A new approach for observing cerebral cisterns and ventricles via a percutaneous lumbosacral route by using fine, flexible fiberscopes

Clinical article

KOKI SHIMOJI, M.D., Ph.D., F.R.C.A.,1,2,3 MAI OGURA, M.D.,4 SANAEGAMOU, M.D.,4 SEKI YUNOKAWA, M.D.,4 HIDETOSHI SAKAMOTO, M.D.,4 SATORU FUKUDA, M.D., Ph.D.,4 AND SHIGEHO MORITA, M.D., Ph.D.4

1Department of Human Sciences, Ube Frontier University Graduate School, Ube, Yamaguchi; 2Pain Control Institute, Shinjuku, Tokyo; 3Department of Anesthesiology, Niigata University Graduate School of Medicine, Niigata; and 4Department of Anesthesiology, Teikyo University School of Medicine, Itabashi-ku, Tokyo, Japan

Object. To establish a new method for the diagnosis of central nervous system diseases, the authors visualized the cerebral cisterns and ventricles via a percutaneous lumbosacral route by using newly developed fine, flexible fiberscopes.

Methods. Fine, flexible fiberscopes, 0.9 and 1.4 mm in diameter, were introduced up to the cerebral cisterns and ventricles through a percutaneous lumbosacral route in awake patients with chronic headache and/or neck pain or those undergoing spinal surgery and in whom MR imaging did not disclose any particular abnormalities in the brain. A lumbosacral subarachnoid puncture was made with a modified method of a continuous epidural block.

Results. In 25 of 31 patients tested, the cerebellomedullary and/or pontine/interpeduncular cisterns were easily and safely reached, and the brainstem structures were visualized. Advancement of the fiberscope beyond the spinal level was abandoned in 6 patients with adhesive spinal arachnoiditis, because the fiberscopes encountered resistance seemingly caused by arachnoid adhesions. Further advancement of the fiberscopes up to the fourth and third ventricles was successfully achieved in 2 patients. A number of arachnoid filaments were found in the cerebellomedullary cistern in 4 patients: 2 with chronic spinal arachnoiditis, 1 with a spinal arachnoid cyst, and 1 with posttraumatic pain syndrome. None of the patients reported pain or any major complication except a postspinal headache and light fever, which were encountered in 4 and 1 patient, respectively.

Conclusions. The approach to the supraspinal structures via the lumbosacral route by using a fine, flexible fiberscope may provide a new, minimally invasive, and safe way to observe the cerebral cisterns and/or brainstem regions.

DOI: 10.3171/2007.12.17287

Key Words • brainstem • cerebral cistern • flexible fiberscope • lumbosacral route

Neuroendoscopy through a bur hole has been used both for the observation and surgical manipulation of the cerebral ventricles following the induction of general anesthesia.1–9,16,17,22 This technique still has risks and requires surgical invasion.3,5,11,12 According to a recent report, the infratentorial–supracerebellar approach to the third ventricle in cadavers still requires retraction of the brain mass.2

We have developed a safe and new method for observing the spinal canal and cisterns by using ultra-fine, flexible fiberscopes,14,15 This method of fiberscopy involves only a percutaneous lumbosacral puncture and can be applied in the diagnosis of spinal canal diseases.21 In the present study, we extended this method to observe the cerebral cis-

**Abbreviation used in this paper: AVM = arteriovenous malformation.**
Lumbosacral fiberscopic approach to the brain

The patients with pain had been treated with continuous epidural block or epidural spinal cord stimulation. These treatments were suspended 5–7 days before and after fiberscopy. All patients had normal coagulation tests and platelet counts before fiberscopy.

Patients were placed in lateral decubitus on the operating table. The skin at the puncture site was cleaned aseptically and numbed with an injection of 5–10 ml of 0.5% lidocaine. In the first 12 cases, a specially designed 14- or 16-gauge Tuohy needle was percutaneously introduced via a paramedian approach and angled ~ 45° in the coronal plane, into the epidural space and then the subarachnoid space at the L-5/S-1 or L-4/L-5 levels. The internal edge of the bevel of the Tuohy needle was polished to avoid damage to the fiberscope during advancing or withdrawing maneuvers. In the latter 13 cases, a 14- or 16-gauge venous catheter was used to introduce the fiberscope. The catheter tip was angled to ~ 60° by heating it prior to insertion. The technique for introducing the needle into the subarachnoid space was basically the same as that for the continuous epidural or spinal block. The fiberscope was introduced through the needle or catheter and advanced rostrally by direct visualization with a video image system, which was attached to a camera (Olympus PTV-F) or a videocassette recording system (Victor CR850) for monitoring and recording. Photographs were taken using an oroesophageal high-intensity light source (Olympus CLV-10) and color film (Olympus 1604-D). The position of the fiberscope tip was also identified and guided by radiography (Fig. 1).

During the procedures, the operator frequently asked each patient if there was pain or paresthesia during the manipulations. No sedatives or local analgesics were used during the procedures to avoid reducing the patient’s perception of pain and other discomfort. Vital signs and the electrocardiogram were also monitored. Lactated Ringer solution was infused through a forearm vein throughout the procedure.

Our fiberscopic method was aimed at approaching the cisterns and cerebral ventricles all the way from the lumbosacral subarachnoid space. However, when the scope encountered resistance or patients complained of transient pain and/or paresthesia during the approach from the spinal arachnoid space to the cistern, further procedures were abandoned and the fiberscope was withdrawn; this occurred in 6 cases with chronic arachnoiditis.

We used 2 types of soft, flexible fiberscopes jointly developed by Olympus Kogaku Co. and our laboratory (Fig. 1). The scopes had external diameters of 1.4 mm (PF14) and 0.9 mm (PF9). The fiberscopes were sterilized with formaldehyde tablets (Efgren, Tateishi Chemicals) for > 10 hours in a plastic box (35 × 35 × 60 cm²) and then kept in the same box for 2–4 days before fiberscopy. On the day of testing, the fiberscopes were washed extensively with sterilized distilled water.11,12

At the end of the fiberscopic examination, 20–40 ml of saline was administered into the epidural space through the Tuohy needle or the catheter by withdrawing it up to the inserted lumbosacral level except in the first 4 patients. All of the patients were restricted to bed rest for 24–48 hours following the fiberscopic tests.

Results

The introduction of fiberscopes from the lumbosacral subarachnoid space to the cerebral cisterns was successful in 25 of the 31 cases tested. The fiberscopes were not further advanced from the spinal levels in the remaining 6 patients. All 6 of these patients had chronic adhesive arachnoiditis and complained of pain (4 cases) or parasthesia (2 cases), with some resistance of the fiberscope during its introduction. The cerebellomedullary cistern was clearly demonstrated in 25 cases (Table 1). We tried to move the tip of the fiberscope ventrally—that is, from the cerebellomedullary to the pontine cistern in 6 cases with a rotating maneuver of the fiberscope; the fiberscope was successfully directed to the pontine cistern in 4 cases. The trial was abandoned in the other 2 cases in which the patients complained of paresthesia at the neck.

We visualized the lower surface of the cerebellum and its blood vessels, the dorsal surface of the medulla oblongata, the nerve roots, and the arachnoid filaments in all 25 cases in which the fiberscope was situated in the cerebellomedullary cistern (Fig. 2A–D).

Pulsating movements of the blood vessels synchronous with heartbeats were observed. Further advancement from the cerebellomedullary cistern to the fourth and third ventricles was tested in 2 cases and was successful without any complaints (Fig. 2E and F). In the third ventricle, the choroidal telae together with the arachnoid filaments and internal cerebral vessels was demonstrated (Fig. 2F).

The view from the pontine and interpeduncular cisterns revealed the surface of the pons, basilar artery, oculomotor nerve, and even the mammillary body surrounded by branches of the basal vein (Fig. 2G and H).

There were no major complications except headache in 4 cases and a light fever of 38.4°C in 1 case after the tests (Table 1). Headache occurred in 2 of the initial 4 cases in which epidural injections of saline had not been administered, whereas it occurred in only 2 of the later 21 cases in which 20–40 ml of saline had been injected into the epidural space during withdrawal of the fiberscopes (significantly less incidence, p < 0.01, chi-square test). Fever did not occur in the later 21 cases in which the
fiberscope had been carefully washed with distilled water both before and during the fiberscopy procedures.

There were a number of arachnoid filaments found in the cerebellomedullary cistern (Fig. 2A–D) in 4 patients: 2 with chronic spinal arachnoiditis, 1 with a spinal arachnoid cyst, and 1 with posttraumatic neck-shoulder syndrome. There were no pathological findings in the fourth and third ventricles of the 2 patients tested (Figs. 2E and F and 3)

### Discussion

Data in the present study demonstrated that the brainstem structures can be safely and easily visualized using fine, flexible fiberscopes via the lumbosacral route.

The safety of this technique is assured with the following 5 precautions. First, the fiberscopes were introduced through a subarachnoid puncture at the lumbosacral level (L-5/S-1 or L-4/L-5 level), which eliminates the possibility of injuring the spinal cord. Second, the fiberscopes are fine and flexible enough to float easily in the cerebrospinal fluid. Thus, even when the fiberscope hit the roots or vessels in the cerebrospinal fluid, it could slip out of those structures without causing any discomfort in all 25 patients (but not the 6 patients with chronic arachnoiditis). Even in these 6 cases with arachnoiditis, paresthesia-like discomfort could have been relieved by intensive readjustment of the fiberscope tip; however, we refrained from further procedures in these 6 patients. Third, all procedures were performed in patients during wakefulness, and the patients were instructed beforehand to report any discomfort or dysesthesia during the procedures. Fourth, the operator communicated with the patients frequently throughout the procedures and monitored the patient's general condition. Fifth, constant visualization through the fiberscopic image and x-ray image showed the position of the fiberscope tip during the procedures.

The safety of the technique is further supported by the absence of any major complications afterward. Headache occurred in the first 4 cases but was less frequent in the later 21 cases in which saline had been injected epidurally during withdrawal of the Tuohy needle or catheter. Headache occurred in 2 of the later cases after the patient had gone to the bathroom on foot soon after testing. The results suggest that these headaches were caused by dural puncture and were prevented by the epidural saline in-

---

**TABLE 1: Brainstem fiberscopy in 25 patients**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Diagnosis</th>
<th>Fiberscope Type</th>
<th>Range of Observation</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67, M</td>
<td>shoulder-neck syndrome</td>
<td>PF9</td>
<td>S1–Cm</td>
<td>none</td>
</tr>
<tr>
<td>2</td>
<td>40, M</td>
<td>chronic arachnoiditis</td>
<td>PF9</td>
<td>S1–Cm, Cp</td>
<td>headache</td>
</tr>
<tr>
<td>3</td>
<td>64, F</td>
<td>posttraumatic pain syndrome</td>
<td>PF9</td>
<td>S1–Cm</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>62, F</td>
<td>aseptic arachnoiditis</td>
<td>PF14</td>
<td>S1–Cm</td>
<td>headache, fever</td>
</tr>
<tr>
<td>5</td>
<td>60, M</td>
<td>adhesive arachnoiditis</td>
<td>PF9</td>
<td>S1–Cm</td>
<td>none</td>
</tr>
<tr>
<td>6</td>
<td>62, M</td>
<td>adhesive arachnoiditis</td>
<td>PF9</td>
<td>S1–Cm</td>
<td>none</td>
</tr>
<tr>
<td>7†</td>
<td>48, F</td>
<td>arachnoid cyst</td>
<td>PF9</td>
<td>S1–Cm, Cp</td>
<td>none</td>
</tr>
<tr>
<td>8</td>
<td>60, M</td>
<td>posttraumatic pain syndrome</td>
<td>PF9</td>
<td>L5–Cm, Cp, Ci</td>
<td>none</td>
</tr>
<tr>
<td>9</td>
<td>61, F</td>
<td>spinal canal stenosis</td>
<td>PF14</td>
<td>L5–Cm, Cp</td>
<td>none</td>
</tr>
<tr>
<td>10</td>
<td>73, M</td>
<td>spinal canal stenosis</td>
<td>PF14</td>
<td>L/S–Cm</td>
<td>none</td>
</tr>
<tr>
<td>11</td>
<td>72, F</td>
<td>spinal canal stenosis</td>
<td>PF9</td>
<td>L/S–Cm, Cp</td>
<td>none</td>
</tr>
<tr>
<td>12</td>
<td>77, M</td>
<td>spinal canal stenosis</td>
<td>PF14</td>
<td>L/S–Cm</td>
<td>none</td>
</tr>
<tr>
<td>13</td>
<td>69, M</td>
<td>spinal canal stenosis</td>
<td>PF9</td>
<td>L–Cm</td>
<td>none</td>
</tr>
<tr>
<td>14†</td>
<td>6, M</td>
<td>cervical spine aplasia</td>
<td>PF9</td>
<td>L/S–Cm, Cp, Ci</td>
<td>none</td>
</tr>
<tr>
<td>15†</td>
<td>49, F</td>
<td>HAM (myelopathy)</td>
<td>PF14</td>
<td>L5–Cm, Cp</td>
<td>none</td>
</tr>
<tr>
<td>16†</td>
<td>73, M</td>
<td>cervical spondylosis</td>
<td>PF9</td>
<td>L–Cm</td>
<td>none</td>
</tr>
<tr>
<td>17</td>
<td>70, M</td>
<td>cervical neuralgia</td>
<td>PF14</td>
<td>L–Cm</td>
<td>none</td>
</tr>
<tr>
<td>18</td>
<td>71, M</td>
<td>spinal canal stenosis</td>
<td>PF14</td>
<td>L/S–Cm</td>
<td>none</td>
</tr>
<tr>
<td>19</td>
<td>71, F</td>
<td>spinal canal stenosis</td>
<td>PF14</td>
<td>L/S–Cm</td>
<td>none</td>
</tr>
<tr>
<td>20</td>
<td>77, F</td>
<td>spinal canal stenosis, fracture</td>
<td>PF14</td>
<td>L/S–Cm, Cp</td>
<td>headache</td>
</tr>
<tr>
<td>21</td>
<td>75, F</td>
<td>spinal canal stenosis, fracture</td>
<td>PF14</td>
<td>L/S–Cm, Cp, Ci</td>
<td>none</td>
</tr>
<tr>
<td>22†</td>
<td>43, M</td>
<td>spinal AVM</td>
<td>PF14</td>
<td>L/S–Cm</td>
<td>none</td>
</tr>
<tr>
<td>23†</td>
<td>62, M</td>
<td>spinal AVM</td>
<td>PF14</td>
<td>L/S–Cm, Cp</td>
<td>none</td>
</tr>
<tr>
<td>24†</td>
<td>76, M</td>
<td>posttraumatic pain syndrome</td>
<td>PF14</td>
<td>L/S–Cm, Cp, V</td>
<td>headache</td>
</tr>
<tr>
<td>25</td>
<td>62, M</td>
<td>chronic arachnoiditis</td>
<td>PF14</td>
<td>L/S–Cm, Cp, V</td>
<td>none</td>
</tr>
</tbody>
</table>

* Ci = cisterna interpeduncularis; Cm = cisterna cerebellomedullaris; Cp = cisterna pontis; HAM = human T-lymphotropic virus type I–associated myelopathy; V = ventricle.

† Indicates surgical patients.
Lumbosacral fiberscopic approach to the brain

Fig. 2. Fiberscopic images. A: View from the entrance of the cerebellomedullary cistern. A number of arachnoid filaments were found. a = posterior inferior cerebellar artery; c = cerebellum (tonsil); d = dura mater with arachnoid; f = arachnoid filaments; m = surface of medulla oblongata. B: View from the cerebellomedullary cistern. a = posterior inferior cerebellar artery; c = cerebellum (tonsil); f = arachnoid filaments; m = surface of medulla oblongata (lateral tubercle); n = accessory nerve root. C: Closer view of medulla oblongata. c = cerebellum; f = arachnoid filaments; m = medulla oblongata (medial tubercle); v = posterior spinal veins. D: Closer view of cerebellar surface. c = cerebellum (tonsil); f = arachnoid filaments. E: View of fourth ventricle. e = medial eminence; p = cerebellar peduncle; v = internal vein. F: View of third ventricle. ch = choroid tela; f = arachnoid filaments; v = internal cerebral vessels. G: View from pontine cistern. a = basilar artery; b = mamillary body; cp = cerebral peduncle; n = oculomotor nerve; p = pons. H: View from interpseuduncular cistern. a = posterior communicating artery; b = mamillary body; cp = cerebral peduncle; p = pons; v = posterior spinal veins.

Fig. 3. Radiographs, lateral (upper) and ventroposterior (lower) views, showing the tip of the fiberscope in the third ventricle (arrows).
between these findings and a patient’s original complaints. Further study is needed to answer this question.

This method still might have some limitations. First, the technique can hardly be performed when there is an obstructive or inflammatory disease of the spinal arachnoid space, which can hinder advancement of the fiberscope through the space. We encountered this problem in 6 patients in the present study. This disadvantage, however, could reveal unexpected findings of chronic adhesive arachnoiditis. Second, the procedure needs some improvement in terms of manipulation of the fiberscope tip. Successful placement of the tip from the dorsal to ventral subarachnoid spaces was achieved in only 4 of 6 cases tested by rotating, withdrawing, or readvancing the fiberscope in the present study. The development of a proper angling device that does not increase the outer diameter of the fiberscope may improve the approach of the fiberscope to every part of the brainstem. With regard to the safe limit in fiberscope diameter, Stefanov et al.18 have reported that in > 100 human cadavers the subarachnoid space seems to be large enough for coaxial exploration from the spinal subarachnoid space through the cerebral aqueduct by using a 3.0–5.0-mm-diameter fiberscope. Fujimoto and colleagues7 and Purdy et al.13 have also demonstrated that the spinal canal, posterior fossa, and ventricular system can be approached even with 3.8–5.0-mm-diameter fiberscopes and that a stent can be passed across the third ventricle through a lumbar puncture in cadavers. Further improvements based on clinical experience may also allow routine placement of the fiberscope tip at an intended site in the brainstem subarachnoid space.

Approaching the cisterns from the lumbosacral region has several advantages. First, it may be safer and less invasive than direct approaches from the skull or cistern puncture.20 Second, it allows simultaneous observation of the entire spinal canal throughout the procedure. Third, the present technique might be relevant for direct diagnosis or confirmation of cisternal or ventricular abnormalities such as cystic diseases and AVM. We have shown that in the spinal canal this method could reveal these disorders even when MR imaging or CT scanning shows no particular findings.19,21 Finally, this method may allow microsurgery through a small lumbosacral puncture, instead of requiring a bur hole on the scalp, when additional developments to the technique, such as attaching a working channel and tip angling device, are developed with only a minimal increase in the outer diameter of the fiberscope.19,21

Conclusions

Fiberscopy may provide great promise in the diagnosis of brainstem and ventricular diseases by a simple lumbosacral puncture and by direct visualization through the fiberscope when MR imaging or CT scanning does not disclose any abnormality in these brain areas.

Disclosure

This paper was supported by Grant-in-Aid No. K810557137 from the Japanese Ministry of Education, Sciences, Culture and Sports.

Acknowledgments

We thank Mr. Y. Sato and Dr. M. Tomita, Department of Anesthesiology, Niigata University Graduate School of Medicine, for their skillful assistance throughout this study. We also thank Professor K. Kumaki, Niigata University Graduate School of Medicine, for kindly providing brain specimens; and Professor T. Nakada, Brain Research Institute, Niigata University, and Dr. W. Hamann, Department of Anesthesiology, Guy’s, King’s, and St. Thomas Hospital, London University, for valuable discussions during this study.

References

17. Song JK, Abou-Khali B, Konrad PE: Intraventricular monitoring for temporal lobe epilepsy: report on techniques and initial


Accepted December 17, 2007.
Current address for Dr. Shimoji: Clinical Research Center for Anesthesiologists, International University of Health and Welfare, Nogizaka, Tokyo, Japan.
Address correspondence to: Koki Shimoji, M.D., Ph.D., F.R.C.A., Pain Control Institute, 45-304 Yarai-cho, Shinjuku, Tokyo 162-0805, Japan. email: koki-shimoji@nifty.com.