Arachnoscopy: a special application of spinal intradural endoscopy

UWE MAX MAUER, M.D.,1 ANDREAS GOTTSCHALK, M.D.,2 ULRICH KUNZ, PROF., M.D.,1 AND CHRIS SCHULZ, M.D.1

Departments of 1Neurosurgery and 2Radiology, German Armed Forces Hospital of Ulm, Germany

Object. The microsurgical removal of obstructions to CSF flow is the treatment of choice in the surgical management of intradural arachnoid cysts. Cardiac-gated phase-contrast MR imaging is an effective tool for the primary diagnosis and localization of arachnoid cysts. Microsurgery, however, does not lend itself to assessments of further adhesions beyond the borders of the exposed area. The use of a thin endoscope allows surgeons to assess intraoperatively whether the exposure is wide enough.

Methods. Between 2006 and 2010, a single neurosurgeon performed 31 consecutive microsurgical procedures with endoscopic assistance in 28 patients with spinal arachnoid adhesions. A MurphyScope endoscope was used for this purpose. The CSF flow was studied before and after surgery in all patients by using phase-contrast MR imaging in the region of the craniocervical junction, the cervical spine, the thoracic spine, and the lumbar spine.

Results. In all 31 procedures, CSF flow obstructions were detected at the level identified by phase-contrast MR imaging. In 29 procedures, image quality was sufficient for an inspection of the adjacent subarachnoid space. In 6 cases, the surgeon detected further adhesions that obstructed CSF flow in the adjacent subarachnoid space that were not visualized with the microscope. In all cases, these adhesions were identified and removed during microsurgery.

Conclusions. Arachnoscopy is a helpful adjunct to microsurgery and can be performed safely and easily. It allows the surgeon to detect further adhesions in the subarachnoid space that would remain undetected by microscopy alone. (DOI: 10.3171/2011.1.FOCUS10291)

Key Words • spinal endoscopy • arachnoscopy • syringomyelia • cardiac-gated phase-contrast magnetic resonance imaging • arachnoid adhesion • cerebrospinal fluid flow • cerebrospinal fluid pulsation

Ventricular endoscopy is an accepted and widely used procedure. Endoscopic third ventriculostomy has become a routine method in almost all neurosurgery departments. By contrast, endoscopy of the spinal subarachnoid space is a method that is not yet routinely used. Arachnoscopy is a procedure that allows surgeons to visualize adhesions that obstruct the subarachnoid space.5,21

Spinal intradural arachnoid cysts can lead to neurological symptoms20 or cause syringomyelia. This is a disorder in which a cavity forms within the spinal cord, and it is associated with a wide variety of diseases. Obstruction of CSF flow either at the craniocervical junction or in the spinal subarachnoid space is a factor common to all conditions that cause syringomyelia.5 The CSF pulsations are a result of the flow of blood into the nervous system, which leads to a volume shift from cranial to spinal spaces and from the extracellular to the subarachnoid space. Syringomyelia is thus not a disease in itself, but a symptom of a wide variety of diseases that are associated with an obstruction of pulsatile CSF flow.

Spinal intradural CSF flow obstruction can be caused by trauma (for example, accident or previous surgery) or inflammation. In countries with a high incidence of tuberculosis and syphilis such as Ethiopia,13 severe elongated arachnoid adhesions appear to be more common. In some cases, a true intradural arachnoid cyst is the cause of flow obstruction. The cause underlying the formation of an arachnoid cyst in the apparent absence of inflammation or a similar condition is unknown. Perret et al.23 postulated that the cysts are caused by a dilation of the septum posticum, which longitudinally divides the posterior subarachnoid space in the midline. This would explain why arachnoid cysts are commonly located dorsal to the spinal cord. More recent publications, however, do not support this theory.11 Arachnoid webs are a variant of arachnoid cysts.22 Weblike adhesions do not completely block but considerably obstruct the flow of CSF. Intradural arachnoid cysts can cause neurological symptoms in the absence of syringomyelia simply by compressing the spinal cord.20,29

In the past, drains were widely used to treat syringo-
myeloma.1 This method, however, did not prove effective in the long term.24 For this reason, most authors today believe that the best treatment for syringomyelia is a causal approach involving the removal of CSF flow obstruction and not the placement of shunts.2,4,15 Causal treatment requires that the operating surgeon know the exact location of CSF obstruction. In addition, the surgeon must assess intraoperatively whether the exposure is wide enough to allow all adhesions to be removed.

The literature reports that myelography in conjunction with postmyelography CT scanning is the standard method of identifying the location of flow obstruction.3,16 We were able to show, however, that cardiac-gated phase-contrast MR imaging, which is a completely noninvasive procedure, is more sensitive in detecting adhesions than myelography.18

Because the site of flow obstruction can be localized with increasing accuracy, the microsurgical procedure requires only a small opening. In our experience, hemilaminectomy or interlaminar fenestration (that is, unilateral partial removal of adjacent vertebral arches without interruption of continuity) with duraplasty and dural tenting sutures are sufficient in many cases.19 Larger openings are likely to increase the risk of new scar formation after surgery.17 Minimizing the size of exposure is, however, associated with growing uncertainty as to whether further relevant adhesions might be found in the vicinity of the exposed area. For this reason, we collected data prospectively and investigated whether the adjunctive use of an endoscope helps the operating surgeon determine the required size of the exposure and thus increases the safety of microsurgical lysis of adhesions.

Methods

Between 2006 and 2010, a single surgeon in a neurosurgery department performed 31 consecutive microsurgical procedures in 28 patients (13 female and 15 male patients; median age 42 years, range 12–76 years) with intraspinal arachnoid adhesions. After the surgeon completed each procedure, he inspected the subarachnoid space as far as possible in the cranial and caudal directions from the exposed area by using a MurphyScope, which is a single-use disposable endoscope with a diameter of 1.4 mm, 10,000 pixel fibers, a malleable tip, and an irrigation channel. The length of the endoscope can be adjusted as required. The microscope usually allows the surgeon to evaluate 2 vertebral levels. When it is used together with the endoscope, at least 2 further levels—1 in each direction—can be examined additionally. As a result, this technique allows the surgeon to evaluate a total of 4 vertebral levels.

All patients underwent preoperative MR imaging of the brain and the entire spine, including Gd enhancement and cardiac-gated phase-contrast CSF flow studies of the craniocervical junction as well as the cervical, thoracic, and lumbar spine in the median sagittal plane for the visualization of craniocaudal CSF flow. Velocity encoding at 3 cm/second was initially selected, and was increased to 5 cm/second, 8 cm/second, and 10 cm/second if “aliasing” was observed. If no flow was visible at 3 cm/second, we controlled cardiac gating and the position of the field of view, and performed another study at 1 cm/second.

Surgery was performed only on strict indications. When patients presented with syringomyelia as a result of subarachnoid CSF flow obstruction, surgery was performed only in those with evidence of a major increase in syrinx size or with severe syringomyelia and neurological deterioration. Patients who presented with intradural arachnoid cysts and spinal cord compression in the absence of syringomyelia underwent surgery only if spinal cord compression caused clinical signs and symptoms.

Cardiac-gated phase-contrast MR imaging of the entire spine was repeated within the first 7 days of surgery, after 3 months, and after 1 year.

Results

Six patients had posttraumatic syringomyelia, and 1 female patient had a history of bacterial meningitis. The other 21 adhesions were of unknown origin. Five patients had undergone previous surgery at another institution, 4 of them for syringomyelia and 1 for a traumatic dural tear. One female patient had undergone occipital decompression and duraplasty related to a Chiari malformation. A lumbar meningomyelocele had been closed immediately after birth in 1 boy.

Syringomyelia was detected at all levels of the spinal cord. Intradural adhesions were found only in the region of the thoracic spine, and most frequently in the upper thoracic spine. All 3 adhesions that were detected at T-12 were traumatic.

In none of the patients with syringomyelia were standard MR imaging studies able to demonstrate the level of CSF flow obstruction. In patients without syringomyelia, the presence of spinal cord compression, displacement, or caliber changes always suggested the location of a cyst on standard MR imaging studies.

During all 31 surgical procedures, CSF flow obstruction was detected at the level identified by phase-contrast MR imaging (Fig. 1). We gained access via hemilaminectomy in 22 cases, extended interlaminar fenestration in 6 cases, and the existing laminectomy in 3 cases.

Despite sufficiently high resolution (Fig. 2), useful diagnostic information was not obtained in 2 cases (during the first 5 procedures) as a result of poor-quality MurphyScope images. After a few minor technical problems with the endoscope adapter and the camera had been resolved, we were able to improve image quality. In 29 procedures, the image quality was sufficient and it was possible for the operating surgeon to assess the adjacent subarachnoid space for the presence of adhesions and CSF flow obstructions (Fig. 3). In the first 5 cases, operative times increased by an average of 15 minutes. This extra time was reduced from 20 minutes in the beginning to 10 minutes by the end of the series. In 17 cases, a median septum was detected between the spinal cord and the arachnoid. Because it extended in the direction of CSF flow and did not obstruct CSF pulsations, however, it was considered to be physiological.

In 6 cases, the surgeon identified further adhesions that were obstructing CSF flow and were located in the adjacent subarachnoid space. This region could not be
visualized with the microscope. The surgeon did not, however, attempt to advance the MurphyScope past these adhesions. Instead, he enlarged the incision in the ligamentum flavum, removed as much bone as required, and opened the dura mater to expose the previously undetected adhesions. In all 6 cases, the endoscopically identified adhesions were noted and removed during microsurgery. In 1 case, the exposure had to be extended by 1 complete vertebral level via an additional hemilaminectomy. In all other cases, an enlargement of the incision and the removal of adjacent bone tissue were sufficient. In 3 of these 6 patients, we observed a rapid and persistent decrease in syrinx size. Two of these patients developed new adhesions in the area of exposure and required further surgery. One of the patients without syringomyelia had a favorable course. In summary, all patients who required an extended exposure on the basis of the endoscopic findings initially benefited from surgery.

The MR imaging studies that were performed in the 1st postoperative week demonstrated free CSF flow in all patients. In 18 of the 22 patients with syringomyelia, MR imaging revealed a decrease in syrinx size (Fig. 4). In the remaining 4 patients with this disorder, MR imaging studies demonstrated free CSF flow but no marked decrease in the size of the syrinx. In all 6 patients without syringomyelia, the spinal cord appeared decompressed.

Two patients required revision of the operative site for a persistent collection of CSF during the first 4 weeks. Prior to the procedure in our hospital, 1 of these patients had undergone surgery at another institution. In only 1 case did we observe a persistent deterioration in a patient’s neurological condition; however, this was not clinically relevant. In 1 patient with posttraumatic incomplete paraplegia, the sensitive area of 1 leg was persistently larger after surgery. One patient experienced a superficial wound-healing problem. Intensive wound management was administered and the wound healed well; no deep...
infection occurred, and no revision was required. There were no other relevant complications, and in particular no cases of meningitis, thrombosis, or death. The complication rate was thus 13% (4 of 31 procedures).

During a mean follow-up period of 2 years (median 3 years, range 1–5 years), no change in syrinx size was noted in the 4 patients who did not show a decrease in the size of the syrinx cavity after surgery. Four patients with a marked decrease in syrinx size developed new adhesions and required further surgery. Each of these patients had previously undergone intradural surgery; 3 had undergone intradural surgery at another institution (2 of whom had developed postoperative infection), and 1 had undergone surgery for a meningomyelocele. Two of these revision surgeries took place during the study period, and were thus performed with endoscopic assistance. Over a period of 2.5 years, another patient showed an increase in syrinx size and free CSF flow in the treated area, and developed a new relevant CSF flow obstruction 5 vertebral levels below the surgical site. Accordingly, the recurrence rate was 14% (4 of 28 patients).

Discussion

As early as the end of the 20th century, endoscopic spinal intradural procedures were described as new surgical methods in a few publications, which, however, referred to individual cases of application. Arachnoscopy has not become established as a routine procedure. In the majority of cases, flexible ultrathin endoscopes are used. Statistical methods allowed Zaaroor et al. to show that an endoscope designed to be used within the spinal intradural space must be smaller than 2.5 mm in diameter.

In particular, the endoscopic examination and treatment of syrinx cavities have been repeatedly described in the past. According to the current understanding of the pathophysiological mechanisms of syringomyelia, however, this is not an effective approach to treatment. In 3 of 4 patients who underwent percutaneous endoscopic placement of a syringopleural shunt, Guest et al. had to convert the procedure to an open laminectomy. To our knowledge, there is only one other publication describing the adjunctive use of an endoscope for the inspection of the subarachnoid space during microsurgery for the causal management of syringomyelia. During microsurgical procedures in 6 patients with intradural arachnoid cysts, Endo et al. used a flexible endoscope to inspect areas that could not be visualized otherwise. In 3 patients, they also resected adjacent adhesions endoscopically. Such cases, however, are associated with the highest risk of injury to the spinal cord or a spinal artery. When we investigated the use of flexible ultrathin endoscopes, we found that image quality was insufficient. In addition, the use of flexible endoscopes carries a considerable risk of a spinal cord lesion caused by the rear parts of the instrument, which cannot be seen by the surgeon.

Some authors favor the percutaneous insertion of an endoscope through a Tuohy needle. Shimoji et al. reported that they successfully advanced a fiberscope to the fourth and third ventricles via a percutaneous route. Karakhan et al. described different approaches, including a dorsal paramedian approach to the intradural space via interlaminar fenestration or hemilaminectomy. Woods et al. used the same type of endoscope as we did.
Endoscope-assisted surgery of intradural adhesions

in the study presented here, and performed endoscopy to diagnose tethered cord syndrome prior to wide exposure of the dura.

The rate of complications in our patients (13%) is similar to that in larger series. Klekamp et al.,\textsuperscript{13} for example, reported a rate of 24% in 51 patients after microsurgery. At least it can be said that endoscopic assistance does not increase the rate of complications.

A recurrence rate of 14% for all patients after a mean period of 2 years is acceptable compared with other series.\textsuperscript{15} All patients who required revision surgery had undergone previous surgery, and some of them had developed subsequent infections. Klekamp et al.,\textsuperscript{15} observed a long-term recurrence rate of 83% in patients with extensive scarring, and 45% in patients with minor scarring. Poor outcomes were reported by Dolan\textsuperscript{8} in 17% of the patients (7 of 41) who underwent arachnoid dissection and duroplasty, and by Shikata et al.\textsuperscript{25} in 22% of the patients (8 of 36) who underwent arachnolysis. It was interesting to note that Shikata et al. observed a better clinical outcome in patients who also underwent a fusion of the treated segment. In our series, the follow-up period is too short to conclude that we obtained better outcomes in our patients. Klekamp et al. reported, however, that almost all recurrences occurred within the 1st year after causal surgery, which consisted of lysis of intradural adhesions via laminectomy. After that period, stabilization was achieved. In our study, too, recurrences occurred within the 1st postoperative year after an excellent initial outcome.

Of course, we cannot answer the question whether the endoscopically detected adhesions were the cause of syringomyelia or whether it would have been sufficient to remove the adhesions that were visualized with the microscope. In addition, we must admit that the risk of spinal cord injury increases with the distance from the site of the opening, and that the rigid technique itself limits the area that can be evaluated. In our opinion, endoscopic therapy—unlike endoscopic diagnosis—is not safe at present, and can entail risks.

Conclusions

Arachnoscopy is a safe, simple, and effective tool for use in microsurgical procedures, and is associated with good immediate postoperative results. An enlargement of the access site can prevent an early revision in some patients. An improvement in long-term outcome, however, cannot yet be proven.

Disclosure

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 to the study and manuscript preparation include the following. Conception and design: Mauer. Acquisition of data: Mauer, Gottschalk, Schulz. Analysis and interpretation of data: Mauer, Gottschalk, Schulz. Drafting the article: Mauer. Critically revising the article: Kunz, Schulz. Reviewed final version of the manuscript and approved it for submission: Mauer, Kunz. Statistical analysis: Mauer. Administrative/technical/material support: Gottschalk, Kunz. Study supervision: Kunz.

References


Neurosurg Focus / Volume 30 / April 2011

Manuscript submitted December 5, 2010.
Accepted January 17, 2011.

*Address correspondence to:* Uwe Max Mauer, M.D., Department of Neurosurgery, German Armed Forces Hospital, Oberer Eselsberg 40, D-89070 Ulm, Germany. *email:* uwe-max.mauer@dgn.de.