Does subjective improvement in adults with intracranial arachnoid cysts justify surgical treatment?

Katrin Rabiei, MD, PhD,1,2 Per Hellström, PhD,1 Mats Högfeldt-Johansson, MD,1,2 and Magnus Tisell, MD, PhD1,2

1Institute of Neuroscience and Physiology, Sahlgrenska Academy; and 2Department of Neurosurgery, Sahlgrenska University Hospital, Gothenburg, Sweden

OBJECTIVE Subjective improvement of patients who have undergone surgery for intracranial arachnoid cysts has justified surgical treatment. The current study aimed to evaluate the outcome of surgical treatment for arachnoid cysts using standardized interviews and assessments of neuropsychological function and balance. The relationship between arachnoid cyst location, postoperative improvement, and arachnoid cyst volume was also examined.

METHODS The authors performed a prospective, population-based study. One hundred nine patients underwent neurological, neuropsychological, and physiotherapeutic examinations. The arachnoid cysts were considered symptomatic in 75 patients, 53 of whom agreed to undergo surgery. In 32 patients, results of the differential diagnosis revealed that the symptoms were due to a different underlying condition and were unrelated to an arachnoid cyst. Neuropsychological testing included target reaction time, Grooved Pegboard, Rey Auditory Verbal Learning, Rey Osterrieth complex figure, and Stroop tests. Balance tests included the extended Falls Efficacy Scale, Romberg, and sharpened Romberg with open and closed eyes. The tests were repeated 5 months postoperatively. Cyst volume was pre- and postoperatively measured using OsirIX software.

RESULTS Patients who underwent surgery did not have results on balance and neuropsychological tests that were different from patients who declined or had symptoms unrelated to the arachnoid cyst. Patients with a temporal arachnoid cyst performed within the normal range on the neuropsychological tests. Seventy-seven percent of the patients who underwent surgery reported improvement, yet there were no differences in test results before and after surgery. Arachnoid cysts in the temporal region and posterior fossa did not influence the preoperative results of neuropsychological and motor tests. The arachnoid cyst volume decreased postoperatively (p < 0.0001), but there was no relationship between volume reduction and clinical improvement.

CONCLUSIONS The results of this study speak against objectively verifiable improvement following surgical treatment in adults with intracranial arachnoid cysts.

https://thejns.org/doi/abs/10.3171/2016.9.JNS161139

KEY WORDS intracranial arachnoid cysts; neuropsychological testing; balance testing; cyst volume

Arachnoid cysts are benign, fluid-filled malformations of the arachnoid tissue.20 Intracranial arachnoid cysts have a prevalence of around 2%, and most are found incidentally.19 Individuals with arachnoid cysts may be asymptomatic or present with a wide range of neurological symptoms and signs.1 Symptoms related to arachnoid cysts are either secondary to hydrocephalus or due to compression of the adjacent neural tissue.1,27 Headache, dizziness or imbalance, and cognitive impairment are among the most common symptoms associated with an arachnoid cyst.1 However, these symptoms are frequently encountered in the general population and are subjective and difficult to validate. Hence, the causal link between them and an arachnoid cyst is often uncertain or dubious. The indication for surgical treatment is therefore challenging in the case of the most common symptoms associated with arachnoid cysts.1,19

The aim of this study was to evaluate the clinical effect...
of surgical fenestration of intracranial arachnoid cysts. In addition to the patients’ reported symptoms, cognitive and balance impairment were tested before and after surgery. Furthermore, we aimed to examine, using volumetrics, whether postoperative improvement and radiological reduction in cyst volume were related.

**Methods**

**Patient Population**

All adults who had de novo cysts and were from the western region of Sweden were prospectively and consecutively included in this study between December 2004 and December 2009. During this time, 125 patients (57 females and 68 males) between 18 and 83 years old (mean age 43 years) were included. The reasons for the initial imaging studies obtained in these patients were headache, dizziness or imbalance, trauma, visual disturbance, seizures, cognitive impairment, and focal neurological signs (Supplemental eTable 1).

Evaluations of images and referrals were performed by 2 senior neurosurgeons. All images were also reviewed by a neuroradiologist. One patient had an epidermoid cyst, and another patient was found to have a mega cisterna magna; both patients were excluded. Fourteen patients were excluded from further investigation due to the combination of a lack of symptoms and a small cyst, leaving 109 patients for further evaluation (Fig. 1).

The study was approved by the Ethics Committee for Medical Research at Gothenburg University, and all patients gave their written consent to participate in the study.

**Clinical Examination**

One hundred nine patients were admitted for evaluation in the Hydrocephalus Research Unit at Sahlgrenska University Hospital. The evaluations included MRI and neurological, neuropsychological, and physiotherapeutic examinations and were all based on predetermined fixed protocols. In addition to medical history and routine neurological examination, previous head trauma, hospital admissions, and complications during birth and trauma in early childhood and later in life were recorded. The neurological examinations included the Mini–Mental State Examination (MMSE), the Bingley visual memory test, and the identical forms test. If headache was present, extensive headache anamnesis was part of the fixed protocol. At least 2 senior consultant neurologists were involved in the evaluation of the patients. Only patients with headache classified by the International Headache Society’s ICHD-2 (International Classification of Headache Disorders, 2nd edition) as “headache attributed to nonvascular intracranial disorder” or “headache related to space-occupying lesion” were considered to have arachnoid cyst–related headache.

A fixed protocol was used for the MRI examinations of all patients with arachnoid cysts, including FLAIR-, diffusion-, and T1-weighted sequences, to allow both a differential diagnosis and volumetric measurements.

After the examinations, each case was discussed at a multidisciplinary conference, and patients whose symptoms had no other explanation were offered surgery. Two patients were excluded at this point, based on nascent vascular dementia and Parkinson’s dementia, leaving 107 patients in the study (mean age 47.3 years, SD 16.2 years, range 18–76 years). Seventy-five patients were considered symptomatic and were offered surgical treatment, of whom 53 consented and 22 declined (Fig. 1). In 32 patients, the symptoms were found to be unrelated to the arachnoid cyst and were caused by a different underlying condition (e.g., tension headaches or migraine). Patient characteristics and test results are presented in Table 1.

The surgical method of choice was fenestration performed under general anesthesia. Patients who had undergone surgery were evaluated using the same test battery and by the same research team following the same protocols 5 months postoperatively. The treating neurosurgeons were not part of the evaluation team. All new and residual symptoms and the patients’ reported outcome of surgery were noted by a neurologist who did not take part in the patient’s surgical treatment. MRI was repeated 5 months and 1 year postoperatively. Patients who declined surgery underwent follow-up by visiting the neurosurgical outpatient clinic.

**Neuropsychological Testing**

The same neuropsychologist (P.H.) examined all patients. A clinical interview including medical history, educational and occupational background, and patient symptoms preceded the neuropsychological testing. The psychometric tests performed were 1) target reaction time, 2) Grooved Pegboard test performed with the dominant and nondominant hand (Lafayette Instrumentation Co.), 3) the Rey Auditory Verbal Learning Test (RA VLT), 4) the Rey–Osterrieth complex figure (ROCF), and 5) the Swedish Stroop test. These tests measure different aspects of memory and recall: verbal learning and recall (RA VLT), visuospatial learning and recall (ROCF), attention and cognitive control (Stroop test and target reaction time), and manual dexterity (Grooved Pegboard test). These tests involve the function of many brain structures, including the temporal lobe region, anterior cingulate, the dorsolateral prefrontal cortex, and the head of the left caudate. For neuropsychological tests, T-values based on the subject’s age and sex were calculated (Table 1).

**Balance Testing**

An experienced physiotherapist conducted the same standardized tests in all patients. The examination started with an interview about the patient’s symptoms. The balance tests performed were the expanded version of the Falls Efficacy Scale, Swedish version [FES(S)]; the Romberg test; and the sharpened Romberg test with open and closed eyes. The tests were performed twice, and the best test value was noted.

**Cyst Volume Measurement**

The cyst volume was measured preoperatively and 5 months and 1 year postoperatively using FLAIR sequences of 1.5-T MR images and OsiriX software version 6.5. The region of interest was manually outlined on each MRI slice and was calculated by the software.
Statistical Analysis

The chi-square test was used for nonordered categorical variables, Fisher’s exact test for dichotomous variables, and the Mann-Whitney U-test for continuous variables. For comparison over time, the Wilcoxon signed-rank test was used for continuous variables and the sign test for categorical variables. For comparisons between 3 groups, the Mantel-Haenszel chi-square test was used for ordered categorical variables and the Kruskal-Wallis test for continuous variables. All tests were 2-tailed; p < 0.05 was considered significant. The data were analyzed using version 9.4 of the SAS System for Windows (SAS Institute).

Results

Overall, the patients exhibited a wide range of symptoms, including headache (60%), dizziness and/or imbalance (42%), cognitive impairment (17%), seizures (9%),...
Can subjective improvement justify surgery for arachnoid cysts?

**Surgically Treated Patients**

Of the 53 patients who underwent surgical treatment, 50 underwent open microsurgical fenestration and 3 underwent endoscopic fenestration. Shunting was performed after the procedure in 4 patients because of concomitant hydrocephalus.

Eleven patients (21%) suffered 15 complications, of which 13 were transient and 2 caused permanent sequelae (3.8%). Six additional surgical procedures were performed to treat the different complications.

The transient complications consisted of epidural hematoma (1 case), subdural hematoma (2 cases), subdural hygroma (2 cases), CSF leakage (3 cases), meningitis (1 case), occipital neuralgia (1 case), pseudomeningocele (1 case), and transient aphasia related to edema in the left temporal lobe region (1 case). One patient with persistent CSF leakage (who initially underwent surgery in the posterior fossa) underwent reoperation with endoscopic third ventriculostomy and, later on, ventriculoperitoneal shunting.

The permanent complications consisted of a venous infarction in combination with intracerebral hematoma following ligation of frontal bridging veins, which resulted in complete damage to the right frontal lobe. The second patient developed epileptic seizures following a subdural empyema that was surgically evacuated with removal of the bone flap and reoperation with cranioplasty.

At the 5-month follow-up, 41 (77%) patients described their overall symptoms as improved, 8 (15%) considered their symptoms to be unchanged, and 2 (4%) were worse. One patient was lost to follow-up and another did not answer this question. However, when comparing the number of symptoms before and after surgery, only 23 (43%) patients were found to have complete remission of at least 1 preoperative symptom, while 26 (49%) were unchanged and 3 (6%) had more symptoms than before surgery. Patients reported improvement of headache and dizziness but not of cognitive symptoms (Table 3).

No arachnoid cyst location could be associated with patient-reported improvement. Furthermore, no arachnoid cyst location could be associated with improvement defined as remission of at least 1 clinical symptom. Neither

![Flowchart showing the patient population. AC = arachnoid cyst.](image-url)

**FIG. 1.** Flowchart showing the patient population. AC = arachnoid cyst.
headache nor dizziness was associated with a particular arachnoid cyst location.

Neuropsychological Testing

The neuropsychological test results of the surgically treated patients were similar to those of patients who declined or had symptoms unrelated to the arachnoid cyst. Overall, the test results were within the reference range for all groups (Table 1). Following surgery, the patients did not improve on any of the test variables except perhaps target reaction time (p = 0.048) (Table 4). Furthermore, there were no differences in the test results of patients who reported cognitive impairment and those who did not. Additionally, patients with temporal arachnoid cysts performed similarly to patients with an arachnoid cyst in other locations. A temporal location was not found to affect the results of the balance tests.

The results of the balance tests were similar between the patients who underwent surgery and those who declined surgery or had symptoms unrelated to their arachnoid cyst (Table 1). The patients who underwent surgery did not improve on any of the test parameters (Table 4). Furthermore, the results of the balance tests did not differ between those with posterior fossa arachnoid cysts and those with arachnoid cysts in other locations. A temporal location was not found to affect the results of the balance tests.

Patients reporting dizziness/imbalance preoperatively exhibited worse results on the Romberg test (p = 0.004) and the sharpened Romberg tests with the eyes open (p = 0.012) and closed (p = 0.0081), but not on FES(S) (p = 0.085), compared with those who did not experience this symptom. These patients did not improve on any of the performed tests postoperatively. Preoperatively, patients with posterior fossa arachnoid cysts performed similarly on the balance tests to patients with an arachnoid cyst in other locations. However, postoperatively, they performed worse than patients with an arachnoid cyst in other locations on the Romberg test (p = 0.0003) and the sharpened Romberg test with the eyes open (p = 0.015) but not with the eyes closed (p = 0.17), and FES(S) (p = 0.51). The difference between preoperative and postoperative values within the group of patients with posterior fossa cysts was statistically significant only for the Romberg test (p = 0.050).

Cyst Volume Measurements

The mean preoperative cyst volume in surgically

Table 2. Major complaints among all patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Patients (%)</th>
<th>Treated Patients (n = 53)</th>
<th>Declined Surgery Patients (n = 22)</th>
<th>Patients with Unrelated Symptoms (n = 32)</th>
<th>Total (n = 107)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>36 (68)</td>
<td>33 (62)</td>
<td>26 (64)</td>
<td>64 (60)</td>
<td></td>
</tr>
<tr>
<td>Dizziness or imbalance</td>
<td>23 (43)</td>
<td>11 (50)</td>
<td>11 (34)</td>
<td>45 (42)</td>
<td></td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>11 (20)</td>
<td>4 (18)</td>
<td>3 (9)</td>
<td>18 (17)</td>
<td></td>
</tr>
<tr>
<td>Visual disturbance</td>
<td>5 (9)</td>
<td>0 (0)</td>
<td>2 (6)</td>
<td>7 (7)</td>
<td></td>
</tr>
<tr>
<td>Seizures</td>
<td>6 (11)</td>
<td>3 (14)</td>
<td>1 (3)</td>
<td>10 (9)</td>
<td></td>
</tr>
<tr>
<td>Focal neurological symptoms</td>
<td>4 (7)</td>
<td>1 (5)</td>
<td>2 (6)</td>
<td>7 (7)</td>
<td></td>
</tr>
<tr>
<td>Other symptoms</td>
<td>6 (11)</td>
<td>0 (0)</td>
<td>2 (6)</td>
<td>8 (7.5)</td>
<td></td>
</tr>
<tr>
<td>No subjective symptoms</td>
<td>NA</td>
<td>0</td>
<td>2 (6)</td>
<td>3 (3)</td>
<td></td>
</tr>
</tbody>
</table>

Mean values (SD) are presented unless indicated otherwise. The mean values are T-values. For comparison between groups, the Mann-Whitney U-test was used for continuous variables.

* The norms for the initial trial on the ROCF are presented in terms of cutoff values where >40 means that the patient’s performance is less than 1 SD from the mean of healthy individuals and thereby considered normal. The exact T-values are not presented due to a heavily negatively skewed distribution in the normative sample.

Table 3. Major complaints among surgically treated patients before and after surgery

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preop Symptom (n = 53)</th>
<th>Postop Symptom (n = 52)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>36 (68)</td>
<td>19 (37)</td>
<td>0.0003</td>
</tr>
<tr>
<td>Dizziness or imbalance</td>
<td>23 (43)</td>
<td>10 (19)</td>
<td>0.005</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>11 (20)</td>
<td>10 (19)</td>
<td>NS</td>
</tr>
<tr>
<td>Visual disturbance</td>
<td>5 (9)</td>
<td>2 (4)</td>
<td>NS</td>
</tr>
<tr>
<td>Seizures</td>
<td>6 (11)</td>
<td>2 (4)</td>
<td>NS</td>
</tr>
<tr>
<td>Focal neurological symptoms</td>
<td>4 (7)</td>
<td>1 (2)</td>
<td>NS</td>
</tr>
<tr>
<td>Other symptoms</td>
<td>6 (11)</td>
<td>9 (17)</td>
<td>NS</td>
</tr>
<tr>
<td>No subjective symptoms</td>
<td>NA</td>
<td>8 (15)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 4. Neuropsychological and balance test results before and after surgery in surgically treated patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preop Value</th>
<th>Postop Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyst vol in ml</td>
<td>49.5 (52.4)</td>
<td>31.0 (50.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>RAVLT, total</td>
<td>42.2 (13)</td>
<td>42.7 (12)</td>
<td>0.93</td>
</tr>
<tr>
<td>RAVLT, delayed recall</td>
<td>45.8 (13)</td>
<td>45.8 (13)</td>
<td>1.00</td>
</tr>
<tr>
<td>Grooved Pegboard test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant hand</td>
<td>41.2 (23.0)</td>
<td>38.1 (22.9)</td>
<td>0.56</td>
</tr>
<tr>
<td>Nondominant hand</td>
<td>42.1 (19.2)</td>
<td>34.2 (27.0)</td>
<td>0.29</td>
</tr>
<tr>
<td>Target reaction time</td>
<td>49.0 (14.2)</td>
<td>45.4 (12.5)</td>
<td>0.048</td>
</tr>
<tr>
<td>Swedish Stroop test</td>
<td>47.1 (10.7)</td>
<td>49.1 (12.4)</td>
<td>0.80</td>
</tr>
<tr>
<td>ROCF (range)*</td>
<td>&gt;40 (28 to &gt;40)</td>
<td>&gt;40 (28 to &gt;40)</td>
<td>0.63</td>
</tr>
<tr>
<td>Romberg</td>
<td>53.4 (16.9)</td>
<td>53.8 (16.4)</td>
<td>0.83</td>
</tr>
<tr>
<td>Sharpened Romberg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eyes open</td>
<td>49.1 (20.2)</td>
<td>43.2 (24.0)</td>
<td>0.41</td>
</tr>
<tr>
<td>Eyes closed</td>
<td>21.1 (21.4)</td>
<td>25.2 (24.3)</td>
<td>0.51</td>
</tr>
<tr>
<td>FES(S)</td>
<td>5.49 (0.66)</td>
<td>5.48 (0.80)</td>
<td>0.74</td>
</tr>
</tbody>
</table>
treated patients was 49 ml (SD 52.4 ml, median 30 ml). At follow-up, this volume was reduced to 31 ml (SD 50.9 ml, median 11 ml) (p < 0.0001). The cyst volume further decreased to 29 ml (SD 49.4 ml, median 9 ml) at the 1-year radiological follow-up (p = 0.0005). Clinical improvement was not related to a reduction in cyst volume (p = 0.71).

**Patients Who Declined Surgery and Patients With Symptoms Unrelated to the Arachnoid Cyst**

Of the 22 patients who declined surgery, 11 (50%) reported spontaneous improvement in their presenting symptoms within 3 months and did not desire further follow-up. Eight patients’ conditions improved over the following year. The remaining 3 patients eventually underwent surgery.

**Neuropsychological Testing and Balance Testing**

There were no differences in performance on the Romberg test, sharpened Romberg tests with the eyes open and closed, FES(S), target reaction time, RAVLT, ROCF, and Swedish Stroop test between the patients who declined surgical treatment and those who underwent surgery and patients with symptoms unrelated to arachnoid cyst. Patients who declined surgery performed better than patients who underwent surgery on the Grooved Pegboard test performed with the dominant hand. At the same time, patients who were not offered surgery performed worse than the other groups on the same test (Table 1).

**Cyst Volume Measurements**

The mean cyst volume in patients who declined surgery was 44 ml (SD 36.7 ml, median 27.8 ml) and did not differ from patients who underwent surgery (p = 0.96). Patients with symptoms unrelated to their arachnoid cyst had a smaller mean arachnoid cyst volume of 18 ml (SD 20.8 ml, median 9.8 ml) than patients who accepted surgical treatment and those who declined surgery (p = 0.0025 and p = 0.0006, respectively).

**Discussion**

In this prospective study on adult patients with arachnoid cysts, we found no differences in the test results of patients considered to be symptomatic and those whose symptoms were not considered to be related to their arachnoid cyst. Furthermore, arachnoid cyst location did not influence the results of any of the performed tests. The majority of the surgically treated patients (77%) rated themselves as having improved at follow-up. However, only 43% had complete remission of at least 1 preoperative symptom. Furthermore, the test results did not improve in those who underwent surgical treatment. Half of the patients who declined surgical treatment (50%) improved spontaneously within 3 months and 86% within the 1st year.

The main strength of our study is the prospective design, the defined population, the extensive preoperative and postoperative examinations, and the volumetric measurement of the arachnoid cyst volume. However, the study is uncontrolled, and the follow-up time is relatively short.

A primary arachnoid cyst is a benign condition and is often found incidentally, with a reported prevalence of 2% and no association with the most common symptoms ascribed to it in the general population. The increased use of medical imaging in the assessment of patients reporting multifactorial and prevalent symptoms has led to an increase in the number of identified arachnoid cysts. In such cases, clinical evaluation is challenging and complex. In our study, headache was the most frequently reported symptom in the group of patients who underwent surgery, whereas it was less prevalent among those who declined surgery. The headache was improved in a significant number of our patients (47% of those who complained of headache preoperatively did not suffer from headache at follow-up). This beneficial effect may be due to our multidisciplinary approach to patient evaluation, with the involvement of experienced neurologists and a physiotherapist (evaluation of exertion headache). However, we cannot rule out the placebo effect of surgery on symptom improvement during this relatively short-term follow-up.

Dizziness or imbalance, the second most common symptom in arachnoid cyst, is yet another complex and multifactorial condition. Our patients reported a high rate of improvement regarding this symptom postoperatively (57% of those who suffered preoperatively no longer reported dizziness or imbalance during follow-up). However, their test results did not improve postoperatively. In the arachnoid cyst patients in our study, the dizziness/imbalance may have had causes other than the arachnoid cyst, and, if at all related to the arachnoid cyst, this symptom did not respond to surgical decompression despite subjective reports of improvement. Furthermore, perhaps surprisingly, the performance of patients with a posterior fossa arachnoid cyst did not differ from those with arachnoid cysts in other locations preoperatively, but had deteriorated following surgical treatment. However, the difference between pre- and postoperative results within this group was statistically significant only on the Romberg test, possibly due to the small number of patients.

Complaints of cognitive disturbances are often associated with arachnoid cysts and have been used as a justification for surgical treatment, especially in the case of temporal arachnoid cysts. Our results do not show that a temporal arachnoid cyst causes cognitive disturbances but rather confirm the quiescent nature of arachnoid cysts. Furthermore, following surgery, the only significant difference in the neuropsychological test results of surgically treated patients was impaired performance on the target reaction time test.

The high improvement rates reported in previous studies have also been used to justify surgical treatment, despite the risk of complications. The evaluation of improvement diverges considerably. In accordance with most previous studies, we found a high rate of improvement (77%) when asking patients about the evaluation of their symptoms. However, the rate of improvement drops to less than half when total remission of at least 1 symptom is required. We speculate that patient-reported improvement rates, at least in part, might reflect the impact of anxiety of
being diagnosed with an intracranial lesion and the subsequent postoperative relief that is unrelated to the arachnoid cyst itself. In fact, in our recent study on children with arachnoid cysts, almost all patients or parents considered the surgery worthwhile, based on the preoperative anxiety connected to the diagnosis of the arachnoid cyst and regardless of the impact of surgery on their symptoms.

The high rate of improvement may also be spontaneous. In our study, 86% of the 22 patients who declined surgery eventually improved. Since there was no difference in arachnoid cyst volume between these patients and those who chose surgery (p = 0.96), this improvement rate, similar to that of many surgical series, is remarkable. Furthermore, we found that improvement was unrelated to the arachnoid cyst volume in the patients who underwent surgery, making the disappearance or decompression of the arachnoid cyst as a measure of surgical outcome pointless.

In Sweden, the rate of surgery for intracranial arachnoid cyst in adults has almost doubled over the past 5 years compared with the study period, according to the Swedish National Board of Health (The National Board of Health and Welfare, www.socialstyrelsen.se/english, accessed on March 25, 2016) (Supplemental eFig. 1). The increasing use of radiological examinations, together with a common radiological finding, frequently encountered symptoms ascribed to it, and a high reported rate of improvement in surgical series are perhaps the underlying causes. In this study, surgery was offered to all patients in whom other causes of their symptoms were ruled out. Yet, the benign nature, and what is now known about the natural history of arachnoid cysts, together with the risk of serious complications associated with surgical treatment and the lack of verifiable improvement despite diminished cyst size, speak mainly against surgical treatment.

Conclusions

We found no differences in the neuropsychological and balance test results of patients with and those without symptomatic arachnoid cysts. Results on balance and cognitive performance tests did not improve in surgically treated patients, despite self-reported improvement and reduction in the arachnoid cyst volume. The results of the study speak against objectively verifiable improvement after surgical treatment in adults with intracranial arachnoid cysts.

Acknowledgments

We gratefully acknowledge Elisabeth Blomstervall for physiotherapeutic assessment of the patients and guidance regarding the interpretation of the balance tests performed, Roberto Doria Mediina for volumetric measurements, all members of the Hydrocephalus Research Unit involved in the evaluation and patient care, especially Gudrun Barrows and Gunilla Ahl-Börjesson for coordination of the study and investigations involved and for extensive work on the patient database, and Cecilia Kjellman at Statistiska Konsultgruppen for the statistical analyses.

The study was supported by the Göteborg Foundation for Neurological Research (ISNF), Sahlgrenska University Hospital’s research foundations, The Göteborg Medical Society and Kristina Stenborg’s Foundation, Edit Jacobson Foundation, the Rune and Ulla Amlöf Foundation, Hjalmar Svensson’s Research Foundation, and the John and Brit Wennerström Foundation. The funders had no role in the study design, the collection and analysis of the data, the data interpretation, or the writing of this paper.

References

16. Osterrieth PA: [The test of copying a complex figure: a contribution to the study of perception and memory.] Arch Psy- chol (Geneve) 30:206–356, 1944 (Fr)
17. Peterson BS, Skudlarski P, Gatenby JC, Zhang H, Anderson
Can subjective improvement justify surgery for arachnoid cysts?

J Neurosurg Volume 128 • January 2018


Rey A: L'examen psychologique dans les cas d'encéphalopathie traumatique. Archives de Psychologie 28:286–340, 1941


Rosset C, Rosset A, Ratib O: General consumer communication tools for improved image management and communication in medicine. J Digit Imaging 18:270–279, 2005


Thurstone L, Jeffrey TE: Perceptual Speed: Identical Forms, Test Administration Manual. Chicago: Industrial Relations Center, 1966


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
Acquisition of data: all authors. Analysis and interpretation of data: Rabiei, Hellström, Tisell. Drafting the article: Rabiei. Critically revising the article: Rabiei, Hellström, Tisell. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Rabiei. Study supervision: Tisell.

Supplemental Information
Online-Only Content
Supplemental material is available with the online version of the article. Supplemental eTable 1 & eFig. 1. https://thejns.org/doi/suppl/10.3171/2016.9.JNS161139.

Correspondence
Katrin Rabiei, Institute of Neuroscience and Physiology, c/o Department of Neurosurgery, Sahlgrenska University Hospital, Blå stråket 5, vån 3, Gothenburg SE-413 45, Sweden. email: katrin.rabiei_tabriz@vgregion.se.