Endoscopic versus Open Microsurgical Excision of Colloid Cysts: A Comparative Analysis and State-of-the-Art Review of Neurosurgical Techniques

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■ BACKGROUND: **The surgical approaches of colloid cysts commonly include endoscopy or open microsurgery. Each approach carries its own challenges, feasibility, and complications. The aim of the current study is to compare endoscopic versus open microsurgical excision of third ventricular colloid cysts.**

■ METHODS: **A retrospective cohort study was conducted to compare the surgical outcomes of endoscopic versus open microsurgical (transcortical-transventricular and transcallosal approaches) excision of colloid cyst of the third ventricle at a tertiary-care medical institute. All patients with a neuroradiologic diagnosis of colloid cyst who subsequently underwent surgical management between January 2003 and June 2020 were included. The neurologic outcome was assessed at the last follow-up visit.**

■ RESULTS: **A total of 32 patients with colloid cysts were included in the study. The mean age was 35.8 ± 18.3 years (range, 4–75 years). Female patients slightly outnumbered male patients ($n = 17$; 53.1%). A total of 21 patients (65.6%) underwent endoscopic resection of the colloid cyst. Complications were encountered in 7 patients (endoscopic, $n = 3$; microsurgery, $n = 4$; $P = 0.151$). Recurrence was identified in 4 patients (endoscopic, $n = 3$; microsurgery, $n = 1$; $P = 0.673$). Most patients improved neurologically on follow-up visits to the clinic (endoscopic, $n = 19$; microsurgery, $n = 9$; $P = 0.482$).**

■ CONCLUSIONS: **Both endoscopic and microsurgical approaches provide favorable surgical outcomes in colloid cyst resection. The complication rates between both approaches is statistically insignificant. The optimal surgical approach for colloid cyst resection remains controversial.**

INTRODUCTION

Colloid cysts of the third ventricle are uncommon lesions, accounting for approximately 1% of all intracranial tumors.[1-3] The estimated incidence of colloid cysts has been reported to be 3.2 per 1,000,000 persons per year.[1] Colloid cysts are commonly located in the rostral, midline, and anterior portion of the third ventricle in the proximity of the foramen of Monro.[4] This anatomic location, in turn, renders patients susceptible to hydrocephalus when the lesion occludes the foramen of Monro, impairing cerebrospinal fluid (CSF) dynamics.[5]

The operative approaches for symptomatic patients with colloid cysts are variable.[6] The surgical approach of colloid cyst resection commonly includes either endoscopy or open microsurgery.[6] In recent years, the use of endoscopy in colloid cysts has gained more popularity among neurosurgeons.[6] However, both endoscopic and microsurgical approaches are feasible for resection of colloid cysts of the third ventricle, with their inherent potential complications.[4]

Key words
- Comparison
- Endoscopy
- Microsurgery
- Resection
- Third ventricle

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
CT: Computed tomography
MRI: Magnetic resonance imaging

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It is difficult to identify the approach of choice for patients and neurosurgeons. Therefore, the aim of the current study is to compare endoscopic versus open microsurgical excision of third ventricular colloid cysts at a tertiary-care medical institute. This comparison will facilitate assessing the outcome of different neurosurgical techniques from a comparative perspective.

METHODS

Patients' Eligibility

A retrospective cohort study was conducted to compare the surgical outcomes of endoscopic versus open microsurgical excision in patients with colloid cyst of the third ventricle. Data were collected for all eligible patients with radiologic evidence of colloid cyst between January 2003 and June 2020.

All patients with a neuroradiologic diagnosis of colloid cyst who were subsequently managed surgically, via endoscopy or open microsurgery, during the specified period were included. The exclusion criteria were applied to patients who were managed conservatively, with incomplete electronic/file records, and without a documented postoperative outcome on follow-up visits. Figure 1 is a flow diagram of the included patients in the study.

Study Setting

The study was conducted at the Neurosurgery Division, Department of Surgery, King Abdulaziz Medical City, Ministry of National Guard—Health Affairs, Riyadh, Saudi Arabia. King Abdulaziz Medical City is one of the largest tertiary-care facilities in Saudi Arabia, located in the eastern region of the capital city of Riyadh. King Abdulaziz Medical City was established in 1983 to provide advanced, specialized medical and surgical care to all national guard employees and their families.

Data Acquisition

Data were retrieved from the archives of the Neurosurgery Division. Data were obtained through the hospital electronic system,

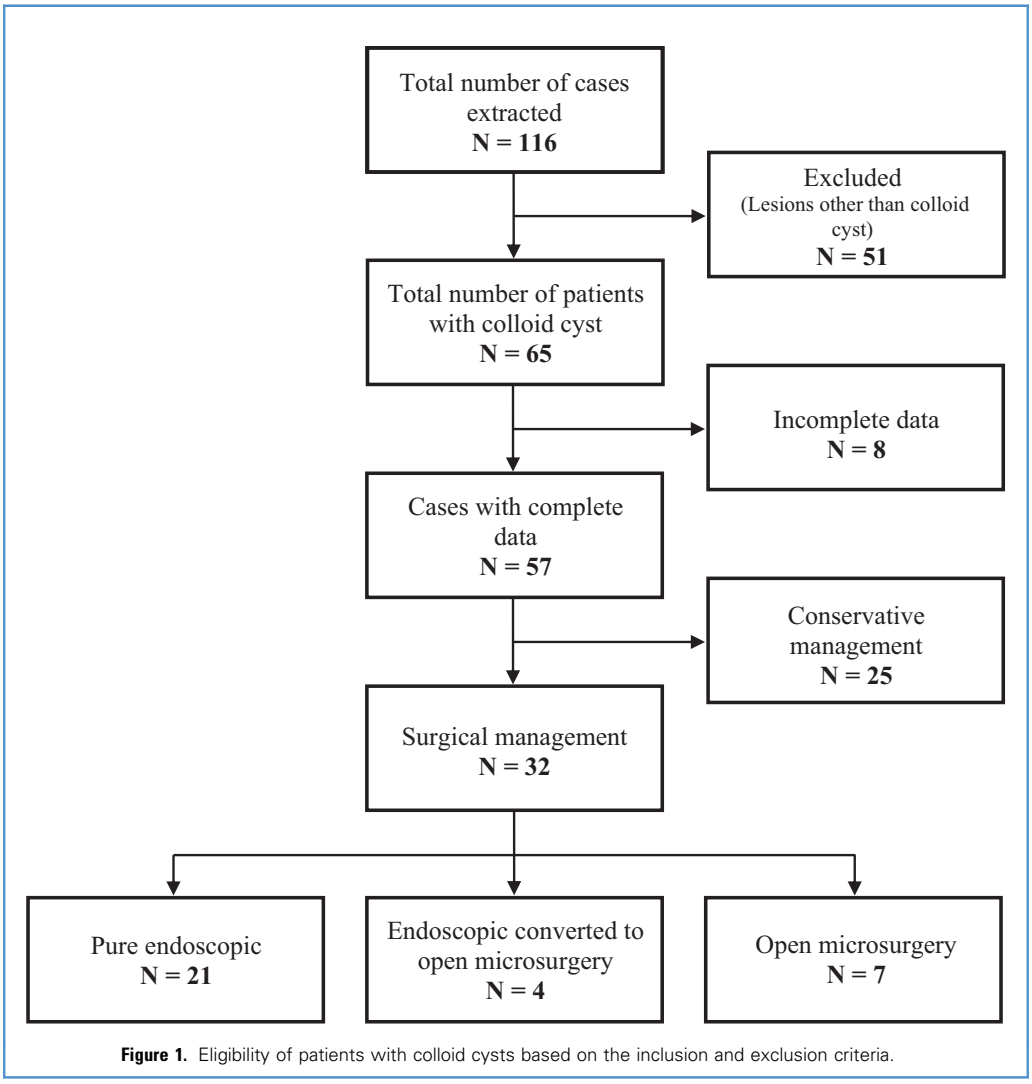

Figure 1. Eligibility of patients with colloid cysts based on the inclusion and exclusion criteria.

including demographics (age, gender, and body mass index) clinical features (signs and symptoms and comorbidities), neuroradiologic description (computed tomography [CT], magnetic resonance imaging [MRI]), preoperative/intraoperative/postoperative course, requirement of external ventricular drainage/ventriculoperitoneal shunts, and outcome (mortality, recurrence, and reoperations).

The Glasgow Coma Scale score was calculated preoperatively. The modified Rankin Scale score was measured preoperatively and postoperatively.[7] The diameter of the cyst was measured in millimeters in anteroposterior and transverse sections. The length of surgery was calculated in minutes from skin incision to complete wound closure. The length of stay in the intensive care unit and ward were calculated in days from the day of admission until the day of discharge. The follow-up duration and time to recurrence were measured in months from the day of diagnosis until the day of last follow-up visit to the clinic. The neurologic outcome was assessed at the last follow-up visit.

Diagnostic Neuroimaging

The neuroradiologic diagnosis was reviewed and confirmed by a senior neuroradiologist. The largest diameters of the cyst, its content, and the presence of hydrocephalus were assessed neuroradiologically. CT and MRI were obtained for preoperative planning and postoperative assessment.

Preoperative MRI was obtained the day before surgery. The images were transferred to the neuronavigational system. Three-dimensional images were subsequently reconstructed. All patients underwent coregistration of the preoperative stereotactic MRI with the surface anatomic landmarks, with an accuracy of 1 mm. Postoperative images were used to assess presence of complications and residual. Follow-up images were obtained for each patient to identify cyst recurrence.

Images Techniques. Thin-slice, multiaxial CT of the brain without intravenous contrast was performed. Multiplanar, multisequential MRI of the brain was performed before and after intravenous contrast. These images include sagittal, axial, coronal, T1-weighted, T2-weighted, fluid-attenuated inversion recovery, and diffusion-weighted sequences. Routine MRI sequences were performed using 1.5-T or 3.0-T for neuronavigation. **Figures 2–5** show illustrative variable appearances of colloid cysts on CT and MRI.

Operative Techniques

Endoscopy. The planned burr hole was outlined approximately 3 cm lateral to the midline and about 2 cm anterior to the coronal suture. Patients were placed in a supine position with the head in a straight position and head elevation 45°. Then, an approximately 3-cm curved incision was performed.

Hemostasis was achieved using bipolar electrocautery forceps. The scalp was spread apart, and a self-retaining retractor was inserted. A burr hole was placed 2 cm anterior to the coronal suture and 3 cm from the midline using a high-speed electric drill. The dura was coagulated and opened.

The endoscope was introduced to visualize and identify the structures of the lateral ventricle, choroid plexus, fornix, anterior septal vein, caudate, and thalamostriate vein. Fenestration of the septum pellucidum was performed. Then, the foramen of Monro was reached. Bipolar electrocautery forceps were used to coagulate the cyst wall. Scissors were used to incise the capsule. Then, a small pediatric nasogastric tube was introduced to the cyst and manual aspiration of the content under controlled pressure was performed.

Forceps were introduced through the endoscope channel to remove the content of the cyst piecemeal. The cyst was gently dissected from the surrounding structures and removed, if possible, in 1 piece. If a residual membrane was still left behind, the membrane was coagulated by bipolar electrocautery forceps. A

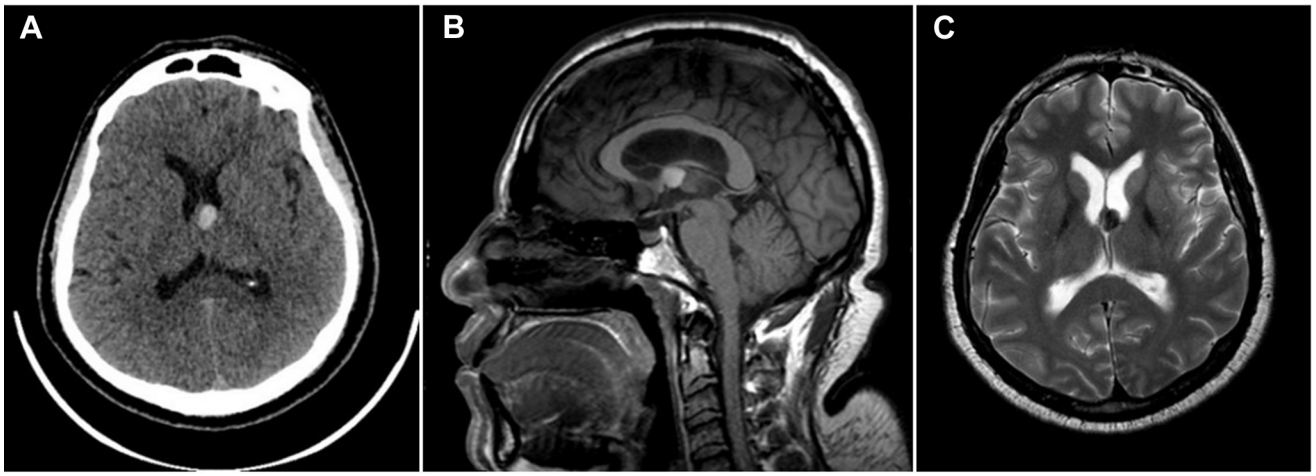

Figure 2. (**A**) Nonenhanced computed tomography scan showing a well-defined hyperdense lesion representing a colloid cyst in the anterior third ventricle, extending to the left foramen of Monro, causing mild hydrocephalus. (**B**) T1-weighted magnetic resonance imaging showing a hyperintense signal of the colloid cyst. (**C**) T2-weighted magnetic resonance imaging showing a hypointense signal of the colloid cyst.

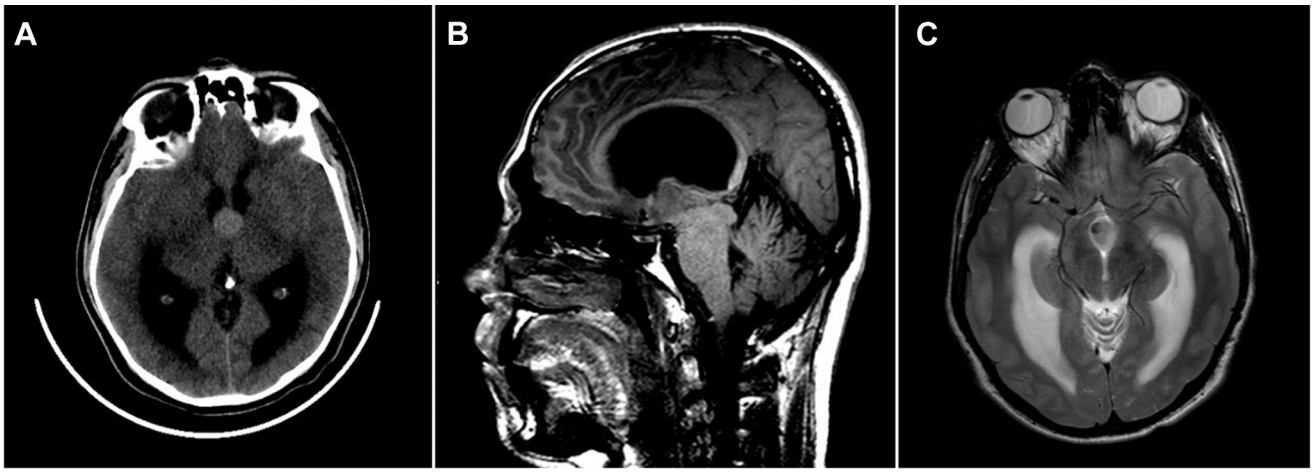

Figure 3. (**A**) Nonenhanced computed tomography scan showing a well-defined hyperdense lesion in the third ventricle causing obstructive hydrocephalus. (**B**) T1-weighted magnetic resonance imaging showing a hypointense signal of the colloid cyst. (**C**) T2-weighted magnetic resonance imaging showing a heterogeneous hyperintense signal of the colloid cyst.

ventricular catheter was softly passed into the frontal hole of the lateral ventricle. Plates were used to cover the burr hole. The skin was closed with sutures and clips.

Open Microsurgery. In open microsurgery, either right frontal transcortical-transventricular or transcallosal approaches were performed. Standard microsurgical techniques were followed in dissecting and resecting the colloid cyst, leaving a ventricular catheter by the end of the procedure.

Two burr holes were made over the superior sagittal sinus and a third burr hole was created 4 cm off the midline to the left side (in cases of external ventricular drain placement). The craniotomy was performed using a high-speed drill. The bone flap was exposed and removed. Gel foams were applied along the superior sagittal sinus. Using the neuronavigation probe, the dura was opened sharply in a C-shaped fashion. The dura was reflected toward the superior sagittal sinus and secured with sutures.

Under high magnification of the microscopy, sharp microdissection was performed to separate the arachnoid membranes between the medial frontal lobe and the falx. An anterior interhemispheric approach was carried out. Further deep microdissection was performed until the corpus callosum was identified. The pericallosal arteries and the surrounding venous structures were kept intact. The pericallosal arteries were gently mobilized during surgery.

Anterior callosotomy (1.5 cm) was performed. The lateral ventricle was then entered. The septum pellucidum, choroid plexus, anterior septal vein, and thalamostriate vein were

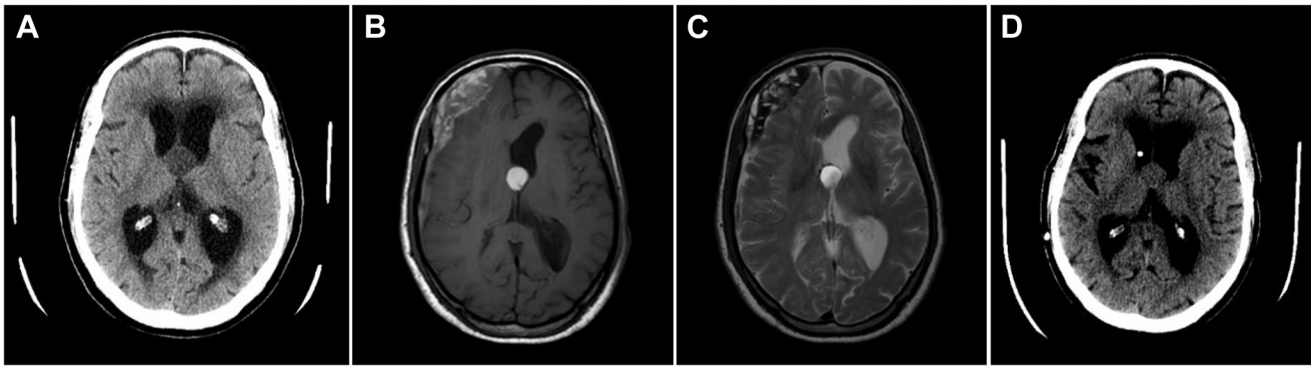

Figure 4. (**A**) Nonenhanced computed tomography scan showing a well-defined hypodense lesion in the third ventricle causing obstructive hydrocephalus. (**B**) T1-weighted magnetic resonance imaging showing a hyperintense signal of the colloid cyst. A large right frontal postoperative subdural hematoma is noted. (**C**) T2-weighted magnetic resonance imaging showing a hyperintense signal of the colloid cyst, with subdural hematoma. (**D**) Nonenhanced computed tomography scan showing a recurrent colloid cyst.

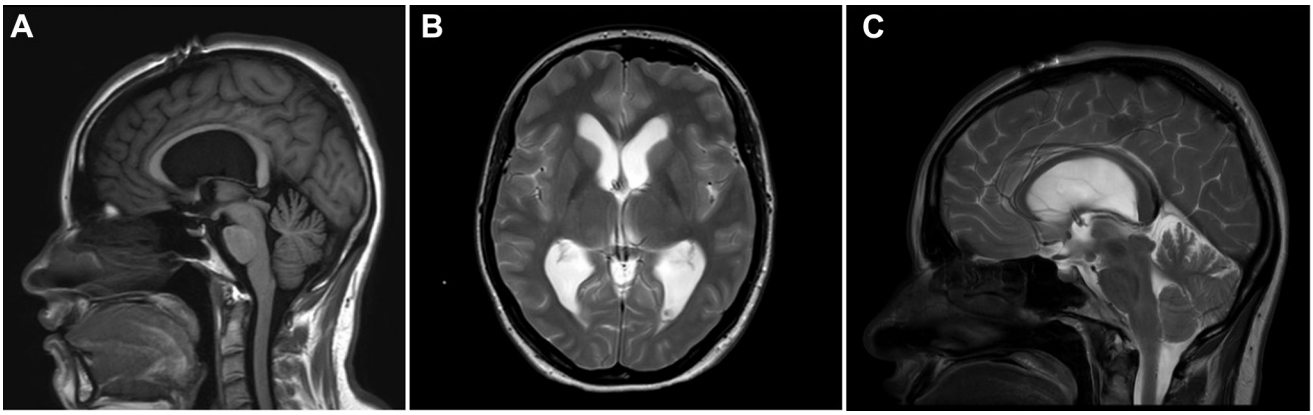

Figure 5. (**A**–**C**) T1-weighted/T2-weighted magnetic resonance imaging showing postsurgical endoscopic resection of the colloid cyst with minimal blood layering in the occipital horns of the lateral ventricle and in left subdural space. These findings resolved spontaneously, with no evidence of recurrence on follow-up.

identified. The choroid plexus was followed to the foramen of Monro. Coagulation of the choroid plexus was performed near the foramen of Monro.

Then, the colloid cyst was identified in the roof of the third ventricle. Circumferential dissection around the cyst was performed. The colloid cyst was detached from its anterior and lateral attachments. Then, the colloid cyst was devascularized from its choroidal arterial feeders in a microscopic fashion. The surface of the cyst was coagulated with bipolar electrocautery forceps and small debulking was performed. Irrigation of the ventricular cavity was performed until it was clear. The bone flap was re-placed using the microfixation system. The scalp was closed using sutures and clips.

Histopathologic Evaluation

Low-power/high-power microscopic examination of all cases was performed. Histopathologic evaluation showed features typical of colloid cyst, including simple cuboidal epithelium-cyst lining and amorphous mucoid content (Figure 6).

Statistical Analysis

Data were analyzed using SPSS version 23 (IBM Corp., Armonk, New York, USA). Descriptive statistical analysis was performed to present the prevalence-related data. Mean and standard deviation were calculated for numeric variables to measure central tendency. The χ^2 test was performed to compare the categorical variables between endoscopy and microsurgery. The independent-sample t test was performed to compare the differences in the means of the continuous variables between endoscopic and microsurgical approaches. A P value $\leq$0.05 was considered significant.

Ethical Considerations

Before the commencement of the study, ethical approval was obtained from King Abdullah International Medical Research

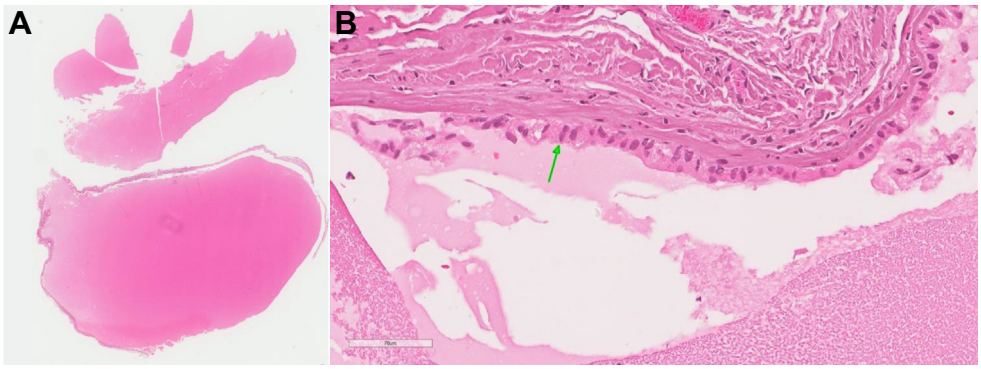

Figure 6. (**A**) Low-power microscopic view showing the whole cyst and its content. (**B**) Higher power shows the attenuated simple epithelial lining (*green arrow*) and adjacent mucoid material.

Table 1. Demographics of all Patients With Colloid Cyst Who Underwent Surgery

Variable	Value
Age (years), mean ± SD	35.8 ± 18.3 (range, 4–75)
1–20 years	7 (21.8)
21–40 years	14 (43.7)
41–60 years	8 (25)
61–80 years	3 (9.3)
Gender	
Male	15 (46.9)
Female	17 (53.1)
Body mass index (kg/m^2)	27.8 ± 6.6
Modified Rankin Scale score*	1 ± 0.03
Comorbidities†	
Diabetes	7 (21.8)
Hypertension	6 (18.7)
Others‡	7 (21.8)
None	21 (65.2)
Signs and symptoms†	
Headache	24 (75)
Nausea and vomiting	10 (31.2)
Gait disturbance	7 (21.8)
Visual disturbance	6 (18.7)
Memory deficit	6 (18.7)
Dizziness	6 (18.7)
Decreased level of consciousness	2 (6.2)
Urinary incontinence	2 (6.2)
Hemiparesis	1 (3.1)
Tinnitus	1 (3.1)
Increased head circumference	1 (3.1)
None	1 (3.1)
Surgical approach	
Endoscopic	21 (65.6)
Open microsurgery§	11 (34.7)

Values are number (%) except where indicated otherwise.
*The modified Rankin Scale score was measured preoperatively.
†Some patients had multiple comorbidities and presented with >1 sign and symptom.
‡Diagnosis of ischemic heart disease, dyslipidemia bronchial asthma, hypothyroidism, and so on.
§Endoscopic resection of colloid cyst was initially attempted in 4 patients. Then, the approach was converted to open microsurgery.

Center, Ministry of National Guard—Health Affairs, Riyadh, Saudi Arabia. Patients' identifiers were concealed. The assigned protocol number was RC20/471/R.

RESULTS

A total of 32 patients with colloid cysts were included in the study. The mean age was 35.8 ± 18.3 years (range, 4–75 years). Female patients slightly outnumbered male patients (17 female patient; 53.1%). The average body mass index was 27.8 ± 6.6 kg/m^2. Eleven patients (34.3%) had comorbidities. The most common presenting symptom was headache (n = 24; 75%), followed by nausea and vomiting (n = 10; 31.2%). Most patients underwent endoscopic resection of the colloid cyst (n = 21; 65.6%). Open microsurgery was performed in 11 patients (34.7%) (Transcortical-transventricular, n = 10; transcallosal, n = 1). Table 1 outlines the baseline characteristics of all patients with colloid cyst who underwent surgical intervention.

The most common radiologic feature on CT was hyperdensity (endoscopic, n = 11; microsurgery, n = 10; P = 0.168). On T1-weighted MRI, hyperintensity was the most frequent radiologic finding (endoscopic, n = 12; microsurgery, n = 9; P = 0.232). Similarly, on T2-weighted MRI, hyperintensity was frequently identified (endoscopic, n = 11; microsurgery, n = 3; P = 0.162). Contrast enhancement was noted in 5 patients and it was peripheral (endoscopic, n = 2; microsurgery, n = 3; P = 0.239). Radiologic evidence of hydrocephalus was observed in 25 patients (endoscopic, n = 16; microsurgery, n = 9; P = 0.715). Table 2 lists the preoperative radiologic findings of colloid cysts.

The mean age of the patients who underwent endoscopic versus open microsurgery was 37.7 ± 20.8 and 32.2 ± 12.5 years (P = 0.030), respectively. The mean cyst diameter (transverse) in patients who underwent endoscopic versus microsurgery was 16.2 ± 9.7 and 18.4 ± 8.2 mm (P = 0.767), respectively. The mean surgery duration in minutes between endoscopic and open microsurgery was 123.6 ± 58.1 and 174.6 ± 85.6 minutes (P = 0.172), respectively. The mean follow-up duration between endoscopic and microsurgery was 85.4 ± 72.5 and 29.1 ± 23 months (P = 0.001), respectively. Table 3 compares the means of the clinicoradiologic findings of patients who underwent surgery.

A right-sided approach was carried out in most patients (endoscopic, n = 15; microsurgery, n = 9; P = 0.519). Radiologic evidence of recurrence was identified in 4 patients (endoscopic, n = 3; microsurgery, n = 1; P = 0.673). Most patients improved neurologically on follow-up visits to the clinic (endoscopic, n = 19; microsurgery, n = 9; P = 0.482). Table 4 compares the postoperative outcome between patients who underwent endoscopy and microsurgery.

Complications occurred in 7 patients (endoscopic, n = 3; microsurgery, n = 4). The most frequent postoperative complications were seizures and pneumocephalus (n = 2; 6.2%). Intraventricular hemorrhage was encountered in 1 patient (3.1%). CSF leak was noted in 1 patient (n = 1; 3.1%). Meningitis occurred in 1 patient (3.1%). Table 5 lists the postoperative complications of all patients.

DISCUSSION

The present retrospective comparative analysis investigated endoscopic versus microsurgical approaches in colloid cyst resection. Our analysis showed that both approaches were feasible, providing satisfactory surgical outcomes for patients with

colloid cysts. The complication rates between both groups were statistically insignificant. Conversion from endoscopy to open microsurgery was carried out if the cyst was large and its wall was adherent to the vascular structures of the third ventricle. The neuroradiologic appearance of colloid cysts in our cohort varied in CT and MRI, likely because of the variable protein content of colloid cysts. However, a hyperdense appearance on CT and a hyperintense signal intensity on T1-weighted and T2-weighted MRI were the most frequent radiologic descriptions. The follow-up duration between endoscopy and microsurgery was statistically significant ($P = 0.001$). Patients who underwent endoscopic resection of the cyst were followed up for prolonged periods (endoscopy, 85.4 months; microsurgery, 29.1 months). Several reasons can be attributable to the longer follow-up period, including, but not limited to, expected higher chances of recurrence, large cysts with adherent content, more patients who underwent endoscopy, and patients who underwent endoscopic resection during the early study period.

Endoscopy

Several advantages of the endoscopic approach in the management of colloid cysts have been reported.[8] This surgical approach uses burr holes instead of craniotomies, is not associated with brain retraction, takes less operative time, requires less hospital stay, and provides higher levels of patient satisfaction.[8,9] In addition, the endoscopic approach provides more safety and effectiveness and is associated with lower rates of recurrence and complications.[4,6,10]

The long-term results after endoscopic excision of colloid cysts have been investigated in the literature. Vorbau et al.[11] retrospectively evaluated a cohort of 20 patients who underwent endoscopic resection and presented their institutional experience. The average follow-up period was 188 months (range, 81–275 months).[11] These investigators showed that endoscopic resection of colloid cysts serves as a safe and effective treatment modality, with excellent long-term outcomes.[11] However, because the risk of recurrence is significant

Table 2. Comparison Between the Surgical Approach and Radiologic Features of Colloid Cyst

	Approach				
	Endoscopic (N = 21)		Open Microsurgery (N = 11)		
Variable	n	%	n	%	*P* Value*
Computed tomography†					0.168
Hypodense	3	16.7	1	9.1	
Isodense	4	22.2	0	0	
Hyperdense	11	61.1	10	90.9	
T1-weighted MRI‡					0.232
Hypointense	7	35	1	10	
Isointense	1	5	0	0	
Hyperintense	12	60	9	90	
T2-weighted MRI‡					0.162
Hypointense	7	35	7	70	
Isointense	2	10	0	0	
Hyperintense	11	55	3	30	
Contrast enhancement§					0.239
No	15	88.2	7	70	
Yes	2	11.8	3	30	
Hydrocephalus					0.715
No	5	23.8	2	18.2	
Yes	16	76.2	9	81.8	

MRI, magnetic resonance imaging.
*Significance is set at <0.05 level.
†Computed tomography scan was not performed for 3 patients. MRI was obtained before computed tomography scans.
‡MRI was not performed for 2 patients. Surgical intervention was carried out emergently.
§Intravenous contrast was not administered for 5 patients. Contrast enhancement was peripheral when present.

Table 3. Comparison Between the Surgical Approach and Clinicoradiologic Parameters

	Approach				
	Endoscopic (N = 21)		Open Microsurgery (N = 11)		
Variable	Mean	SD	Mean	SD	*P* Value*
Age (years)	37.7	20.8	32.2	12.5	0.030
Body mass index (kg/m^2)	27.5	6.8	28.3	6.5	0.771
Glasgow Coma Scale score	14.7	0.5	14.9	0.3	0.084
Modified Rankin Scale score†	1.14	0.3	1.0	0.4	0.593
Cyst diameter (mm)					
Anteroposterior	15.3	6.9	17.6	7.3	0.879
Transverse	16.2	9.7	18.4	8.2	0.767
Surgery duration (minutes)‡	123.6	58.1	174.6	85.6	0.172
Intensive care unit (days)	1.7	1.7	2.0	1.5	0.483
Length of stay (days)	14.3	8.7	20.6	14.7	0.056
Follow-up (months)§	85.4	72.5	29.1	23.0	0.001

SD, standard deviation.
*Significance is set at <0.05 level.
†The Modified Rankin Scale score was measured postoperatively.
‡Surgery duration was calculated in minutes from skin incision to full closure of the wound.
§The follow-up duration were calculated in months from day of surgery until the last visit to the clinic.

after partial resection, achieving total endoscopic resection is advocated.[11]

If there is a possibility of leaving remnants of the cyst capsule, endoscopic-assisted microsurgery can be attempted.[11,12] Because some cysts might not be endoscopically resected because of their location or content, the microscope can provide adequate visualization to allow resection of the cyst. Subtotal and near-total excision of the cysts are acceptable if complete excision possesses the risk of permanent neurologic deficits.[11] Although attempting total resection to avoid recurrence has been linked to higher rates of morbidity,[3,9] Hoffman et al.[13] reported no significant association between the degree of resection and morbidity, with 4.4% rate of morbidity in the complete resection group versus 11.1% in the cyst remnant group.

Similarly, Levine et al.,[12] in their cohort of 35 patients, reported a recurrence rate of 6.3% in their long-term follow-up of patients who underwent endoscopic resection. In these investigators' institution, endoscopic resection is recommended as the initial treatment of choice for patients with colloid cysts.[12] The investigators concluded that adopting minimally invasive techniques is encouraged to facilitate learning the different modalities with which colloid cysts can be treated.[12] Furthermore, Greenlee et al.[14] retrospectively evaluated the long-term outcome of 35 consecutive patients. One patient developed recurrence.[14] However, recurrence was radiologic because the patient was asymptomatic.[14] Boogaarts et al.[15] noted that the recurrence of colloid cysts tends to be in the first 2 years postoperatively. Therefore, regular follow-up visits after endoscopic resection remain essential to monitor recurrence-free survival.[14] Intraoperative endoscopic inspection complemented with postoperative MRI is also essential to precisely determine and predict the recurrence rate. According to Hoffman et al.,[13] intraoperatively observed coagulated remnant in 9 patients was not evident on postoperative MRI. Therefore, immediate postoperative MRI without intraoperative endoscopic inspection is not sensitive in predicting the recurrence rate.[13]

Microsurgery

In 1934, Dandy[16] reported his experience in a series of 21 patients with third ventricular lesions. Thereafter, the transcortical and transcallosal approaches have gained popularity as they have commonly been performed to achieve resection.[1,17-20] Boogaarts et al.[15] reported that an open microsurgical approach provides a better view to enable complete resection of cysts. However, these investigators advocated the transcallosal approach because it avoids injury to the cortical tissue.[15]

The transcallosal interhemispheric and transcortical approaches are commonly reserved for symptomatic or large cysts without associated hydrocephalus.[21] As with any other surgical procedure, these approaches carry their own complications.[15] One of the complications that can occur with the transcallosal approach is venous infarction caused by thrombosis of cortical veins.[15] The transcortical approach can be associated with seizures caused by disruption of the cortical tissue.[21] The interhemispheric transcallosal approach can minimize such disruption of normal structures.[21]

Table 4. Comparison Between the Surgical Approach and Operative Outcomes of Colloid Cyst

	Approach				
	Endoscopic (N = 21)		Open Microsurgery (N = 11)		
Variable	n	%	n	%	*P* Value*
Laterality†					0.519
Left	6	28.6	2	18.2	
Right	15	71.4	9	81.8	
Required external ventricular drain					0.251
No	10	47.6	6	18.2	
Yes, before surgery	3	14.3	3	27.3	
Yes, at the time of surgery	8	38.1	6	54.5	
Yes, after surgery	0	0	0	0	
Required ventriculoperitoneal shunt					0.499
No	15	71.4	8	72.7	
Yes, before surgery	4	19	1	9.1	
Yes, at the time of surgery	1	4.8	0	0	
Yes, after surgery	1	4.8	2	18.2	
Complications					0.151
No	18	85.7	7	63.6	
Yes	3	14.3	4	36.4	
Recurrence					0.673
No	18	85.7	10	90.9	
Yes	3	14.3	1	9.1	
Neurologic outcome‡					0.482
Unchanged	2	9.5	2	18.2	
Improved	19	90.5	9	81.8	

*Significance is set at <0.05 level.
†Laterality of the surgical approach.
‡The neurologic outcome was assessed at the last clinical encounter.

Sabanci et al.[22] retrospectively analyzed the clinical outcome of different transcortical approaches (conventional microsurgery, stereotactic-guided microsurgery, and endoscopic) performed for excision of colloid cysts. Postoperative seizures and neurologic deficits were significantly higher in patients who underwent the conventional approach.[22] The investigators concluded that the microsurgical approach (conventional and stereotactic-guided) offers superior results in terms of the extent of resection.[22]

Sampath et al[23] presented their experience with 10 patients who underwent microsurgical excision of colloid cysts. These investigators concluded that short operative duration and postoperative length of stay can be achieved with the microsurgical approach.[23] This goal can be achieved by performing a small callosotomy (≤1 cm) and dissection around the fornix.[23] However, higher risk of infection was a drawback when performing microsurgical excision.[23]

Esposito et al.[24] recently described a modified approach, interhemispheric transgenual, of the microsurgical transcallosal technique in a cohort of 13 patients. In their technical note, postoperative complications and/or neurologic deficits were not noted in patients who underwent the interhemispheric transgenual approach.[24] The investigators stated that their approach is an effective alternative to the traditional microsurgical approach to achieve complete removal of colloid cysts, with minimal risks of parenchymal or vascular injuries.[24]

Because retraction of the brain tissue is commonly required to facilitate access to a surgical corridor to resect intraventricular lesions, the use of tubular retractors in the resection of colloid

Table 5. Postoperative Complications of all Patients With Colloid Cyst Who Underwent Surgery

Complications*	N	%
Seizures†	2	6.2
Pneumocephalus†	2	6.2
Intraventricular hemorrhage†	1	3.1
Transient memory loss†	1	3.1
Cerebrospinal fluid leak‡	1	3.1
Subdural hemorrhage‡	1	3.1
Meningitis‡	1	3.1
None	25	78.1

*2 patients experienced >1 complication.
†Those complications were encountered in patients who underwent microsurgery.
‡Those complications were encountered in patients who underwent endoscopy.

cysts has been advocated in the literature.[25] Tubular retractors allow even distribution of pressure, via radial dispersion, when performing microsurgery to resect third ventricular colloid cysts.[25-28] The use of tubular retractors provides excellent visualization, favorable outcomes, and safe profiles for neurosurgeons to facilitate resection of deep intraventricular lesions such as colloid cysts and minimizes the risk of iatrogenic injury to the cortical structures.[25,26,28-30]

Endoscopy versus Microsurgery

The optimal surgical choice for the use of endoscopy versus microsurgery in colloid cyst resection remains debatable in the literature.[31] This debate stems from the anatomic location of colloid cysts, being situated in the roof of the third ventricle.[32] The neurologic sequelae of some of the proposed approaches have led to the innovation of less invasive techniques (i.e., stereotactic aspiration of the cyst or placement of CSF shunts).[32] Stereotactic cyst aspiration has been associated with significant cyst recurrence.[32] Simple CSF shunting to treat hydrocephalus without resecting the cyst is a valid alternative for colloid cysts,[32] because most cysts are symptomatic secondarily because of signs of hydrocephalus.[32]

Limitations

A few limitations need to be acknowledged when interpreting the results of the current study. Our study is retrospective and included a limited number of patients. Second, the neuropsychological outcome after colloid cyst resection could not be assessed, via formal assessment tools, because of the retrospective design of the study. However, innumerable efforts were taken to address the obstacles in the current study. Despite these limitations, the current study reviewed the pertinent, state-of-the-art techniques in the neurosurgical armamentarium to resect colloid cysts from a comparative perspective.

CONCLUSIONS

Both endoscopic and microsurgical approaches can be performed with similar efficacy and favorable surgical outcomes. Recurrence can be expected after partial removal of the cyst. Irrespective of the approach, periodic clinical follow-up is advocated to monitor for recurrence-free survival. The complication rates between both approaches are statistically insignificant. Both surgical approaches can be used with a similar risk of complications. Therefore, the optimal surgical approach for colloid cyst resection remains controversial and is yet to be identified. A randomized controlled trial, with a larger cohort, may be required to possibly identify the favorable surgical approach that this study has failed to identify.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Ali Alkhaibary: Conceptualization, Supervision, Project administration, Methodology, Resources, Visualization, Investigation, Writing - original draft, Writing - review & editing. **Laila Baydhi:** Writing - original draft, Writing - review & editing. **Ahoud Alharbi:** Writing - original draft, Writing - review & editing. **Aljoharah A. Alshaikh:** Investigation, Writing - original draft, Writing - review & editing. **Sami Khairy:** Investigation, Writing - original draft, Writing - review & editing. **Munzir Abbas:** Investigation, Writing - original draft, Writing - review & editing. **Ashraf Mohamed Abdelkhalek Aboushady:** Writing - review & editing. **Makki Almuntashri:** Investigation, Writing - original draft, Writing - review & editing. **Ali H. Alassiri:** Investigation, Writing - review & editing. **Ahmed Alkhani:** Conceptualization, Supervision, Writing - review & editing. **Ahmed Abdulrahman Alferayan:** Conceptualization, Supervision, Writing - review & editing. **Ahmed Aloraidi:** Conceptualization, Supervision, Writing - review & editing.

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