Do tumor and ventricular volume predict the need for postresection shunting in colloid cyst patients?

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OBJECTIVE Many colloid cyst patients present with obstructive hydrocephalus that resolves after resection of the cyst. However, a proportion of patients with these cysts will require cerebrospinal fluid shunting after tumor resection, despite resolution of the obstruction at the foramina of Monro. The goal of this study was to determine if colloid cyst size or preoperative ventricular volume predicted the need for postresection shunting.

METHODS In a retrospective study design, ICD-9 codes 742.2 (colloid cyst) and 348.0 (brain cyst) were used to identify patients who had undergone resection of a colloid cyst at the University of Florida over the last 20 years. Preoperative imaging (CT or MRI) with a stereotactic software program developed at the University of Florida was used to measure volumes of the colloid cyst and the lateral ventricles. The relationships among ventricular volume, colloid cyst volume, and postoperative shunting were analyzed.

RESULTS The number of patients included in the study was 67, and their mean age was 37.7 years. Forty percent of the patients were female. Overall, 49.2% of the patients had a transcallosal approach, 35.8% a transcortical approach, and 14.9% an endoscope-assisted surgery. Mean preoperative ventricular volume was 76.5 cc in patients who never received a ventriculoperitoneal shunt (VPS) and 98.1 cc in those who were eventually treated with a VPS ($p = 0.305$). Patients with a postoperative VPS had an initial mean colloid cyst volume of 1.8 cc compared with 0.9 cc in patients without a VPS postoperatively ($p = 0.019$). Patients with colloid cysts larger than 0.6 cc (1-cm diameter) had a 12.8 increased odds of needing a VPS postoperatively (95% CI 1.81–275).

CONCLUSIONS Larger colloid cysts are associated with an increased need for postresection shunting independent of preoperative ventricular size. Prospective studies of patients with colloid cysts are necessary to further identify risks of permanent hydrocephalus.

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KEY WORDS colloid cyst; hydrocephalus; ventriculoperitoneal shunt

COLLOID cysts are benign tumors that arise from the roof of the third ventricle and constitute 0.5%–1% of all central nervous system tumors.^{1,2,4,6,22,24,30} Although many of these cysts are found incidentally, they can cause obstruction of cerebrospinal fluid (CSF) flow, hydrocephalus, and sometimes sudden death given their location near the foramen of Monro.^{1,8,11,31,32} Because of the potential for serious consequences, such as hydrocephalus or death, resection and/or placement of a ventriculoperitoneal shunt (VPS) are recommended for large

or symptomatic colloid cysts. Various surgical approaches for colloid cyst resection have been described, including transcortical, transcallosal, endoscopic, and stereotactic aspiration.^{1,3,5,7,9,10,12,13,16,17,19–21,23,25–28,30} Much of the literature on colloid cysts is focused on the risks and benefits of the different surgical approaches since many patients will have resolution of the hydrocephalus after resection. However, up to 25% of patients will require treatment with a VPS.²⁹ But few studies have evaluated the risks associated with the need for a VPS in patients with colloid cysts.

ABBREVIATIONS CSF = cerebrospinal fluid; EVD = external ventricular drain; LOS = length of stay; VPS = ventriculoperitoneal shunt.

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The VPS rates in colloid cyst patients vary significantly between studies in the literature, and risk factors for the need for permanent CSF diversion are not well described. Increased ventricular size or intraventricular hemorrhage may be associated with an increased need for permanent CSF diversion, although this hypothesis has not been rigorously studied. The objective in the present study was to determine if patient factors such as preoperative ventricular volume or colloid cyst size influenced the likelihood of needing a VPS after colloid cyst resection.

Methods

Using a retrospective study design with institutional review board approval, we analyzed all consecutive patients treated for colloid cysts at the University of Florida from 1994 to 2014. Utilizing ICD-9 codes 742.2 (colloid cyst) and 348.0 (brain cyst), we identified all patients who had undergone resection of a colloid cyst. A chart review was performed, and the following information was collected: age at surgery, sex, surgical approach, placement of an external ventricular drain (EVD), postoperative shunt placement, complications (meningitis, seizure, memory deficit, language deficit, motor deficit, visual deficit, CSF leak), length of stay (LOS), and discharge destination. Ventricular and cyst volumes were calculated in patients with preoperative imaging available for analysis. Using this preoperative imaging (CT or MRI) with a stereotactic software program developed at the University of Florida, we measured the volume of both the colloid cyst and the lateral ventricles.

Statistics

We used the R statistical software package (version 3.0.2, R Foundation for Statistical Computing) to calculate all descriptive statistics and perform all hypothesis tests. For dichotomous outcomes (shunt and postoperative deficit [yes vs no], discharge disposition [home vs rehab]), we used Fisher's exact tests to compare groups on categorical variables and Mann-Whitney tests to compare them on continuous variables. For shunt status, we also used logistic regression to estimate the effect of cyst volume (≤ 0.06 vs > 0.06) when controlling for EVD and postoperative complication. For the LOS outcome, we used Spearman

TABLE 1. Demographics for 67 patients with colloid cysts

Parameter	No. (%)
Mean age in yrs	37.7
Sex	
Female	27 (40.3)
Male	40 (59.7)
Approach	
Transcallosal	33 (49.2)
Transcortical	24 (35.8)
Endoscopic	10 (14.9)

correlations to evaluate the relationship between LOS and continuous variables, and the Mann-Whitney or Kruskal-Wallis tests to evaluate the relationship between LOS and categorical variables. Finally, we used linear regression, with the natural log of LOS as the outcome, to test whether cyst volume (≥ 0.06 vs < 0.06) was associated with LOS when controlling for shunt and EVD status.

Results

Demographics

Sixty-seven patients underwent resection of a colloid cyst at the University of Florida in the period from 1994 to 2014 and met the study inclusion criteria. Mean patient age was 37.7 years, and 40% of the patients were female. As regards surgical approach, 49.2% of patients had a transcallosal approach, 35.8% a transcortical approach, and 14.9% an endoscope-assisted surgery (Table 1). Forty patients had available preoperative imaging that allowed for analysis of cyst and lateral ventricular volumes prior to any intervention; Tables 2 and 3 show patient demographics, cyst volume, ventricular volume, approach, EVD placement, complications, LOS, and discharge disposition for these patients. Fifteen patients (37.5%) underwent placement of a VPS during their treatment course. There was no difference in the age, sex, surgical approach, or discharge disposition among patients who required a postoperative VPS compared with those who did not. Mean ventricular volume in patients with a VPS was 98.1 cc compared with 76.5 cc in patients without a VPS ($p = 0.305$; Fig. 1). Col-

TABLE 2. Surgical approaches and imaging characteristics of 40 patients with preoperative imaging

Parameter	Overall	No Shunt	Shunt	p Value
No. of patients (%)	40	25 (62.5)	15 (37.5)	
Mean age in yrs (range)	36.3 (12–60)	36.3 (13–60)	36.1 (12–54)	0.878
Sex (%)				0.094
Female	16 (40.0)	7 (28)	9 (60)	
Male	24 (60.0)	18 (72)	6 (40)	
Cyst vol in cc (range)	1.2 (0.27–5.6)	0.9 (0.27–2.6)	1.8 (0.29–5.6)	0.019
Ventricular vol in cc (range)	84.6 (4.0–235)	76.5 (4.0–216)	98.1 (7.4–235)	0.305
Approach (%)				0.087
Transcallosal	19 (40.48)	14 (56)	5 (33.3)	
Transcortical	15 (37.5)	6 (24)	9 (60)	
Endoscopic	6 (15.0)	5 (20)	1 (6.7)	

TABLE 3. Patient factors and the likelihood of undergoing placement of a VPS

Parameter	Overall	No Shunt	Shunt	p Value
No. of patients	40	25 (62.5)	15 (37.5)	
EVD placement				0.006
None	10 (25)	10 (40)	0 (0)	
Preop	6 (15)	2 (8)	4 (26.7)	
Intraop	23 (57.5)	13 (52)	10 (67)	
Postop	1 (2.5)	0 (0)	1 (6.7)	
Meningitis				0.351
No	38 (95)	24 (96%)	14 (93.3%)	
Yes	2 (5)	1 (4%)	1 (16.7%)	
CSF leak				0.015
No	36 (90.0)	25 (100)	11 (73.3)	
Yes	4 (10.0)	0 (0%)	4 (26.7)	
Postop seizure				0.359
No	39 (97.5)	25 (100)	14 (93.3)	
Yes	1 (2.5)	0 (0)	1 (6.7)	
New memory deficit				0.519
No	38 (95.0)	23 (92)	15 (100)	
Yes	2 (5.0)	2 (8)	0 (0)	
New language deficit				0.375
No	39 (97.5)	25 (100)	14 (93.3)	
Yes	1 (2.5)	0 (0)	1 (6.7)	
New motor deficit				1
No	38 (95.0)	24 (96)	14 (93.3)	
Yes	2 (5.0)	1 (4)	1 (6.7)	
New visual deficit				NA
No	40 (100)	25 (100)	15 (100)	
Yes	0 (0)	0 (0)	0 (0)	
Other complication				1
No	35 (87.5)	22 (88)	13 (87)	
Yes	5 (12.5)	3 (12)	2 (13)	
LOS in days (range)	9.0 (3–49)	6.9 (3–18)	15.2 (4–49)	<0.0001
Discharged home	35 (87.2)	23 (92)	12 (80)	0.354
Discharge to rehab	5 (12.5)	2 (8)	3 (20)	0.354
Discharge to hospice	0 (0)	0 (0)	0 (0)	NA

NA = not applicable.

loid cyst volume in patients requiring shunting was larger than that in patients who did not require postresection shunting (1.8 vs 0.9 cc, $p = 0.019$; Fig. 2).

Potential Factors Leading to Postresection Shunting

There was a marked increase in the likelihood of postoperative shunting for cyst volumes larger than 0.6 cc (Fig. 3). Patients with colloid cysts larger than 0.6 cc had a 12.8 increased odds of needing a VPS postoperatively (95% CI 1.81–275, $p = 0.031$). Multivariate analysis was performed to see what factors predicted the need for a VPS, a longer LOS, the likelihood of a postoperative complication, or discharge disposition. As expected, patients who underwent placement of VPS were more likely to have an EVD during their treatment course and more likely to have a

CSF leak. Placement of a VPS or an EVD or larger cyst volumes predicted a longer LOS ($p < 0.0001$). Additional multivariate analysis showed that no variables were significant in predicting postoperative deficits or discharge disposition (Table 3).

Of the 67 patients in our cohort, 60 patients had postoperative imaging in our system to evaluate for postoperative hemorrhage. Ventriculoperitoneal shunt placement was evaluated in patients with “any hemorrhage” (parenchymal and intraventricular) and with intraventricular hemorrhage only compared with patients without hemorrhage (Table 4). No statistical difference was found in the VPS rate in patients with any hemorrhage versus no hemorrhage. Patients with postoperative intraventricular hemorrhage had a higher VPS rate (60%) compared with patients with no

FIG. 1. Ventricular volume by postoperative VPS status. **Left:** Preoperative ventricular volume is not predictive of the need for postoperative shunt placement. **Right:** Histograms of ventricular volume versus shunt status.

hemorrhage (40%), but this difference did not reach statistical significance.

Discussion

Many colloid cyst patients present with obstructive hydrocephalus that resolves after cyst resection. However, a number of patients will require CSF diversion after colloid cyst resection despite resolution of the obstruction at the foramina of Monro. In this study we found that an increased colloid cyst volume is associated with a greater need for a VPS, independent of the preoperative ventricular size. We also found a trend between postoperative intraventricular hemorrhage and an increased need for a VPS. Although these findings are not surprising, this is the first study demonstrating colloid cyst size and postoperative intraventricular hemorrhage as risks for permanent CSF diversion after colloid cyst resection. Much of the current literature reports VPS rates for colloid cysts without an in-depth analysis of factors associated with VPS placement.

Sheikh et al. performed a large meta-analysis comparing open surgical and endoscopic resection techniques. They included 1278 patients in their study and found a shunt dependency rate of 6.2% in the microsurgery group

and 3.9% in the endoscopic group ($p = 0.12$).²⁹ In a retrospective study of 134 colloid cyst patients treated with transcallosal resection, 11% of the patients underwent placement of a VPS preoperatively and 1.5% underwent VPS insertion after resection.¹⁸ In another large series of 105 colloid cyst patients, 76 (72.4%) presented with enlarged ventricles. Overall, 7 patients (6.7%) underwent VPS insertion alone and 16 patients (15.2%) had placement of a VPS prior to resection.¹¹

Hernesniemi et al. published a paper that included a meta-analysis of 1167 cases of colloid cysts in the literature, which described surgical approaches and outcomes.¹⁷ Some of the surgical approaches included “shunt operation”; however, it was not specified as the sole treatment or placement postresection (3 of 40 patients). Lewis et al. looked at 19 consecutive patients who underwent surgery for colloid cysts.²¹ Seven patients underwent endoscopic resection, whereas 8 patients were treated via a transcallosal approach. One patient was treated with a VPS alone, and 1 patient required a VPS after a transcallosal approach. Hall and Lunsford reported on their 11-year experience with colloid cysts.¹⁴ These authors had 17 patients, 6 of whom underwent placement of a VPS. Two of the shunts were placed postresection. Morita and Kelly²⁵ described postoperative hydrocephalus in 2 (6.7%) of 30 pa-

FIG. 2. Cyst volume by postoperative VPS status. **Left:** Preoperative colloid cyst volume is predictive of the need for postoperative shunt placement. **Right:** Histograms of colloid cyst volume versus shunt status.

FIG. 3. Probability of requiring a VPS by cyst volume. The data show a marked spike in the likelihood of a shunt for cyst volumes > 0.6 cc.

tients treated with transcortical resection. Hellwig et al.¹⁵ reported on 1 patient (5.6%), among a series of 18 who had undergone endoscopic resection of a colloid cyst, who required revision of a previously placed shunt.

In the present study, more than 30% of the colloid cyst patients were treated with a VPS. This high VPS rate is most likely related to multiple factors including surgeon threshold for shunt placement and cyst size in this patient cohort. Larger colloid cysts were associated with an increased likelihood of postresection VPS, independent of preoperative ventricular size. This phenomenon could be related to the CSF fluid dynamics associated with larger cysts but does not appear to be attributable to an increased risk of intraventricular hemorrhage in resecting larger cysts. Moreover, the fact that a larger cyst size is associated with a higher rate of shunting may argue for earlier resection of colloid cysts while they are smaller in size, rather than conservative management. Additionally, the reasons for a higher shunting rate in large colloid cysts can be speculated to include inherent characteristics of the surgery such as longer operative times, more intraoperative bleeding, more irritation of the ventricular surfaces, or more spillage of cyst contents. Unfortunately, given the

retrospective design of this study, data points such as those suggested would be limited to the operative reports, which did not necessarily include this type of information.

The limitations of this study include its retrospective design and our reliance on ICD-9 coding in identifying all potential patients with colloid cysts. The retrospective design precludes potentially important factors such as intraoperative bleeding that could impact the need for a VPS. Given the limited number of patients in our cohort, we did not delineate the impact of surgical approach on the need for postoperative shunting.

Conclusions

Larger colloid cysts are associated with an increased need for postresection independent of preoperative ventricular size. Prospective studies of colloid cyst patients will be necessary to further identify risks of permanent hydrocephalus.

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TABLE 4. Ventriculoperitoneal shunt status versus postoperative hemorrhage in 60 patients in whom postoperative imaging was available

Parameter	No Shunt	Shunt	p Value
No. of patients	40	20	
Any hemorrhage			0.1739
Yes	20 (50)	14 (70.0)	
No	20 (50)	6 (30.0)	
Intraventricular hemorrhage			0.1102
Yes	15 (37.5)	12 (60)	
No	25 (62.5)	8 (40)	

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Weaver, Bova, Rajon, Quinones-Hinojosa, Rahman. Acquisition of data: Weaver, McCord, Bova, Rajon. Analysis and interpretation of data: Weaver, McCord, Bova, Rajon. Drafting the article: Weaver. Critically revising the article: Weaver, Quinones-Hinojosa, Rahman. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Weaver. Statistical analysis: Weaver, Neal, Rahman. Study supervision: Rahman.

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