

## Endoscopic versus Microsurgical Resection of Third Ventricle Colloid Cysts: A Single-Center Case Series of 140 Consecutive Patients

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■ **BACKGROUND:** Both endoscopic and microsurgery transcortical resection methods are used for colloid cysts of the third ventricle but they have not been compared regarding benefits and pitfalls.

■ **METHODS:** Data of patients who underwent surgical resection of third ventricle colloid cyst via either endoscopic or microsurgery approach by a single surgeon from 2005 to 2020 were retrospectively collected. After administration of criteria, 140 records were retrieved (60 patients through endoscopic resection and 80 patients by a transcranial microsurgery approach). Clinical and surgical measures were compared between the 2 types of surgery after adjustment for confounders.

■ **RESULTS:** Length of hospital stay, postoperative meningitis, operation time, cyst size, and baseline comorbidities were similar between two groups. Gross total resection (GTR) was achieved for all patients in the microsurgery group, whereas in the endoscopic group, resection was lower (90% vs. 100%;  $P = 0.005$ ). Intraoperative hemorrhage occurred in 14 endoscopic patients (23.3%), whereas for the microscopic group, it was zero ( $P < 0.001$ ). Postoperative shunt was required for 2 patients (one in the endoscopic group and the other in the microscopic group). Two patients had tumor recurrence, both of whom were in the endoscopic group. No mortality was detected in either group. Multivariate analyses were insignificant for confounding effects of clinical and demographic factors in occurrence of worse surgical outcomes (non-GTR and hemorrhage).

■ **CONCLUSIONS:** In our series, the rate of intraoperative hemorrhage was higher with the endoscopic method and GTR was lower, even after adjustment for other factors. This situation could be caused by technological shortcomings and limited space for resection maneuvers and management of complications.

### INTRODUCTION

As tumors of the central nervous system become more prevalent, benign colloid cysts have received increasing attention.<sup>1-3</sup> Colloid cysts of the third ventricle are benign tumors that constitute 0.5%–1% of all brain tumors, with variable natural history.<sup>4-6</sup> Although 30% of patients with colloid cysts, especially those with smaller lesions, are asymptomatic, larger lesions cause and present with hydrocephalus. Hydrocephalus is usually caused by occlusion of the foramen of Monro, which can lead to adverse outcomes. Sudden death has been also reported with small lesions as a result of acute hydrocephalus.<sup>7-9</sup> There is no consensus about the optimal surgical approach for colloid cyst resection. A transcranial approach via a transcortical or transcallosal approach has been an acceptable treatment for decades; however, in subsequent years, with major advancements in neuroendoscopic techniques, neurosurgeons have begun to use endoscopic approaches for tumor resection, in the hope of reducing surgical complications.<sup>10-14</sup> In this study, we investigated records of 140 patients over 15 years treated with different approaches with emphasis on the pros and cons of each technique.

### Key words

- Colloid cysts
- Microsurgery
- Neuroendoscopy
- Third ventricle
- Tumor

### Abbreviations

- CI:** Confidence interval  
**GTR:** Gross total resection

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## METHODS

### Patient Characteristics

During the 15 years from 2005 to 2020, data of all patients with a third ventricle colloid cyst who were treated at Erfan Hospital, Tehran by a single surgeon (G.S.) were retrospectively collected from the hospital and office database. Data including age, sex, baseline comorbid conditions, symptoms during workup and diagnosis, presence of hydrocephalus before admission, duration of surgery, duration of hospital stay, extent of resection, need for ventriculoperitoneal shunt placement, intraoperative hemorrhage, and postoperative seizures and meningitis were obtained. Records without these factors, presence of another space-occupying lesion in the brain, or without surgical intervention were excluded. The follow-up period was at least 3 years for every case. Postoperative records of patients were assessed for follow-up. Patients were revisited 1 month, 6 months, and then annually after the operation and imaging was performed to check for recurrence of cyst.

From 2005 to 2012 (phase 1), our patients were treated with either endoscopic (60 patients) or open methods (25 patients), whereas after 2012 (phase 2), all patients underwent microsurgical intervention. A primary report of phase 1 and the method of patient recruitment and intervention can be found in previous studies.<sup>9,14</sup> During the first phase, endoscopy was the method of choice unless there was a previous shunting procedure, the lead surgeon and team presumed cyst removal to be difficult by endoscope, or if it was not possible to suction the contents (based on low intensity on T2-weighted magnetic resonance imaging), reoperation of a referred failed cyst, or patient's preference. To ascertain the accuracy of the size of the ventricular system in patients with no apparent hydrocephalus, a two-dimensional measurement of the frontal Evans ratio was made on preoperative magnetic resonance imaging scans by an independent radiologist. A value  $<0.30$  was considered to indicate a normal-sized ventricle.<sup>14</sup>

### Surgical Techniques

Two main surgical techniques were used to operate on colloid cysts and patients were categorized into 2 groups based on the approach used: an endoscopic approach and a microsurgical approach, as detailed later. No criteria were used for selection of method.

**Endoscopic Approach.** Patients in this group underwent endoscopic cyst resection between 2005 and 2012. This method was the preferred technique in patients with ventriculomegaly because it created space for entrance of instruments and good maneuverability. For patients without ventriculomegaly, endoscopy has also been shown to be feasible and even infusion of saline into ventricles (ventricular insufflation) could create space with close monitoring of vital measures.<sup>14</sup> The twist technique was used in all cases, in which after aspirating cyst content and resecting the cyst wall with microscissors, flexible forceps were applied along the side working channel to twist the cyst wall (twisting maneuver) to loosen the junction of the cyst wall and third ventricle. Then, the cyst wall was pulled gently toward the lateral ventricle used for entry. Simultaneously, the pedicle of the cyst that comprises small vessels was coagulated using a bipolar coagulator along the main

working channel. Details of the endoscopic approach can be found elsewhere.<sup>14</sup> The challenging factor in this approach is presence of cyst wall adhesions to the vellum interpositum and internal cerebral vein, which increases the risk of intraoperative bleeding during gross total resection (GTR), especially in large cysts. Because of anatomic inaccessibility, diathermy coagulation of the originating veins was not possible and this was carried out with irrigation and temporarily increasing intraventricular pressure, a procedure that took more than an hour. Continuous irrigation and aspiration were performed to clear out every bleeding remnant. Moreover, a completing septostomy was carried out to access the other side horn and aspirate leaked blood. No further hemorrhage was detected in these cases by imaging examination of ventricular system, postoperatively.

**Microsurgical Approach.** Patients in this group underwent microsurgical transcranial cyst resection during the study period. For this procedure, either transcallosal or transfrontal entry was used. A transcallosal approach was performed for a fraction of cysts with no apparent ventriculomegaly and no history of previous shunting. The remaining patients underwent a transfrontal approach for cyst resection. The transfrontal approach was performed with a 6-cm linear incision parallel to the midline sagittal suture or a transverse incision 1 cm in front of and parallel to the coronal suture and 3 × 3-cm craniotomy over the superior and middle frontal gyri. More patients in this group were approached from the superior frontal sulcus and a smaller sample were approached transgyrally (middle frontal gyrus). GTR was carried out by en bloc resection of the tumor followed by diathermal coagulation of adhesions and choroidal plexus.

### Statistical Analysis

Quantitative variables were expressed as means (standard deviation) and categorical variables were expressed as counts (percentages). Data were analyzed using a Student t test or Fisher exact test as appropriate. We also used multivariate regression (generalized linear model with logit link) to check for confounding effects of demographic factors and correlation of clinical measures with worse surgical outcomes (GTR and intraoperative hemorrhage). Recurrence and mortality were removed because of low occurrence rate. Any  $P \leq 0.05$  or 95% confidence interval (CI) of  $\beta$  not overlapping with zero was considered significant. Statistical analysis was performed using Python 3 packages embedded in Google Colab (colab.research.google.com).

## RESULTS

### Patient Characteristics

During the study period, records of 186 patients were detected, 140 of whom fulfilled the criteria. Among these patients, 60 underwent endoscopic resection (endoscopic group) and 80 underwent transcranial resection (microsurgery group) (Figure 1). Headache was the most common initial presentation in this study, affecting 85.7% ( $n = 120$ ) of patients. Other presentations were impaired vision (37%), gait instability (19.9%), memory deficit (12.1%), and loss of consciousness (5%) (Table 1). The 2 groups did not differ in terms of presentation or baseline demographic factors or comorbidities.

**Table 1.** Patient's Characteristics

	Total (140 Patients)	Endoscopic Group (60 Patients)	Microscopic Group (80 Patients)	P Value
Demographics				
Age (years), mean $\pm$ standard deviation	36.1 $\pm$ 18.7	37.2 $\pm$ 17.3	35.2 $\pm$ 19.8	0.547
Age range (years)	10–92	12–85	10–92	—
Male/female (n)	94/46	41/19	53/27	0.937
Sex ratio	2/1	2.1/1	1.9/1	—
Clinical presentation, n (%)				
Headache	120 (85.7)	49 (81.6)	71 (88.7)	0.650
Impaired vision	37 (26.4)	18 (30)	20 (25)	0.597
Memory deficits	17 (12.1)	7 (11.6)	10 (12.5)	1.000
Loss of consciousness	7 (5)	4 (6.6)	4 (5)	0.958
Urinary incontinence	12 (8.5)	4 (6.6)	8 (10)	0.694
Gait instability	28 (19.9)	16 (26.6)	12 (15)	0.131

### Surgical Results

The mean cyst size was 1.6 cm and there was no significant difference between the 2 groups (Table 2). The mean operation time was longer in the transcallosal approach (115 minutes); however, there was no significant statistical difference between the 2 groups. The operation for some patients in the endoscopic group lasted up to 180 minutes, because of difficulty in managing bleeding. In our study, no significant difference in length of hospital stay was found between the endoscopic and microscopic groups. GTR (defined as intraoperative total cyst wall removal and its adhesions) was achieved in all patients who underwent the microsurgery approach, whereas in the endoscopic group, it was significantly lower than in the microscopic group ( $P = 0.005$ ) (Table 3).

Overall symptomatic cyst recurrence occurred in 2 patients, both of whom were in the endoscopic group. In these 2 patients, the cyst wall was subtotally resected and coagulated. Intraoperative hemorrhage occurred in 14 patients (23%) undergoing endoscopic cyst resection, whereas no obvious intraventricular hemorrhage was detected in the microscopic group ( $P < 0.001$ ) (Table 4). A postoperative shunt was placed in 2 patients (1 patient in the endoscopic group and 1 in the

microscopic group). Intraoperative external ventricular drain placement was performed in 2 patients, both of whom were in the endoscopic group.

Considering postoperative meningitis, the rate of involvement was similar between endoscopic and microscopic groups (3 patients in the endoscopic group and 2 patients in the transcranial group). There was 1 patient with venous infarction who presented with seizure, decreased level of consciousness, and hemiparesis on the second postoperative day. This patient was treated via a transcallosal approach. Postoperative seizure was seen in 2 patients (2.9%) who underwent a transfrontal transventricular approach.

### DISCUSSION

Microsurgical techniques (transcortical and transcallosal) have been used for many years, although for the past 20 years, the endoscopic transcortical approach via burr hole has received increasing attention. In this study, we present our experience of colloid cyst resection by these 2 methods. Despite providing promising results, the endoscopic approach is challenging and has shortcomings. In our sample, the success rate (GTR) was significantly higher in the microsurgery

**Table 2.** Properties of Cysts and Surgical Results

	Total	Endoscopic Approach	Microscopic Approach	P Value
Cyst size (mm) $\pm$ standard deviation	16.1 $\pm$ 4.9	15.8 $\pm$ 5.0	16.3 $\pm$ 4.9	0.723
Operation time (minutes), median (interquartile range)	108 (86–180)	102 (86–130)	112 (90–180)	0.594
Length of stay (days), median (range)	4 (2–5)	4 (2–5)	4 (2–5)	1.000
Intraoperative bleeding, n (%)	14 (10)	14 (23.3)	0	<0.001
Need for shunt placement, n (%)	2 (1.4)	1 (1.6)	1 (1.2)	—
Gross total resection, n (%)	134 (95.7)	54 (90)	80 (100)	0.005
Recurrence, n (%)	2 (1.4)	2 (3.2)	0	0.181
Mortality (n)	0	0	0	—

**Table 3.** Logistic Regression Analysis for Gross Total Resection

	Endoscopic Surgery		Microscopic Surgery	
	$\beta$ (95% CI)	Adjusted $\beta$ (95% CI)	$\beta$ (95% CI)	Demographics Adjusted $\beta$ (95% CI)
Demographic factors				
Age	-0.03 (-0.09 to 0.023)	-0.28 (-0.6 to 0.02) $\zeta$	-0.03 (-0.07 to 0.15)	-0.03 (-0.07 to 0.15)
Male sex	0.35 (-2.6 to 1.98)	-3.86 (-9.4 to 1.67)	-0.44 (-2.75 to 1.86)	-0.26 (-0.26 to 2.1)
Clinical factors				
Headache	0.55 (-1.8 to 2.9)	2.25 (-3.16 to 7.68)	$\infty$	
Loss of consciousness	$\infty$	Removed	-0.20 (-1.1 to 0.69)	-0.03 (-0.07 to 0.15)
Gait instability	-2.2 (-4.6 to 0.07)	-11.36 (-24.0 to 1.32) $\zeta$	$\infty$	
Cyst size	0.00 (-0.21 to 0.19)	0.24 (-0.29 to 0.76)	0.00 (-0.21 to 0.2)	-0.02 (-0.24 to 0.2)
Operation time	0.06 (-0.06 to 0.19)	0.24 (-0.16 to 0.66)	0.03 (-0.04 to 0.11)	-0.03 (-0.05 to 0.11)

CI, confidence interval.  
P value codes: \*\*\* for values <0.001, \*\* for values <0.01, \* for values <0.05,  $\zeta$  for values <0.1.

group, with a lower rate of recurrence. On the other hand, the endoscopic group had higher rates of intraoperative bleeding, which required management via a long procedure, postoperative seizures were seen more commonly in open surgery (not statistically significant), and other complications were similar between the groups. In open surgery, the surgeon has more maneuverability to perform total resection and manage intraoperative complications, as discussed in more detail.

**Microsurgery**

Historically, before the endoscopic era, the transcranial approach described by Dandy was the established method for colloid cyst resection.<sup>13,15,16</sup> Initial attempts with microscopic transcortical transventricular colloid cyst resection achieved a high rate of GTR of up to 98%, but this approach was accompanied with

arguably high rates of postoperative complications, especially postoperative seizures, rating to up to 8%.<sup>17,18</sup> Therefore, neurosurgeons were encouraged to shift to the interhemispheric transcallosal route. Nevertheless, there was no significant decrease in postoperative complications and postoperative venous infarction became a major challenge with this method.<sup>19-21</sup> These side effects prompted neurosurgeons to try more microinvasive approaches through stereotactic techniques; however, a lower rate of GTR (50% of patients) was achieved, with a significant difference from microsurgical approaches.<sup>22,23</sup>

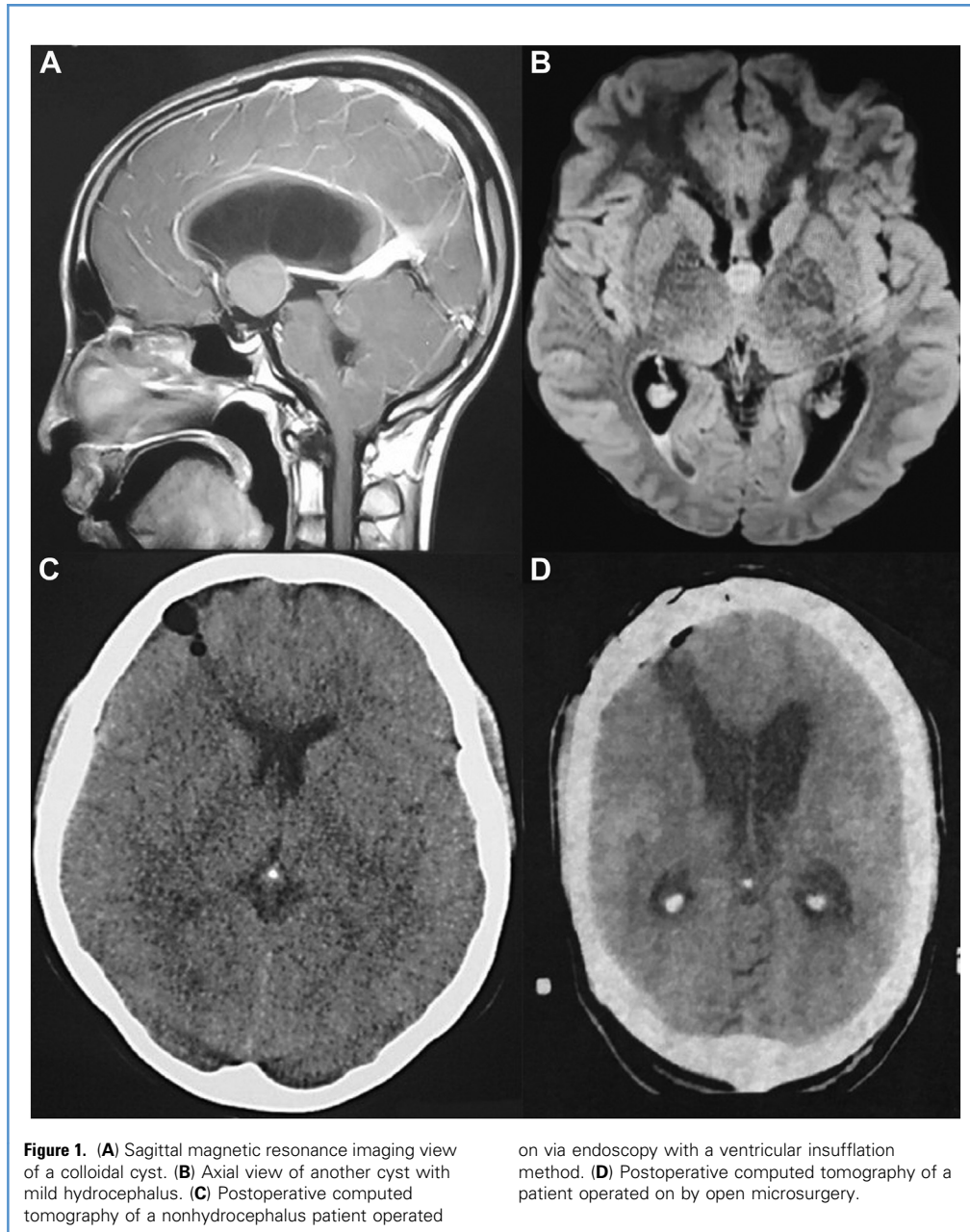
**Endoscopy**

Simultaneously, in the early years of the 21st century, with advancements in neuroendoscopic devices, neuroendoscopy decreased the time of surgery and length of hospitalization and

**Table 4.** Logistic Regression Analysis for Intraoperative Bleeding in Endoscopic Surgery

	Endoscopic Surgery	
	$\beta$ (95% CI)	Adjusted $\beta$ (95% CI)
Demographic factors		
Older age	0.00 (-0.03 to 0.03)	0.02 (-0.02 to 0.06)
Male sex	-0.6 (-2.0 to 0.74)	-0.26 (-1.8 to 1.33)
Clinical factors		
Headache	-0.23 (-1.9 to 1.44)	-0.22 (-2.15 to 1.7)
Loss of consciousness	-0.1 (-2.4 to 2.5)	-1.7 (-4.9 to 1.43)
Gait instability	-1.9 (-0.25 to 3.99)	2.5 (-0.12 to 5.2)
Cyst size	0.09 (-0.03 to 0.22)	0.12 (-0.02 to 0.27) $\zeta$
Operation time	-0.02 (-0.07 to 0.03)	-0.23 (-0.08 to 0.03)

CI, confidence interval.  
P value codes: \*\*\* for values <0.001, \*\* for values <0.01, \* for values <0.05,  $\zeta$  for values <0.1.



gained popularity among neurosurgeons. Preliminary series using an endoscopic approach reported cyst GTR rate of about 60%.<sup>8,24,25</sup> However, despite all progress, subtotal resection of cyst remains high and the recurrence rate exceeds up to 50% of cases. In a meta-analysis of 1741 microsurgery and 1402 endoscopic resections of colloid cysts, GTR was achieved in 98.15% of open surgeries and 91.20% of endoscopies, a statistically significant finding.<sup>26</sup> Also, endoscopy comes with some challenges and limitations, the most important in our experience being the inability to perform bimanual microdissection. In addition, the inability to visualize cyst attachments to the roof of the third

ventricle and deep cerebral veins, especially the internal cerebral vein, because it lies posterior to the tumor and is caudal to the foramen of Monro, led to a lower rate of total tumor resection in our series.<sup>16</sup>

Intraoperative hemorrhage in patients treated by endoscopic cyst resection is a major complication. In our cohort, it occurred in 14 patients (23.3%) and was significantly more common in the microscopic group. In different series with endoscopic resection of colloid cyst, intraoperative hemorrhage has been reported with similar rates.<sup>8,24,25</sup> These findings were further compounded by multivariate analysis that found that no other variable was

detected to have a significant impact on GTR or bleeding and that the differences are inherently related to surgical technique, as previously reported in a large series of patients operated on by 1 surgeon (484 microsurgery and 163 endoscopic surgeries), with rates closely aligned with our findings.<sup>27</sup>

Postoperative seizure is another concern that has been focused on in previous series as a main side effect of the transcortical route and was reported in 8.3%–26% of cases.<sup>8,24,25</sup> Based on a meta-analysis of 1278 cases of third ventricle colloid cyst resection, there was a significant difference in postoperative seizure occurrence, time of surgery, and time of hospital stay between microsurgery and endoscopic approaches<sup>13</sup>; in our study, no statistical trend was found. This finding could be the result of recent advances in microsurgical instruments and increased experience of the microscopic approach. A transsulcal route accompanied with neuronavigation to select an appropriate entry point may minimize the corticotomy and risk of postoperative seizure.<sup>28</sup> Use of a neuronavigation system and opening a small craniotomy of 3 × 3 cm are believed to be other responsible factors.

This report has several limitations. First, the low sample in some subgroups may have led to bias and errors. Another limitation is the long time frame of the study period, including advancements and improvement in the learning curve of surgeons, with later cases using more sophisticated techniques in more experienced hands. On the other hand, we believe that this is the largest single-surgeon experience of colloid cysts operated on via different approaches. A larger study with a prospective randomized design may provide more resilient findings.

## CONCLUSIONS

According to our results, there was no significant difference between the 2 approaches in length of hospital stay, postoperative

meningitis, and operation time. Cyst GTR was achieved in all patients who underwent microsurgery, whereas in the endoscopic group, it was significantly less achievable. Also, the rates of complications and recurrence were also higher in the endoscopic group. Despite advancements in neuroendoscopic surgery for ventricular tumors, this approach still has some limitations and challenges. With future improvements in endoscopy technology, it may become a standard first-line approach for removal of colloid cysts. However, in experienced hands, the transcortical trans-frontal approach could lead to valuable results for third ventricle colloid cyst surgery; surgeons' personal experience and comfort as well as the availability of specialized centers with extensive experience of complicating conditions are the most decisive factors for choosing the treatment approach.

## CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**Guive Sharifi:** Conceptualization. **Esmail Mohammadi:** Formal analysis, Writing – review & editing. **Ali Jafari:** Supervision. **Seyed Ali Mousavinejad:** Formal analysis, Writing – review & editing. **Arefeh Bahranian:** Data curation. **Elham Paraandavaji:** Data curation. **Yahya Daneshmand Khosravi:** Investigation. **Maryam Mohammadkhani:** Investigation.

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