Infections complicating the use of external ventriculostomy

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The use of external ventriculostomy at our institution has been retrospectively analyzed to determine the incidence of cerebrospinal fluid sepsis. Placement of 65 ventriculostomies over a 2-year period resulted in three cases of complicating meningitis and ventriculitis (4.5%). Duration of ventriculostomy placement did not seem related to the rate of infection but the method of placement, the prophylactic antibiotics used, and the monitoring and collecting system employed may be important.

Key Words • external ventriculostomy • meningitis • ventriculitis

External ventriculostomy continues to be important in the diagnosis and treatment of patients with intracranial pathology. Its use for ventriculography and ventricular fluid drainage is widely accepted. Sepsis associated with ventriculostomy is a risk usually regarded as acceptable considering the circumstances involved. As closer monitoring of neurosurgical patients becomes more common, ventriculostomy has been suggested as one of the more reliable methods of determining intracranial pressure. When a ventriculostomy is placed primarily for pressure monitoring, the question of sepsis as a potential hazard must be compared to the value of the information gained. An adverse ventriculostomy infection rate might well deter many surgeons from their use.

This report documents our experience with sepsis associated with ventriculostomies performed primarily for ICP monitoring.

Clinical Material and Method

All patients who had external ventriculostomies placed at this institution between July 1, 1971, and June 30, 1973, comprise the data base. During this period, 73 ventriculostomies (out of 75 attempted) were placed in 64 patients for intracranial pressure monitoring or drainage of ventricular cerebrospinal fluid (CSF). Table 1 indicates the various diagnoses that led to ventriculostomy placement. Eight patients died from their primary disease process while in the hospital and none had ventriculitis or meningitis clinically or at postmortem examination (six autopsies). Since the death of these patients limited adequate clinical follow up, they are deleted from the series. The 65 ventriculostomies in the remaining 56 patients were in place from 12 hours to 9 days with a mean placement time of 4.0 days.

All ventriculostomies were placed with the twist drill technique at either the paramedian coronal suture or the forehead as described by Kaufmann and Clark. This procedure was performed in the intensive care unit under local anesthesia or as an adjunct to surgical therapy in the operating room. The hair was widely shaved, and the scalp painted with tincture of iodine followed by alcohol; the
area was then prepared with an adhesive plastic drape. The incisional area was infiltrated with 0.5% Xylocaine with epinephrine, 1:100,000. A 5-mm scalp incision allowed placement of a 9/64 in. drill hole in the calvaria down to but not including the dura. A sharp No. 15 needle was used to make a puncture hole in the dura through which a polyethylene No. 8 French infant feeding tube (cut to appropriate length, fitted with a blunt needle, and passed over a blunt stylet) fits quite snugly. Ventricular puncture was usually indicated by the appearance of CSF in the transparent tubing. After stylet removal the tubing was fitted with a closed three-way stopcock with its female outlets covered by sterile caps. The incision was snugly closed around the tubing with silk, sprayed with Aeroplast,* covered with a miniature sterile tracheostomy-like dressing measuring $2 \times 2$ in.; this was heavily sprayed with Aeroplast and covered with 1-in. non-sterile waterproof adhesive tape. This dressing was not disturbed until the ventriculostomy was removed.

The female outlets of the three-way connector were attached to a sterile saline-filled transducer system and monitor device and/or a drainage system of intravenous tubing and an expandable nonvented polyethylene blood transfer pack.† All connections were doubly secured with adhesive tape.

One ventricular tube became dislodged and CSF leaked through the scalp incision around the tubing in another patient early in the series; leakage did not recur following the placement procedure described above. The system became disconnected due to movement of the patient in two instances and was considered sufficient cause for immediate removal of the ventriculostomy. Elective removal of the ventricular tubing was preceded by withdrawal of a CSF specimen for analysis and culture from the tubing, after which a single silk suture was placed in the incision to close it snugly. The ventriculostomy site was not dressed.

Antibiotics were administered from the time of ventriculostomy placement to 2 to 3 days following removal in 62 instances. The agents employed were ampicillin (500 mg, every 6 hrs) in 29 cases, methicillin (500 mg, every 6 hrs) in 25 cases, and a variety of other antibiotics in the remaining eight cases.

**Summary of Cases**

Three patients developed clinical meningitis, defined as fever, increased obtundation, and positive bacteriological cultures from CSF (Table 2). One patient recovered with appropriate antibiosis, and the other two died. The average duration of ventriculostomy placement in these three infected patients was 2.7 days, and all were receiving prophylactic ampicillin.

Four patients developed fever and CSF leukocytosis 7 to 14 days following ventriculostomy removal. All had undergone craniotomy and all had the ventriculostomy routinely removed; cultures yielded no growth. Lumbar CSF obtained at that time was sterile in all but one patient, whose CSF grew *Staphylococcus epidermidis*; this bacterium was also cultured from his septic craniotomy wound which was draining CSF.

We did not consider the ventriculostomy at fault in these four cases because of the time delay between the ventriculostomy and symptoms, the lack of bacteriological confirmation in three cases, and the obvious septic wound in the fourth.

Cultures were not obtained upon removal of the ventriculostomy in 12 of 65 instances. Unfortunately, the three patients whose sepsis was secondary to the ventriculostomy are in this group. Of the 53 cultures obtained, 46 were sterile while seven grew a scant number of organisms (three *Staphylococcus aureus*; three *Staphylococcus epidermidis*; one *Hemophilus influenzae*). Six of these seven

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* Aeroplast manufactured by Parke, Davis and Company, Detroit, Michigan 48232.
† Blood transfer pack TA-10 manufactured by Travenol Laboratories, Hyland Division, Los Angeles, California 90039.

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**TABLE 1**

Reasons for 65 ventriculostomies in 56 patients

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>cerebral trauma</td>
<td>21</td>
</tr>
<tr>
<td>hemorrhage</td>
<td>21</td>
</tr>
<tr>
<td>intracranial hematoma</td>
<td>21</td>
</tr>
<tr>
<td>subarachnoid hemorrhage</td>
<td>15</td>
</tr>
<tr>
<td>tumors</td>
<td>8</td>
</tr>
<tr>
<td>total</td>
<td>65</td>
</tr>
</tbody>
</table>
Infections associated with external ventriculostomy

Table 2
Course in three patients developing meningitis following ventriculostomy

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Ventriculostomy Type, Duration</th>
<th>Antibiotic</th>
<th>Organism Cultured</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>cerebellar infarct</td>
<td>coronal, 2 days</td>
<td>ampicillin</td>
<td>Pseudomonas</td>
<td>died</td>
</tr>
<tr>
<td>brain stem contusion</td>
<td>coronal, 3 days</td>
<td>ampicillin</td>
<td>Pseudomonas</td>
<td>died</td>
</tr>
<tr>
<td>basal skull fracture</td>
<td>forehead, 3 days</td>
<td>ampicillin</td>
<td>Serratia</td>
<td>recovered</td>
</tr>
<tr>
<td>acute subdural hematoma</td>
<td></td>
<td></td>
<td>Klebsiella</td>
<td></td>
</tr>
</tbody>
</table>

Positive cultures were not obtained with our standard technique; in those cases the tubing tip was submitted for culture. None of the seven patients in whom organisms were grown developed any clinical signs or symptoms of central nervous system sepsis, which supports the contention that tubing-tip cultures result in inaccurate bacteriological information about the cavity being drained. 2

Cell counts were obtained on only 24 CSF specimens, none of them from the infected group. Red cell counts ranged from 0 to 62,000 and white cell counts from 0 to 8050. There was no correlation between either the CSF white blood cell count and the number of red blood cells present (hemogenic leukocytosis), or between the white cell count and the duration of ventriculostomy placement (foreign body effect, Fig. 1). Only three of the samples that grew organisms (two tip cultures and one from fluid itself) also had cell counts obtained. These counts were 80 (60% polymorphonuclear cells), 150 (90% polymorphonuclear cells), and 5200 (55% polymorphonuclear cells). White cell counts in those patients who grew nothing from CSF cultures taken at removal of the ventriculostomy ranged from 0 to 5 in nine cases, 5 to 50 in six cases, 50 to 250 in four cases, and were 950 and 2700 in one case each.

Discussion

Lundberg’s 1960 monograph indicated a very low infection rate following ventriculostomies. Wyler and Kelly 6 reported an infection rate varying from 9% to 27% in a series of 102 ventriculostomies. Staphylococcus was the organism most frequently isolated. Our infection rate was 4.6% based upon three documented infections in 65 ventriculostomies in patients without a CSF fistula.

Wyler and Kelly based their infection rate upon the number of patients rather than the number of ventriculostomies in a group of 44 patients receiving prophylactic antibiotics. Since their series contained 102 ventriculostomies on 70 patients, recalculation of their rate of sepsis based upon number of infections per number of ventriculostomies would probably approach 6%, a value more in keeping with our experience. Failure to use prophylactic antibiotics was associated with an 18% infection rate in Wyler and Kelly’s series. Only three patients did not receive antibiotics in our series, and although none became infected, this sample is too small for significant analysis.

Lundberg treated all ventriculostomies with prophylactic streptomycin and/or
penicillin or sulfonamides, Wyler and Kelly used ampicillin, and ampicillin or methicillin were used on our patients. All of our cases of sepsis as well as those developing ventriculitis while being treated prophylactically by Wyler and Kelly occurred when ampicillin was used.

Wyler and Kelly interpreted their data to support the concept that duration of placement was directly related to sepsis. The average duration of ventriculostomy placement in their infected group was 8.1 to 10 days, while nonseptic cases ranged from 2.5 to 5 days. Lundberg's series contained 58 ventriculostomies that were in place for a week or more. None of these became infected. Our infected cases had a mean placement time of 2.7 days, shorter than that of the nonseptic group (4.0 days). In our series, we cannot confirm a relationship between duration of ventriculostomy placement and sepsis in patients treated with prophylactic antibiotics.

How the ventriculostomy is used may be significant. In Lundberg's series the ventriculostomy was used primarily for recording intracranial pressure by way of a closed strain-gauge system. Wyler and Kelly generally used their ventriculostomies for CSF drainage and employed an air-vented collection bottle containing an antibiotic solution. Poppen reported no infection in 500 ventriculostomies used for drainage in which he employed a closed system. Bering used an air-vented system for drainage in 29 ventriculostomies, five of which developed ventriculitis.

After conversion from an air-vented bottle for CSF collection to the closed system we have described, we had no occurrences of sepsis related to ventriculostomy.

Lundberg recommended that the dural opening be no larger than absolutely necessary to accommodate the ventricular tube, so as to decrease the possibilities of CSF egress along the catheter tract. Our early practice, like that of Wyler and Kelly, was to perforate the dura with a twist drill bit, which results in a dural opening a bit larger than the ventriculostomy tubing. The only barrier to CSF leakage is coaptation of the scalp incision to the tubing. Leakage of CSF through the incision occurred in one of our patients with this technique; the wound became septic and the patient died. After a modification of our procedure to include penetration of the dura with a sharp No. 15 needle, which allows a snug fit around the No. 8 French tube, no sepsis associated with ventriculostomy has occurred.

Conclusions

Ventriculostomy free of septic complications appears to be an attainable goal. We would recommend that:

1. Placement technique include dural penetration in such a manner as to result in a snug fit between tubing and dura.
2. Limited dressings be employed so that any leakage of CSF through the scalp incision is rapidly recognized.
3. Parenteral antistaphylococcal antibiotics (methicillin, dicloxacillin) be routinely administered while the ventriculostomy is in place and for a day or two following its removal.
4. A closed system be maintained at all times which precludes the use of open manometers for pressure measurement or air-vented bottles for CSF collection.

Since we have followed this regimen, we have experienced no intracranial sepsis in our last 38 consecutive ventriculostomies.

References


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