Surgical treatment of syringomyelia in patients with Chiari I malformation remains controversial. We have treated these patients with both foramen magnum decompression and syringosubarachnoid shunt, depending on the size of syrinx. In this study, we describe our surgical procedure for the treatment of 59 patients with Chiari I malformation and syringomyelia, and we also discuss treatment-related outcomes.

**CLINICAL MATERIAL AND METHODS**

Between 1982 and April 2000, 117 patients with syringomyelia associated with Chiari I malformation were treated in Hokkaido University Hospital and its affiliated hospitals. Among them, 59 patients underwent placement of a syringosubarachnoid shunt as an initial treatment. These 59 patients form the basis of this study. There were 18 male and 41 female patients who ranged in age from 4 to 62 years (mean 28 years). A diagnosis of syringomyelia was established using MR imaging in all but three patients treated early in the series, in whom the diagnosis was reached using delayed computerized tomography myelography.

Selection of surgical procedures was based on the following principles. In patients with symptoms of Chiari I malformation, in whom a small-sized syrinx was documented, we performed decompressive surgery in the foramen magnum. In patients with a large-sized syrinx, we preferred to use syringosubarachnoid shunt. We judged the syrinx as large when the greatest transverse width divided by the width of the spinal cord at the same level exceeded 70%, as seen on axial MR images.

**Evolution of the Shunting Procedure**

The surgical technique used in our institution has been previously described. Our surgical procedure, however, has evolved over time. Initially we performed laminectomy and myelotomy in the posterior midline. Later, the procedure included DREZ myelotomy. Presently, the shunting procedure includes hemilaminectomy and DREZ myelotomy and the shunt tube placed in the ventrolateral subarachnoid space. Here we describe this latest modification.

**Technique for Placement of Syringosubarachnoid Shunts**

A hemilaminectomy is performed at the level where the syrinx was the largest in diameter. After exposing one side of the lamina, rougeurs and a diamond burr are used, after which bone dust collected. After the hemilaminectomy, an approximately $2 \times 1.7$-cm bone window is opened. The dura is opened and the dura mater stitched to the paravertebral muscle. The arachnoid membrane is opened and secured to the dura by using a small titanium clip. At the DREZ, the thinnest portion of the spinal cord is observed in most cases. A DREZ myelotomy is performed, approximately 2.5 to 3 mm in length, by using a microknife or scissors. After the myelotomy, clear fluid is observed to exit the syrinx. Before deflation of the spinal cord, the

Syringosubarachnoid shunt for syringomyelia associated with Chiari I malformation

**Object.** The authors describe the surgical procedures for placing syringosubarachnoid shunts and the results of surgery, as well as the prevention of shunt malfunction.

**Methods.** The series consisted of 59 patients with syringomyelia associated with Chiari I malformation in whom syringosubarachnoid shunts were placed. Their ages ranged from 4 to 62 years (median 28 years). The follow-up period ranged from 13 to 219 months. The authors principally implanted the shunts in patients with large-sized syringes. Neurological improvement was satisfactory, and postoperative magnetic resonance imaging demonstrated that the syringes had resolved or decreased in size in all patients. Reoperation was necessary in 10 patients who were treated before 1993.

**Conclusions.** To prevent shunt malfunction, both dorsal root entry zone myelotomy and placement of the syringosubarachnoid shunt tube into the ventral subarachnoid space are useful.

**KEY WORDS • Chiari malformation • syringomyelia • syringosubarachnoid shunt**
syringosubarachnoid shunt catheter is inserted. One end of the catheter is inserted into the syrinx in a cephalic direction and the other end is implanted into the ventrolateral subarachnoid space in a caudal direction (Fig. 1). The tube is secured to the pia mater with No. 8-0 nylon sutures. Gore-tex membrane (W.L. Gore & Associates, Inc., Flagstaff, AZ) is used as an inner sheet to prevent arachnoiditis. After closing the dura mater, a mixture of bone dust and fibrine glue (Bolheal; Chemo-Sero-Therapeutic Research Institute, Kumamoto, Japan) is placed on the dura mater to prevent cerebrospinal fluid leakage. The fascia, subcutaneous tissue, and skin are closed.

RESULTS

The results of surgery were successful. A representative case is illustrated in Fig. 2. No patient suffered a major surgery-related complication, and there were no deaths. Table 1 provides a summary of the results. The follow-up period ranged from 13 to 219 months (mean 115 months).

Fig. 1. Intraoperative photographs. A: After opening the dura, the left DREZ is almost transparent. B: A DREZ myelotomy of approximately 2.5 to 3 mm is performed. C: The syringosubarachnoid shunt tube is inserted into the syrinx. D: The syringosubarachnoid shunt tube is secured using No. 8-0 nylon suture.

Fig. 2. Representative imaging study. This 26-year-old woman presented with left hemijacket-type hypalgesia and pain in the left hand. Left: Sagittal MR image revealing a syrinx from C-2 to T-11. Center: Axial image demonstrating the syrinx lateralized to the left. Right: Postoperative MR image demonstrating reduction in size of the syrinx 2 weeks after surgery.
Surgical treatment of syringomyelia

Postoperatively the, lower cranial nerve dysfunction improved in two (25%) out of eight patients. Motor function improved in 32 (86%) of 37 patients sensory disturbance improved in 46 (90%) of 51 patients, and pain decreased in 16 (89%) of 18 patients.

Postoperative MR imaging demonstrated a marked decrease in the size of the syrinx in all patients. Secondary surgery, however, was necessary in 10 patients in whom the shunt malfunctioned (Table 2). The causes of the malfunction were as follows: 1) local arachnoiditis (six patients); 2) multiloculated syrinx (three patients); and 3) shunt tube migration to the lumbar level (one patient). All 10 of these patients had undergone shunt placement before 1993, when we inserted the shunt tube into the dorsal or lateral subarachnoid space. In 1993, we modified our technique and now place the subarachnoid end into the ventral portion of subarachnoid space. There have been no cases of shunt malfunction since that time.

DISCUSSION

Several surgical procedures have been performed for the treatment of syringomyelia associated with Chiari I malformation, including foramen magnum decompression with or without plugging of the obex,2,3,6 as well as the placement of syringosubarachnoid shunts.4,5,7,9,10 syringoperitoneal1 and thecoperitoneal shunts.11,12

Foramen magnum decompression has become the preferred procedure because it improves cerebrospinal fluid circulation around the foramen magnum. Placement of a syringosubarachnoid shunt, however, can cause the syrinx, even a large-sized syrinx, to deflate rapidly. It is also a less invasive treatment than the decompressive procedure. There have been some reports in which the authors indicated a potential risk of spinal cord injury when myelotomy is undertaken. When the site of myelotomy is the paper-thin DREZ, however, as first described by Rhoton,10 the risk of spinal cord injury is significantly reduced. In our series, there were no cases of myelotomy-induced injury.

The primary criticism of the syringosubarachnoid shunt is delayed shunt malfunction caused by local arachnoiditis around the shunt tube. Nauta, et al.,4 have reported a precise description of the microsurgical anatomy of the spinal subarachnoid space. Anatomically, many trabeculae exist between the pia mater and arachnoid membrane on the dorsal side of the spinal cord. Studies of the ventral subarachnoid space, however, have shown that there are no trabeculae between pia mater and arachnoid membrane. When the subarachnoid end of the shunt was placed ventrally, we had no further cases of shunt malfunction.

### TABLE 1

<table>
<thead>
<tr>
<th>Presenting Sign or Symptom</th>
<th>No. of Cases</th>
<th>Postoperative Status</th>
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<tbody>
<tr>
<td>cranial nerve</td>
<td>8</td>
<td>Improved: 2 (25%)</td>
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<tr>
<td></td>
<td></td>
<td>Unchanged: 6 (75%)</td>
</tr>
<tr>
<td>motor weakness</td>
<td>37</td>
<td>Improved: 32 (86%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unchanged: 5 (14%)</td>
</tr>
<tr>
<td>sensory disturbance</td>
<td>51</td>
<td>Improved: 46 (90%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unchanged: 5 (10%)</td>
</tr>
<tr>
<td>pain</td>
<td>18</td>
<td>Improved: 16 (89%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unchanged: 2 (11%)</td>
</tr>
</tbody>
</table>

### TABLE 2

<table>
<thead>
<tr>
<th>Site of Subarachnoid Tube</th>
<th>No. of Cases</th>
<th>Shunt Malfunction</th>
</tr>
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<tr>
<td>subarachnoid space</td>
<td>35</td>
<td>Worsened: 10 (29%)</td>
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<tr>
<td>dorsal</td>
<td>24</td>
<td>Improved: 0</td>
</tr>
<tr>
<td>ventral</td>
<td>24</td>
<td>Improved: 0</td>
</tr>
</tbody>
</table>

CONCLUSIONS

We believe that in cases of significant syringomyelia associated with Chiari I malformation a syringosubarachnoid shunt can be placed safely through a small hemilaminectomy and DREZ myelotomy. Placement of the subarachnoid end of the shunt into the ventral subarachnoid space is associated with a reduced incidence of shunt malfunction.

References


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