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Original Article

Functional status of surgically treated pineal cyst patients

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ABSTRACT

Background: Microsurgical removal represents a well-accepted treatment option for symptomatic benign pineal cysts (PCs). However, very few studies have quantitatively evaluated the functional status of surgically treated PC patients.

Methods: A detailed analysis of preoperative, immediate postoperative, and long-term clinical and radiological characteristics was performed. The functional status of the patients was categorized using the modified Rankin scale (mRS) and the Chicago Chiari Outcome Scale (CCOS). In addition, a comparative analysis between pediatric and adult patients with PCs was carried out.

Results: Overall, pediatric patients experienced better long-term mRS scores than adults. The differences between the pre-, the immediate post-, and the last postoperative mRS of the patients were statistically significant for the total population ($P < 0.001$). All patients obtained a CCOS of 11 or more, which reflects a good/optimal result after microneurosurgery. The type of the surgical approach was independently associated with the postoperative complications ($P < 0.01$), more frequently reported with the midline supracerebellar infratentorial (SCIT) approach than with its paramedian modification.

Conclusion: The functional status of properly selected symptomatic patients with PCs may improve significantly after their surgical management through a paramedian SCIT approach in sitting position.

Keywords: Functional status, Microneurosurgery, Paramedian supracerebellar infratentorial approach, Pineal cyst, Sitting position

INTRODUCTION

Benign pineal cysts (PCs) represent incidental findings on magnetic resonance imaging in most of the cases. However, at times, benign PCs are associated with various symptoms and may require microsurgical resection.[3,10,11,13-15,17]

We recently published our experience on the surgical management of benign PCs in a large cohort of patients. Although the limitations of a single-center, retrospective study, it provided us interesting results.[6] Here, we provide a more detailed and updated quantitative analysis of the surgically treated PC patients with emphasis on their pre- and postoperative functional status.

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In addition, since our population study included many pediatric patients with specific physiopathological features, we performed a comparative analysis between pediatric and adult PC patients.

MATERIALS AND METHODS

Population study and design

This project has been approved by the Ethics Committee of HUH. Records of patients surgically treated for histologically confirmed PCs at our institution from 1997 to 2015 were retrieved retrospectively from our database. Preoperative, immediate postoperative, and long-term clinical and radiological characteristics were noted.

The functional status of the patients was categorized using the modified Rankin scale (mRS) and the Chicago Chiari Outcome Scale (CCOS). The CCOS was introduced by Majovsky *et al*. for the evaluation of PC surgery.[8,16] The CCOS evaluates the clinical outcome in terms of pain, associated symptoms, functionality, and complications [Table 1].[1] For children, the mRS was scored with age-specific modification.[4,19] As proposed by the American Academy of Pediatrics, we consider 21 years, the age upper limit for pediatric patients.[2,12]

Statistical analysis

RStudio version 1.2.5001-3 was used for the statistical analysis. Only available data were analyzed, and missing data were not extrapolated. Nonparametric Fisher exact test or Mann–Whitney/Wilcoxon test was utilized wherever appropriate for the identification of differences between children and adult populations. The difference in the matched pre- and immediate postoperative functional status of the patients was compared using the Wilcoxon test. Univariate analysis and bivariate correlations were followed by multiple regression models of all plausible and statistically significant variables for the identification of predictors for the postoperative complications (events instead of patients), as well as for the functional status (last mRS). A generalized linear model with binomial link was applied to evaluate the postoperative complications; and a generalized linear model with quasipoisson link was used to evaluate the last mRS. The raw p-value cutoff for significance was set at 0.05. Adjustments of *P*-values were performed with the Benjamini-Hochberg procedure with significance level at $\alpha = 0.1$

RESULTS

Sixty histologically confirmed PCs underwent surgery at our institution from 1997 to 2015 as previously reported.[6]

Preoperative evaluation

The preoperative clinical presentation of the patients is detailed in [Table 2]. Headache and visual dysfunctions were the most frequent symptoms. No significant difference was observed between pediatric and adult populations. The preoperative mRS was similar in the two groups. In pediatric patients, the most frequent symptoms were headache, nausea-vomiting, and visual impairment. Ten (25%) adults suffered from vertigo that was absent in the pediatric group.

[Table 3] describes the radiological features of the lesions. No significant difference was registered between children and adult populations in terms of cyst appearance nor size. The PCs appearance on MRI-T1WI sequences with and without contrast largely varied and did not allow to recognize typical features. On the other hand, on T2WI sequences, around 90% of the PCs were isointense compared to the cerebrospinal liquid.

An analysis of the surgical criteria for the management of the PC patients is reported in [Table 4]. Details were well described in our previous publication as well.[6] The incidence of cyst growth and hydrocephalus in the pediatric population was two-fold higher than in adults. However, no statistical difference was observed. Hydrocephalus was present in 37% of the cases. All hydrocephalus cases except one were primarily managed by direct cyst removal. The surgical criteria for the management of PCs did not significantly differ between pediatric and adult patients.

Surgical features

[Table 5] includes a comparison of the surgical management of PCs in children and adults. No significant difference

Table 1: The Chicago Chiari Outcome Scale. Adapted from ahmed el Damaty *et al*.

Pain	Nonpain	Functionality	Complications	Total score
1: Worse	1: Worse	1: Unable to attend	1: Persistent complication, poorly controlled	4: Incapacitated outcome
2: Unchanged and refractory to medication	2: Unchanged and refractory to medication	2: Unchanged and refractory to medication	2: Unchanged and refractory to medication	8: Impaired outcome
3: Improved or controlled with medication	3: Improved or controlled with medication	3: Improved or controlled with medication	3: Improved or controlled with medication	12: Functional outcome
4: Resolved	4: Resolved	4: Fully functional	4: Uncomplicated course	16: Excellent outcome

Table 2: Preoperative evaluation features of pineal cyst patients. For categorical variables, absolute number (percentage). For numeric variables, median [interquartile range].

	All	Adult	Pediatric	*P*-value	Adjusted *P*-value	*n*
	n=60	*n*=41	*n*=19			
Age	30.0 [19;37]	35.0 [30;40]	16 [13;18]	-	-	60
Sex: Females	44 (73%)	27 (66%)	17 (90%)	0.066	0.66	60
Incidental findings	4 (7%)	3 (8%)	1 (6%)	1.00	1.00	58
Headache	45 (78%)	30 (75 %)	15 (83 %)	0.74	1.00	58
Visual and oculomotor dysfunctions	16 (28%)	11 (28%)	5 (28%)	1.00	1.00	58
Nausea and vomiting	12 (21%)	6 (15%)	6 (33%)	0.16	1.00	58
Vertigo	10 (17%)	10 (25%)	0	0.02	0.22	58
Psychiatric symptoms	9 (16%)	7 (18%)	2 (11%)	0.71	1.00	58
Sensory disorders	8 (14%)	6 (15%)	2 (11%)	1.00	1.00	58
Memory problems	5 (9%)	4 (10%)	1 (6%)	1.00	1.00	58
Preoperative mRS: 0, 1, 2, 3, 4	3, 6, 30, 16, 3	2, 4, 19, 12, 3	1, 2, 11, 4, 0	0.51	1.00	58

Table 3: MRI imaging of pineal cyst patients. For categorical variables, absolute number (percentage). For numeric variables, median [interquartile range].

	All	Adult	Pediatric	*P*-value	Adjusted *P*-value	*n*
	n=60	*n*=41	*n*=19			
T1WI MRI (CSF)						56
Isointense	9 (16%)	8 (21%)	1 (6%)	0.25	1.00	
Low hyperintense	32 (57%)	20 (51%)	12 (71%)	0.24	1.00	
Moderate hyperintense	14 (25%)	11 (28%)	3 (18%)	0.51	1.00	
High hyperintense	1 (2%)	0	1 (6%)	0.30	1.00	
T1WI MRI with contrast						51
No enhancement	12 (24%)	10 (28%)	2 (13%)	0.47	1.00	
Ring enhancement	26 (51%)	16 (44%)	10 (67%)	0.22	1.00	
Solid appearance	22 (43%)	15 (42%)	7 (47%)	0.77	1.00	
Intracystic septa	11 (22%)	10 (28%)	1 (7%)	0.14	1.00	
T2WI MRI (CSF)						55
Isointense	51 (93%)	36 (95%)	15 (88%)	0.58	1.00	
Hypointense	4 (7%)	2 (5%)	2 (12%)	0.58	1.00	
Anterior-posterior size	19 [16;23]	18.7 [16;23]	19[16;23)	0.93	1.00	57
Cranio-caudal size	12.5 [14.4;16.7]	12.8 [11;15.7]	12 [10;13.4]	0.52	1.00	55
Axial wide size	14.8 [12;18]	14.5 [12;17.6]	16[12.8;19.1]	0.59	1.00	56
Cyst volume in mm^3	1901 [1120 ;2709]	1901 [1121;2599]	1659 [1105;2821]	0.94	1.00	54

Table 4: Surgical indications of pineal cyst patients. For categorical variables, absolute number (percentage). For numeric variables, median [interquartile range].

	All	Adult	Pediatric	*P*-value	Adjusted *P*-value	*n*
	n=60 (%)	*n*=41 (%)	*n*=19 (%)			
Double vision	7 (12)	4 (10)	3 (16)	0.67	1.00	59
Other visual deficits	9 (15)	7 (18)	2 (11)	0.71	1.00	59
Hydrocephalus	15 (25)	8 (20)	7 (37)	0.20	1.00	59
Suspected fluctuant hydrocephalus	6 (10)	5 (13)	1 (5)	0.65	1.00	59
Cyst growth	10 (17)	5 (13)	5 (26)	0.26	1.00	59
Solid tumor suspicion	24 (41)	16 (40)	8 (42)	1.00	1.00	59
Large cysts with minor symptoms	19 (32)	16 (40)	3 (16)	0.084	0.588	59

Table 5: Surgical intervention features of pineal cyst patients. For categorical variables, absolute number (percentage). For numeric variables, median [interquartile range].

	All	Adult	Pediatric	*P*-value	Adjusted *P*-value	*n*
	n=60	*n*=41	*n*=19			
Preliminary shunt surgery	1 (2%)	1 (2%)	0	1.00	1.00	60
Preliminary endoscopic procedure	1 (2%)	1 (2%)	0	1.00	1.00	60
Primary treatment						60
Microsurgery	59 (98%)	40 (98%)	19 (100%)	1.00	1.00	
Stereotactic biopsy	1 (2%)	1 (2%)	0	1.00	1.00	
Surgical position*						60
Sitting position	58 (97%)	39 (95%)	19 (100%)	1.00	1.00	
Park bench position	1 (2%)	1 (2%)	0	1.00	1.00	
Supine position	1 (2%)	1 (2%)	0	1.00	1.00	
Surgical approach*						60
Midline SCIT	29 (48%)	19 (46%)	10 (53%)	0.78	1.00	
Paramedian SCIT	29 (48%)	20 (49%)	9 (47%)	1.00	1.00	
Transtentorial	1 (2%)	1 (2%)	0	1.00	1.00	
Frontal stereotactic procedure	1 (2%)	1 (2%)	0	1.00	1.00	
Bone flap surface (mm^2)	1018 [855; 1256]	1004 [823;1257]	1068 [962;1257]	0.34	1.00	60
Extent of resection						60
Complete	58 (97%)	39 (95%)	19 (100%)	1.00	1.00	
Subtotal	1 (2%)	1 (2%)	0	1.00	1.00	
Biopsy and puncture	1 (2%)	1 (2%)	0	1.00	1.00	
Postoperative shunt	0	0	0	-		60
Postoperative endoscopy	1 (2%)	1 (2%)	0	1.00	1.00	60

*Surgical position and surgical approach for the primary treatment modality

was observed in terms of preliminary management of hydrocephalus, primary surgical treatment, surgical position of the patient, surgical approach, extent of surgical resection, time of microsurgical removal, nor complementary treatment. One adult patient underwent stereotactic fenestration. Another adult patient underwent an occipital transtentorial approach, while an SCIT approach in sitting position was performed in all the others 58 patients (19 children and 39 adults).

Postoperative outcome

The outcome of the surgically treated PC patients is presented in [Table 6]. No differences were observed between children and adults in terms of clinical and radiological follow-up, survival rate, postoperative complications, and functional status of the patients. Imaging studies of eight patients were unavailable in the system. Thus, for these patients, the information about the extent of PCs resection were retrieved from their medical files.

Overall, pediatric patients experienced better long-term mRS scores than adults after the surgical operation [Figure 1]. However, statistical differences after p-values adjustments were not consistent. The differences between the matched pre-, immediate post-, and last postoperative functional status of the patients (mRS) were statistically significant for the pediatric group, as well as for the adults and the total population ($P < 0.001$) [Figure 2].

All pediatric and adult patients obtained a CCOS over 11, which represents a good/optimal result after microneurosurgery.[8,16] As observed in the immediate mRS, the resolution of the symptoms was obtained soon after the surgical resection. This could explain the relatively short clinical follow-up in some patients. Only one adult patient was lost in the long-term follow-up, as observed in the Finnish registry system. All pediatric patients remained cyst-related symptom free at the last median (interquartile range) clinical follow-up of 3 (2–7) months.

Multivariate analysis was used to investigate whether age, cyst volume, hydrocephalus, sex, and surgical approach were predictors of postoperative complications. After multiple regression analysis, only the surgical approach ($P < 0.05$) remained as the single independent predictor for postoperative complications [Figure 3]. The paramedian supracerebellar infratentorial (SCIT) approach linked with lower risks of postoperative complications compared to the midline SCIT approach (log odds ratio = –0.82). Multivariate analysis was used to investigate whether age, cyst volume, hydrocephalus, preoperative mRS, sex, surgical approach, and surgical complications were predictors of the long-term mRS. After multiple regression analysis, only the age

Table 6: Outcome of surgically treated pineal cyst patients. For categorical variables, absolute number (percentage). For numeric variables, median [interquartile range].

	All	Adult	Pediatric	*P*-value	Adjusted *P*-value	*n*
	n=60	*n*=41	*n*=19			
Clinical follow-up in months	3 [2;10]	3 [2;15]	3 [2;6.8]	0.64	1.00	55
Survival follow-up from Finnish registry system in months	162 [88;206]	173 [90;210]	148 [86;203]	0.40	1.00	59
Survival rate	59 (100%)	40 (100%)	19 (100%)	1.00	1.00	59
Radiological follow-up in months	6.1 [0.4; 43]	20.3 [1.2;74]	2.4 [0.1; 13]	0.09	1.00	52
Small cyst remnant	2 (3%)	2 (5%)	0	1.00	1.00	60
Postoperative complications	16 (27%)	9 (23%)	7 (37%)	0.35	1.00	59
Approach-related complications	9 (15%)	5 (13%)	4 (21%)	0.45	1.00	
Minor pseudomeningocele	5 (8%)	4 (10%)	1 (5%)	1.00	1.00	
Other complications	4 (7%)	2 (5%)	2 (11%)	0.59	1.00	
Postoperative impairment: Parinaud's syndrome	1 (2%)	1 (3%)	0	1.00	1.00	59
Immediate mRS: 0, 1, 2, 3	31, 21, 6, 1	23, 13, 4, 0	8, 8, 2, 1	0.49	1.00	59
Long-term mRS: 0, 1, 2	48, 10, 1	29, 10, 1	19, 0, 0	0.01	0.17	59
CCOS total: 11, 12, 14, 15, 16	1, 3, 2, 18, 35	1, 3, 2, 11, 23	0, 0, 0, 7, 12	0.50	1.00	59
CCOS pain: 2, 3, 4	1, 6, 52	1, 6, 33	0, 0, 19	0.085	1.00	59
CCOS no pain: 3, 4	5, 54	5, 35	0, 19	0.17	1.00	59
CCOS functionality: 3, 4	4, 55	4, 36	0, 19	0.30	1.00	59
CCOS complications: 2, 3, 4	3, 16, 40	3, 9, 28	0, 7, 12	0.77	1.00	59
Overall mortality	0	0	0	1.00	1.00	59

CCOS: Chicago Chiari Outcome Scale, mRS: Modified Rankin scale, immediate mRS evaluated at hospital discharge of the patient

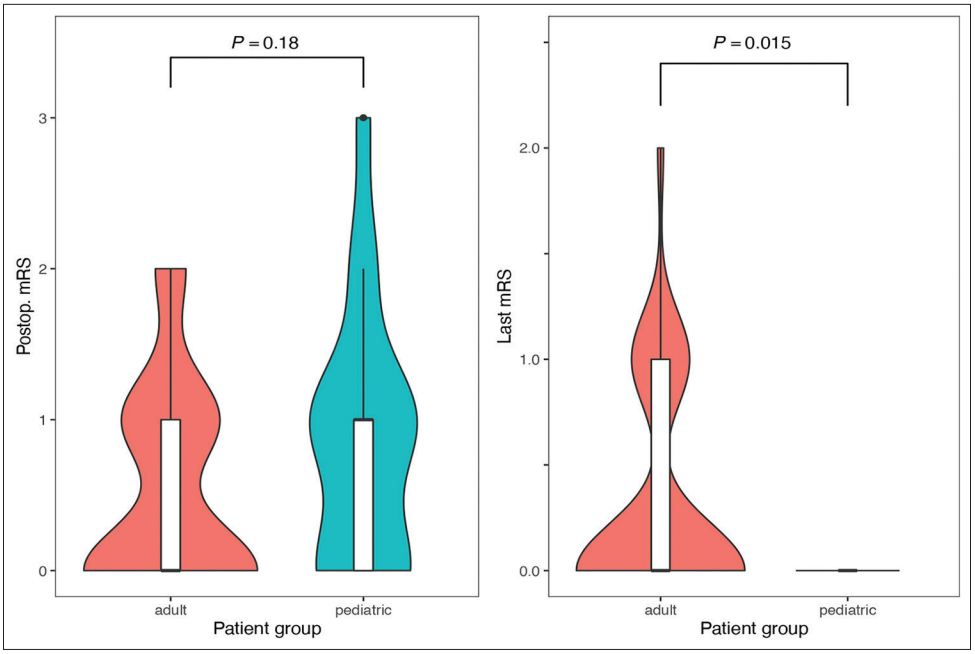

Figure 1: Immediate and last functional status of surgically treated pineal cyst patients measured by the modified Rankin scale.

of the patients ($P < 0.05$) remains as the single independent predictor for the last mRS [Figure 4].

DISCUSSION

Here, we report the postoperative long-term functional outcome in pediatric and adult patients of our previous publication on the largest series of surgically treated PCs.[6] The differences between the quantitatively measured pre- and postoperative functional status of the patients were highly significant. The outcome analysis was carried out by comparing the pre- and postoperative mRS, and on the summary, outcome offered by the CCOS. These results underline the impact of the microsurgical resection on PCs patients' outcomes. On the

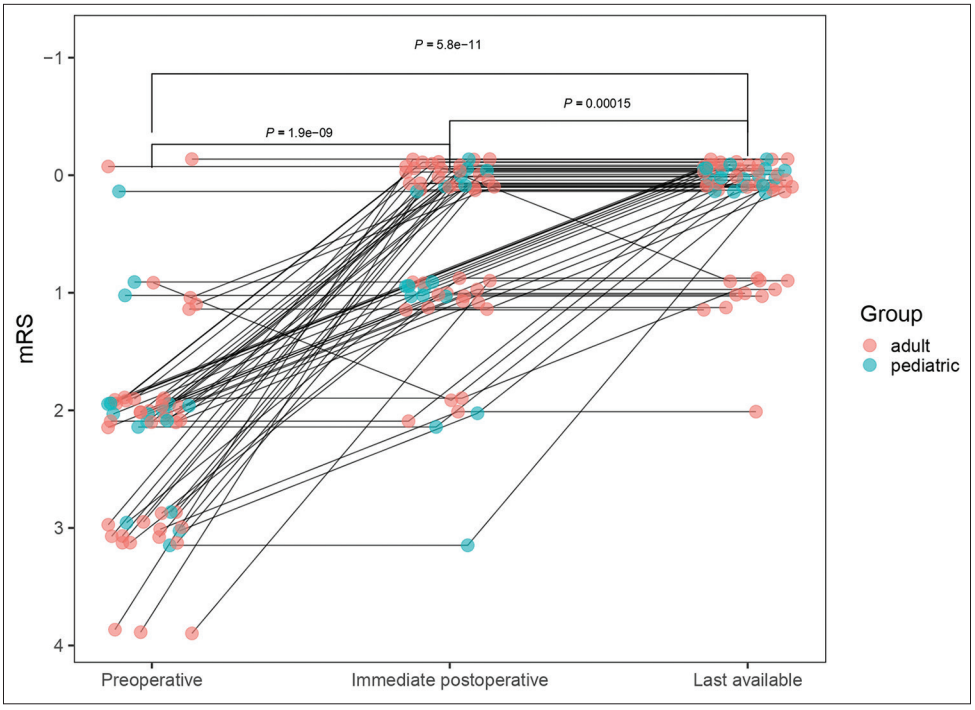

Figure 2: Functional outcome trajectories of surgically treated pineal cyst patients; modified Rankin scale.

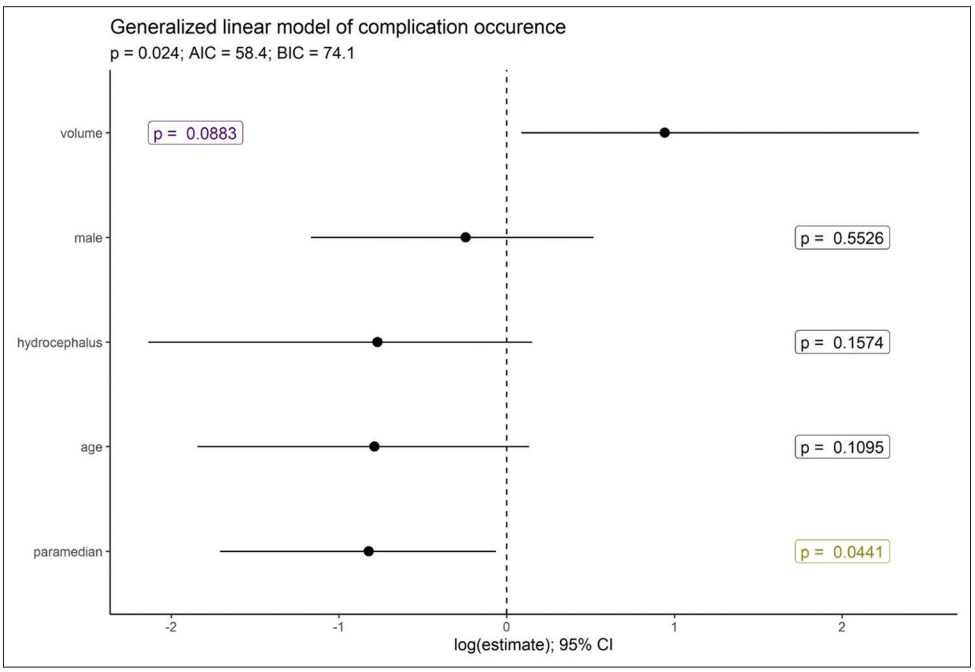

Figure 3: Multiple regression model for the identification of predictors for postoperative complications; paramedian, paramedian supracerebellar infratentorial approach; volume, pineal cyst volume.

other hand, at the last mRS evaluation, the pediatric population showed better outcomes than adults, and further research should be performed in this regard. However, different factors could explain this finding: (a) the pediatric patients, on average, presented a better preoperative functional status than adults, and the long-term clinical outcome is correlated with the preoperative mRS; (b) although we scored the pediatric disability with age-specific modifications, the mRS scales of pediatric and adult patients still remain different, thus hindering an optimal comparison; (c) a minor postoperative

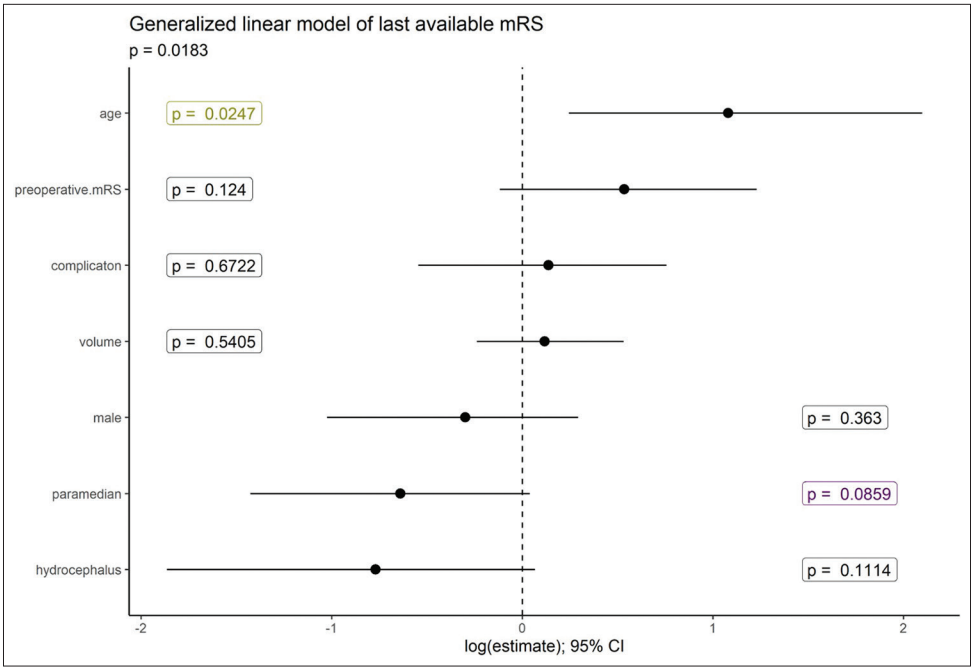

Figure 4: Multiple regression model for the identification of predictors for the modified Rankin scale at the last clinical evaluation; paramedian, paramedian supracerebellar infratentorial approach; volume, pineal cyst volume.

discomfort (mRS 1) might be unnoticed and unreported by the pediatric patients; (d) the retrospective design of the study may represent a limitation for the accuracy of the data; and (e) the active neuroplasticity of the pediatric patients might offer a better recovery of the minor postoperative dysfunctions (mRS 1) as well.

Very few studies have quantitatively evaluated the functional status of surgically treated PC patients.[8,9,16,18] Majovsky *et al*. and Damaty *et al*. used the CCOS for the outcome evaluation of their cases.[8,16] Damaty *et al*. reported 41 patients with a CCOS of 11 or more and two patients with bad outcomes after microsurgical resection. Majovsky *et al*. reported a mean CCOS of 15 (range 12–16) after microsurgical treatment of 21 patients. Some other studies focused on the evaluation of specific symptoms.[9,18] However, most of the studies provided only a qualitative description of their results.[3,10,11,13-15,17] On the other hand, a quantitative evaluation of the potential clinical improvement offered by the surgical management of PCs is paramount to justify their removal, as PCs are benign lesions.

We previously described the postoperative complications after the surgical removal of PCs in our series.[6] Transient visual impairment appeared in some cases. Approach-related complications were more frequently observed during the first period of the study, when the midline SCIT approach was mostly performed. We recently performed a comparative evaluation between the midline and the paramedian SCIT approaches in pineal region surgery. There, the paramedian approach resulted in a simplified, less invasive, and safer procedure than the midline approach for the management of pineal region lesions in sitting praying position.[7] As above mentioned, the SCIT approach in sitting position was performed in 58 of the 60 PC patients. The patient who underwent the occipital transtentorial approach in park bench position presented a temporary Parinaud's syndrome after surgery that solved at the last evaluation 2 months later. On the other hand, the patient who underwent the stereotactic cyst fenestration did not experience postoperative complications. However, a small remnant of the cyst was present at the last postoperative imaging 3 months later.[6] We support a judicious microsurgical management of PCs through a paramedian SCIT approach in sitting praying position since this procedure allowed us to obtain good/optimal postoperative functional statuses and low rates of postoperative complications.[5-7]

The long-term clinical and radiological follow-up was relatively short in our series. Thus, the disease-related symptoms solved soon after surgery. Only one patient was lost at the long-term follow-up evaluated in the Finnish registry system 2018. The mortality was null, and all patients except two were cyst free and the last radiological evaluation.

The most important limitation of this study was its retrospective nature, which could have hindered an accurate evaluation of the functional status mainly in pediatric patients.

CONCLUSION

The functional status of PC patients improves significantly after their surgical management through a paramedian SCIT approach in sitting position, especially in pediatric patients. Adequate surgical criteria are essential for the selection of the cases.

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Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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