle (n = 4)/third ventricle (n = 3)/both lateral and third ventricle (n = 1)	Transcortical/transaqueductal	22	Intraoperative bleeding
Husain et al., 2007 <sup>9</sup>	Lateral ventricle (n = 6)/third ventricle (n = 6)/fourth ventricle (n = 10)	Transcortical/transaqueductal	21	No
Bergsneider, 1999 <sup>10</sup>	Fourth ventricle (n = 5)	Trans-foramen of Magendie (flexible endoscope via midline posterior approach)	5	Pneumocephalus (n = 1) Rupture of cyst wall (n = 1) Ventriculoperitoneal shunt (n = 2)
A.ceja Espinosa et al., 2017 <sup>11</sup>	Fourth ventricle (n = 1)	Transcerebellar (suboccipital burr hole)	1	No
Anandh et al., 2001 <sup>12</sup>	Fourth ventricle (n = 3) Lateral ventricle (n = 4) Third ventricle (n = 1) Both lateral and third ventricle (n = 1)	Transcortical/transaqueductal	9	Intraventricular bleeding (n = 2) Periaqueductal injury leading to postoperative left hemiparesis and bilateral ptosis (n = 1)
Cudlip et al., 1998 <sup>13</sup>	Third ventricle (n = 1)	Transcortical-trans-foramen of Monro	1	No
Psarros et al., 2003 <sup>14</sup>	Third ventricle (n = 3) Fourth ventricle and lateral ventricle (n = 2) Third ventricle and lateral ventricle (n = 1) Lateral ventricle (n = 1)	Transcortical-trans-foramen of Monro/ transaqueductal	7	Intraventricular bleeding (n = 1) Akinetic mutism (n = 1) Ependymitis (n = 3)
Kaif et al., 2018 <sup>15</sup>	Third ventricle (n = 16) Fourth ventricle (n = 12) Lateral ventricle (n = 1) Septum cavum (n = 1)	Transcortical-foramen of Monro Transaqueductal	30	Ventriculoperitoneal shunt (n = 2)
Zymer et al., 2003 <sup>16</sup>	Fourth ventricle (n = 1)	Transaqueductal	1	No
Present study	Third ventricle (n = 1) Fourth ventricle (n = 7) Lateral ventricle (n = 3) Both lateral and third ventricle (n = 1)	Transcortical-trans-foramen of Monro/transaqueductal	12	Ptosis (improved in follow-up)

manipulation of the aqueduct during cyst wall removal, leading to traction injury in the periaqueductal region, which improved to near-normal eye opening at 6-month follow-up.

## DISCUSSION

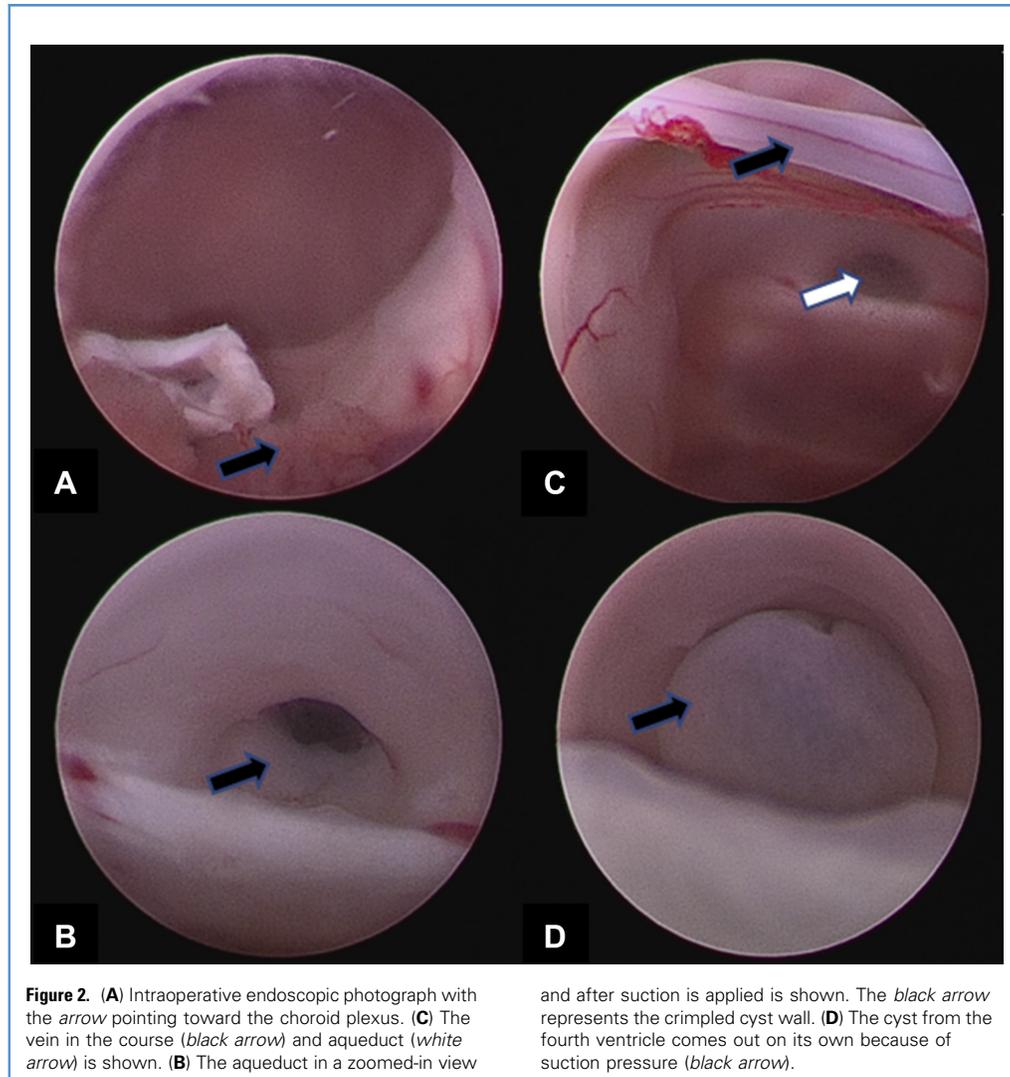
IVN affects the younger population, with the mean age in our study being  $21.9 \pm 8.36$  years. Although our study had male preponderance, other studies show more prevalence in the female sex. The contradictory finding in sex distribution might be because of the poor hygiene standards of men, who often have their meals in the farms.<sup>6,7</sup>

Seven patients in our study had cysts located in the fourth ventricle (58.3%), which corroborates with most surgical series (Figure 1) with similar incidence rates of 43%–70% (Table 2). The second common site was the lateral ventricle. Other rare sites

include the third ventricle and the Sylvian aqueduct with incidence rates of 7%–9%.<sup>3</sup>

IVN usually presents with features of hydrocephalus. Other presentations include, decreased visual acuity, altered mental status, and cranial nerve palsies or even sudden death.<sup>17</sup>

Radiologic investigation with MRI forms the mainstay of investigations, guiding the need of urgent intervention, and also defines the surgical corridor. In a patient with cystic lesion and scolex on MRI, along with clinical features of raised intracranial pressure, the first provisional diagnosis should be IVN.<sup>18,19</sup> The cyst may show ring-like enhancement on contrast-enhanced MRI. In our study, scolex was seen in 9 cases (75%) and ependymal enhancement was seen in 3 cases (25%), but no ring-like enhancement was found. The serologic investigations to directly detect antigen or indirectly detect the antibody response remains less accepted and is often negative in intraventricular NCC.<sup>20</sup>



Usually the live dormant cyst behaves in different ways, thereby dictating the surgical approach and outcome. The live cyst is an excellent parasite with no reaction and may deform and pass through very narrow channels and spaces, and sometimes they are highly mobile. Therefore, they cause intermittent blockages as they move. On the other hand, the reaction to the proteins discharged through the endopore of the dying or dead cyst often causes a reaction. This may cause the cyst to get fixed to surrounding structures. The dead cyst therefore demands more dissection and pulling and may cause a permanent obstruction.

It has been shown that postoperative medical therapy decreases the incidence of recurrence and shunt failure.<sup>21</sup> We prescribed albendazole to all our patients at dosages of 15 mg/kg/d in the postoperative period for 6 weeks. Albendazole has superior efficacy over praziquantel.<sup>21–23</sup> Antiepileptic drugs are usually prescribed for associated intraparenchymal NCC, but its use is controversial. Corticosteroids are used to relieve symptoms caused

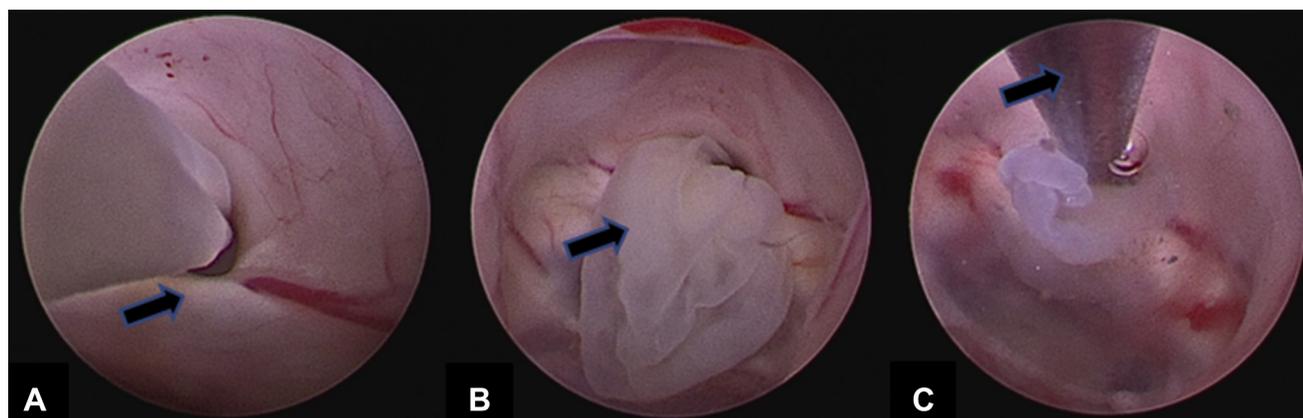
by larval death, which is supposed to occur 2–5 days after initiation of therapy.<sup>24</sup>

#### Preoperative External Ventricular Drainage

There are reports of cyst migration and resolution of hydrocephalus with preoperative external ventricular drainage.<sup>4,25</sup> The need for external ventricular drainage depends on presentation and prevention of postoperative cerebrospinal fluid leak. The decompressed ventricles are not suitable for neuroendoscopy, and ventricular drains further increase the risk of infection. We prefer direct surgical excision to diversion.

#### Trajectory of Scope

We prefer curvilinear scalp incision and precoronal burr holes in all our patients. The other way of marking the site is using neuronavigation guidance,<sup>26</sup> using thin cuts of sagittal T2-weighted magnetic resonance imaging and trajectory connecting the



**Figure 3.** (A) After suction is applied through a 6-French infant feeding tube and syringe and the cyst wall is grasped and rotated (arrow), it is pulled out.

The crimped cyst wall (arrow) is shown coming out with the last part adhered (B), and the last part is grasped (arrow) and excised (C).

foramen of Monro and aqueduct. In 2 cases we had to extend the size of the burr hole anteriorly for proper negotiation of endoscope and instruments. Trajectory should always be based on the principle that the manipulation at foramen of Monro should be minimal.<sup>27</sup>

### Surgical Technique

The transfrontal transaqueductal approach described by Schroeder et al.<sup>28</sup> for aqueductal stenosis was later modified for removal of intraventricular NCC by Anandh et al.<sup>12</sup> The fourth ventricle NCC was dealt endoscopically using suboccipital craniotomy. Anandh used a flexible endoscope, whereas Zymberg et al.<sup>16</sup> used a rigid endoscope for the same approach. Husain et al.<sup>9</sup> described another approach via the transventricular transforaminal for removal of NCC. We used rigid endoscopes in all our patients as our initial experience (Figure 2). A flexible scope inside a rigid scope, called the scope in scope technique, has been described successfully. Bergsneider et al.<sup>10</sup> also preferred a rigid endoscope for cyst removal.

### Cerebrospinal Fluid Diversion

We did third ventriculostomy in all 12 patients. It is thought that reversal of the cerebrospinal fluid pressure gradient leads to proximal migration of the cyst, helping the surgeon to grasp and pull it. The pericyclic inflammation especially in racemose variety leads to postoperative obstruction to cerebrospinal fluid flow. Therefore, performing third ventriculostomy is always safe. Two of our patients required postoperative ventriculoperitoneal shunt. In 1 patient, initially endoscopic third ventriculostomy was done, but

thereafter the patient was readmitted for wound bulge and ventriculoperitoneal shunt was done.

Detachment of the cyst (Figure 3) is tricky because the cyst wall can easily slip out of the ventricle. Husain et al.<sup>9</sup> used a 5-French angiographic catheter, and Zymberg et al.<sup>16</sup> used a 6-French catheter to retrieve the cyst. We used a 6-French infant feeding tube. The negative pressure is applied using a 2-mL syringe. The low friction tubing and smooth tip minimizes iatrogenic trauma. Sinha and Sharma<sup>29</sup> also described a similar procedure to excise the fourth ventricular NCC without any postoperative deficits in their series. There was no incidence of intraoperative bleeding event in our series. Minor ooze from the third ventriculostomy stoma site was controlled with continuous irrigation using normal saline.

Compared with intraparenchymal NCC, the prognosis of intraventricular cysts is guarded because of the sudden nature of their presentation and the ineffectiveness of anthelmintic drugs.<sup>8</sup> One patient developed ptosis in the immediate postoperative period, which improved completely at follow-up. There were no deaths in our study.

### CONCLUSIONS

IVN is a rare disease with fatal complications of hydrocephalus, if left untreated. MRI remains the investigation of choice. An endoscopic approach is safe with better tissue handling than any microsurgical approach. Postoperative oral albendazole should be given to prevent recurrence and shunt failure. The key to success is entry point and trajectory of endoscope.

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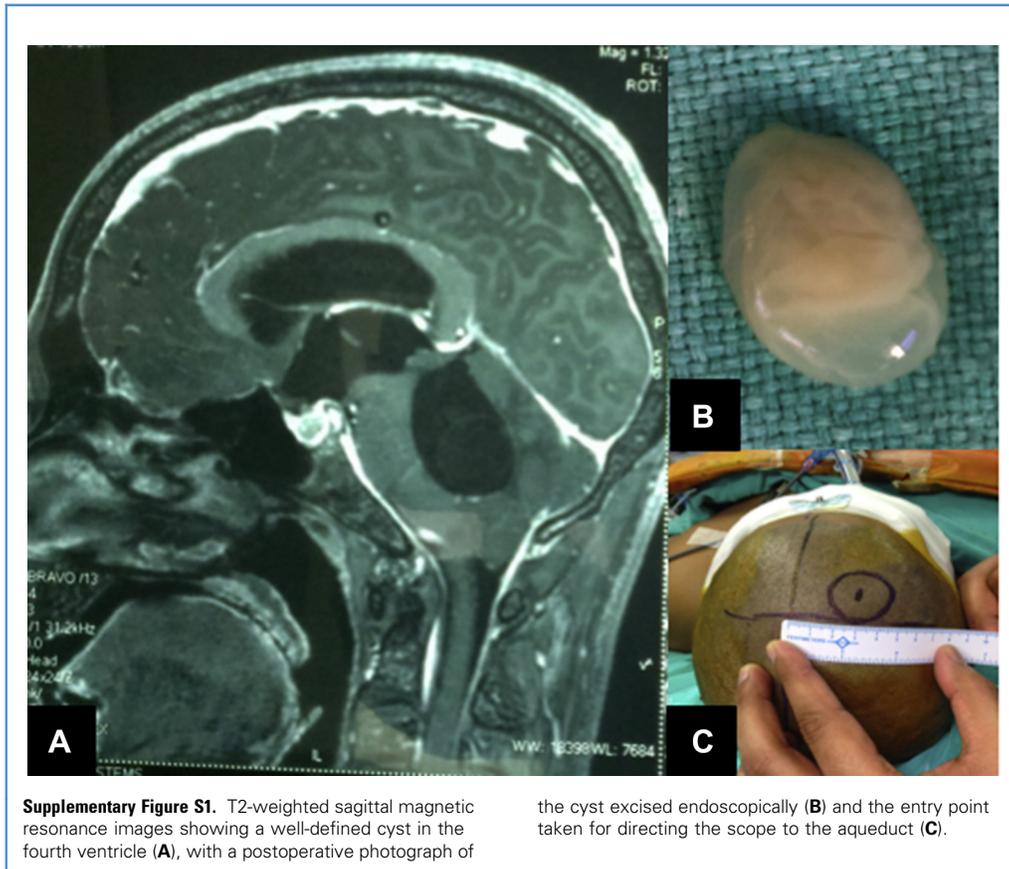
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## SUPPLEMENTARY DATA



**Supplementary Figure S1.** T2-weighted sagittal magnetic resonance images showing a well-defined cyst in the fourth ventricle (A), with a postoperative photograph of

the cyst excised endoscopically (B) and the entry point taken for directing the scope to the aqueduct (C).