A telescopic ventriculoatrial shunt that elongates with growth

Technical note

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A ventriculoatrial (VA) shunt catheter has been developed, based on a double telescopic principle, that elongates during longitudinal growth of the child. It is implanted in patients by a technique similar to that used for other VA shunts, with minor modifications. Radiopaque markers on the expandable portion of the shunt allow radiographic measurement of the “growth” of the shunt. These shunts have been implanted in 18 children with hydrocephalus; in 15 they continue to function, a duration of from 1 to 4 years. In eight this was the initial shunt, while in 10 others the telescopic shunt was implanted at the time of revision of a standard shunt. One additional special model was implanted directly in the auricle by thoracotomy and is functioning over 5 months later. This type of shunt may largely eliminate the need for prophylactic lengthening of VA shunts during growth and prevent the problem of distal shunt obstruction due to growth.

KEY WORDS telescopic shunt cerebrospinal fluid hydrocephalus

The incidence of complications of ventriculoatrial (VA) shunts for hydrocephalus has tended to decrease with increased surgical experience and technical advances. The one problem that has not been resolved is that of distal shunt obstruction due to growth in infants and children. Since the standard shunt does not elongate as the infant or child grows, its distal end is gradually drawn upward into the superior vena cava where it tends to become obstructed. Thus, several additional operations may be necessary to lengthen the shunt prophylactically during growth, or to attempt to lengthen it urgently if it becomes obstructed due to growth and the child is shunt-dependent. Because of this, some neurosurgeons have changed to ventriculoperitoneal shunting in infants and young children, although many agree that VA shunting is the most effective of extracranial shunting procedures. It seemed to me that a VA shunt could be devised which would elongate as the child grew. The simple principles which might be applicable were the loop, the “accordion” pleat, and the telescope. The latter seemed least likely to be kinked or damaged by scar tissue. If the site of entry of the shunt into the venous system is considered the fixed
point, there are two gradients of growth, namely, that between the vein entry site and the cranial entry site superiorly, and that between the venous site and the auricle inferiorly. Thus a double telescopic mechanism seemed appropriate.

In 1963, I first contacted Mr. Rudolph Schulte* with this concept. At that time Mr. Schulte was exploring another type of expandable shunt and nothing further was done. In 1968, we again discussed the concept and Mr. Schulte made a prototype for me to try. The early model incorporated the small "infant" cardiac catheter, and this tended to kink and obstruct readily. This was apparent after use in one case and the shunt was altered to the present model.

The telescopic shunt is shown in Fig. 1. The distal segment (cardiac end) becomes adherent in the superior vena cava, with the little irregularities on its surface preventing easy withdrawal of this segment. Increase in distance between the auricle and the cervical fixation site causes this distal segment to elongate with growth. Increase in distance between the attachment to the cranial flushing device and the cervical fixation site causes the proximal segment to enlarge.

The "telescopic" shunt as currently made will allow 2.5 cm of longitudinal elongation between the cranial burr hole and the venous entry site, and 2.5 cm of elongation between the venous entry site and the auricle.

**Technique**

The surgical technique for implantation of this shunt is similar to that used for ordinary VA shunting. The proper length of a telescopic shunt measured from the fixation site in the vein to the tip of the cardiac catheter, is determined by inserting a special tube, supplied with every telescopic shunt, with radiopaque marks at every centimeter, through the facial or jugular vein to the auricle. This is checked by radiography (Fig. 2); measurements on the film give the correct length of shunt required. The shunt is now available in 6, 7, 8, and 9 cm lengths.

In placing the telescopic catheter, a shunt passer, which is a thin-walled tube with stylet, is inserted in the subcutaneous tunnel between the cranial and cervical incisions. The cardiac end of the telescopic shunt is passed through the shunt-passing tube from above to the cervical incision, with special care not to put any longitudinal tension on the shunt. The telescopic shunt is threaded into the vein until the distal collar lies within the vein; a suture is tied around the vein at the point of indentation of the collar. The shunt-passing tube is then carefully withdrawn into the cranial incision, and the proximal end of the telescopic catheter is cut to proper length to connect to the cranial

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Flushing device. Sufficient slack must be allowed so that when the neck is straightened after the operation, there will be no longitudinal pull on the proximal end of the telescopic shunt.

Since the two adjacent flanged ends of the catheter, lying within the telescopic cylinder are radiopaque, periodic x-ray films including the head, neck and chest, will delineate elongation of the shunt, which may be measured.

Results

Expandable telescopic shunts were implanted in 18 children between June, 1969, and February, 1972. In eight children, this was the initial shunt (Table 1). In two of these cases, shunt obstruction by particulate matter necessitated replacement of the shunt after 1 and 14 months respectively; telescopic shunts were replaced in both patients. All shunts are still functioning at the time of this writing over 1 to 4 years later. The "growth" of the shunt, measured by x-ray, was 13 to 38 mm, excluding the one achondroplastic dwarf in whom it was 4 mm (Table 1).

Telescopic shunts were implanted in 10 children at the time of revision of standard shunts. Six of these are functioning 1½ to 4 years later, and have "grown" 5 to 40 mm (Table 2). In three others, the telescopic shunt was used via thoracotomy after multiple previous shunt obstructions; technical problems ensued, and the telescopic shunts have been removed. In the tenth patient the telescopic shunt was implanted into the auricle through a thoracotomy, and it continues to function over 1 year later. In one additional case, not included in the 18, a special model was implanted at thoracotomy and has functioned for 5 months as this is written. At least four additional infants with hydrocephalus were treated with telescopic shunts by two other neurosurgeons, and the shunts were reported still functioning 8 to 14 months postoperatively.3,5

During the 4 years that the shunt has been in use, several modifications have been made. These have been done to improve and simplify the radiological measurement of "growth" of the shunt, and to make the plastic cylinder in the cervical area more flexible. There has been no essential change in the basic design of the shunt during this time.

In the earliest model, only the distal tip was radiopaque, so that measurement of shunt "growth" was quite crude. The next model was that described here, in which the adjacent ends of the two segments within the cylinder also are radiopaque so that their separation can be followed radiographically.

Figure 3 is a radiograph of the third patient in Table 1, taken 1 week after implantation of the telescopic shunt at 4 weeks of age. The ends of the two segments are in apposition. Ten months later, the radiopaque ends had separated 16 mm; and 2 years after that, the total growth of the shunt was 38 mm (Fig. 4). In all films, the distal end of the shunt remained at the level of the T-5 vertebra. The child was clinically well when last examined in February, 1973, at 3½ years of age.

In the radiographs of the model of the
TABLE 1

<table>
<thead>
<tr>
<th>Sex</th>
<th>Birth Date</th>
<th>Diagnosis</th>
<th>Date of Telescopic Shunt</th>
<th>Latest X-ray Film</th>
<th>Extension of Shunt Measured by X-ray (mm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>12/24/68</td>
<td>porencephaly, hydrocephalus</td>
<td>8/14/69</td>
<td>6/19/72</td>
<td>32</td>
<td>tip of cardiac end remains at T-6 on all films</td>
</tr>
<tr>
<td>M</td>
<td>5/8/67</td>
<td>achondroplasia, hydrocephalus</td>
<td>8/21/69</td>
<td>3/8/72</td>
<td>4</td>
<td>slow longitudinal trunk growth due to achondroplasia</td>
</tr>
<tr>
<td>F</td>
<td>9/8/69</td>
<td>Arnold-Chiari</td>
<td>10/3/69</td>
<td>8/17/72</td>
<td>38</td>
<td>cardiac tip at T-5; child well 2/7/73</td>
</tr>
<tr>
<td>M</td>
<td>7/30/69</td>
<td>postmeningitis, hydrocephalus</td>
<td>8/28/70</td>
<td>6/15/72</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>4/6/70</td>
<td>idiopathic nonobstructive hydrocephalus</td>
<td>10/21/70</td>
<td>8/11/71</td>
<td>13</td>
<td>December, 1971, obstructed shunt; entire shunt replaced 12/17/71</td>
</tr>
<tr>
<td>M</td>
<td>2/1/71</td>
<td>Arnold-Chiari</td>
<td>(2/8/71)</td>
<td>3/2/72</td>
<td>33</td>
<td>initial shunt obstructed, replaced on 3/1/71; ventricular end replaced 4/13/71; child well December, 1972</td>
</tr>
<tr>
<td>M</td>
<td>12/12/71</td>
<td>Arnold-Chiari</td>
<td>1/3/72</td>
<td>11/15/72</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>2/26/71</td>
<td>postmeningitis, hydrocephalus</td>
<td>2/7/72</td>
<td>1/17/73</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

Shunt just demonstrated, one could not tell how much each segment was elongating. Therefore, radiopaque bands were incorporated at either end of the outer cylinder, 5 cm apart. These serve two purposes. Since the distance between these two bands is fixed, correction for radiological distortion on films is facilitated. Moreover, the radiopaque catheter ends within the cylinder may be measured in reference to these outer bands, allowing separate evaluation of the "growth" of the two portions of the shunt.

TABLE 2

<table>
<thead>
<tr>
<th>Sex</th>
<th>Birth Date</th>
<th>Diagnosis</th>
<th>Date of Telescopic Shunt</th>
<th>Latest X-ray Film</th>
<th>Extension of Shunt Measured by X-ray (mm)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>4/25/67</td>
<td>Arnold-Chiari</td>
<td>6/12/69</td>
<td>11/13/71</td>
<td>22</td>
<td>first model: ends not radiopaque, so &quot;growth&quot; estimated from measurements; distal end remains at T-7</td>
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<tr>
<td>M</td>
<td>10/16/67</td>
<td>aqueductal stenosis</td>
<td>9/8/69</td>
<td>2/10/71</td>
<td>23</td>
<td>cardiac tip remains at T-7</td>
</tr>
<tr>
<td>F</td>
<td>7/4/67</td>
<td>aqueductal stenosis</td>
<td>9/9/69</td>
<td>1/24/73</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>6/16/62</td>
<td>Arnold-Chiari</td>
<td>4/14/71</td>
<td>1/22/73</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1/9/68</td>
<td>Arnold-Chiari</td>
<td>4/26/71</td>
<td>1/19/72</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>7/20/68</td>
<td>posthemorrhagic hydrocephalus</td>
<td>8/17/71</td>
<td>10/30/72</td>
<td>5</td>
<td>shunt obstruction 10/30/72, shunt replaced</td>
</tr>
</tbody>
</table>

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Fig. 3. Left: Radiograph of child taken 1 week after implantation of telescopic shunt. Right: Enlargement of area marked with square. The radiopaque ends of catheter (Fig. 1 F and G) are shown overlying C-1 vertebra (arrows).

Fig. 4. Left: Enlargement of radiograph of same patient as in Fig. 3 taken 10 months later. Shunt has “grown” (ends separated) 16 mm. Right: Radiograph taken 2 years later; shunt has now “grown” a total of 38 mm.
Burton L. Wise

Figure 5 reproduces a portion of a radiograph demonstrating this type of shunt.

In some patients, the cylinder seemed somewhat rigid, so that in the most recent models, the cylinder has had a metal spring incorporated in its wall to make it more flexible.

Finally, a special model was devised for direct implantation during thoracotomy. In this model, the distal collar is tied into the auricle or azygos vein, and the entire 5 cm tube with an elongation potential is in the proximal segment. The distal segment protrudes 3 cm into the auricle (Fig. 6).

A preliminary report of this shunt has been published.6

References


3. Goodman S: Personal communication


5. Tolchin S: Personal communication


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