Function of parietal and frontal shunts in childhood hydrocephalus

A. LELAND ALBRIGHT, M.D., STEPHEN J. HAINES, M.D., AND FLOYD H. TAYLOR, Sc.D.

Departments of Neurological Surgery and Community Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania and Department of Neurosurgery, University of Minnesota, Minneapolis, Minnesota

This study was performed to determine if cerebrospinal fluid (CSF) shunts inserted via the frontal and parietal regions function for similar lengths of time. The medical records of 114 children with CSF shunts were reviewed. In 83 of these cases computerized tomography scans were also available. Ninety percent of the operations were to insert the child's first shunt. The site of insertion, cause of hydrocephalus, patient's age, surgeon, duration of function (time from insertion to malfunction or to latest follow-up evaluation), presence of infection, catheter location within the ventricle, and duration of function of the subsequent shunt were recorded. Data were analyzed by the chi-square, logistic regression, and life-table methods. Shunts had been inserted via the frontal route in 62 children and via the parietal route in 52. The children's ages, causes of hydrocephalus, and infection rates were similar in both groups. Duration of shunt function was predicted by the site of shunt insertion and the catheter position within the ventricles: shunts inserted via the frontal region functioned significantly longer than parietally inserted shunts, both as the initial shunt (Wilcoxon, p = 0.0008) and after a malfunction, and catheters positioned within the ipsilateral frontal horn functioned significantly longer than those in other ventricular locations (Wilcoxon, p = 0.03).

Key Words • hydrocephalus • ventriculoperitoneal shunt • frontal region • parietal region

The treatment of childhood hydrocephalus is hindered by the two common complications of cerebrospinal fluid (CSF) shunts: obstruction and infection. The most common site of shunt obstruction is the ventricular catheter.\textsuperscript{4,5} Catheters are usually inserted into the ventricular system either frontally, along the coronal suture at the pupillary line, or posteriorly, in the parietal region. Neurosurgeons have strong opinions as to which of the sites is preferable.

At the Children's Hospital of Pittsburgh, the years 1978 to 1981 were a period of transition from inserting shunts parietally to frontally, and children treated during that transition time have been followed long enough to be compared. This study was performed to determine if the duration of function was similar for shunts inserted via the frontal and parietal regions.

Clinical Material and Methods

Patient Population

The medical records of 180 children with CSF shunts who were treated at the Children's Hospital of Pittsburgh from 1978 to 1981 and of 20 additional patients treated at the University of Minnesota Hospital were reviewed. Eighty-six children were excluded: those whose hydrocephalus was associated with tumors (because of uncertainty that persisted after tumor removal); those with hydrocephalus associated with cysts, if the shunt was inserted into the cysts; and those lost to follow-up study.

The study group comprised 114 children undergoing their first shunt in our hospitals; 90% were undergoing placement of their first shunt in any hospital. Four shunts were ventriculosternal and 110 were ventriculoperitoneal. Ventricular catheters were not inserted with radiographic or ultrasound guidance, and none of the catheters had flanges. Postoperative computerized tomography (CT) scans were available for 83 of these children.

Study Methods

For each patient, the site of catheter insertion, the cause of hydrocephalus, patient's age (in years) at shunt operation, surgeon, duration of function, presence or absence of infection, and location of the ventricular catheter on CT were recorded. For children whose shunts malfunctioned and required another operation,
the duration of function was measured for the second shunt. The insertion site was either frontal or parietal. Causes of hydrocephalus were listed as myelomeningocele, aqueductal stenosis, intraventricular hemorrhage, or "other." Surgeons were listed as A, B, C, D (those who inserted the majority of the shunts), and E (other surgeons). The duration of function was recorded as the number of years from shunt insertion to revision or to the latest follow-up evaluation. Infection was listed as present if CSF cultures were positive; in that event, all shunts were removed. The location of the ventricular catheter as indicated by CT was graded as good if the catheter was located in the ipsilateral ventricle anterior to the foramen of Monro, as fair if it was in the contralateral frontal horn or near the choroid plexus, and as poor if it was partially located in the parenchyma.

Statistical Analysis

The data were summarized by descriptive statistical methods. Chi-square tests were used to examine different pairs of variables for possible association between them. All chi-square tests were reported with the Yates' correction. A stepwise logistic regression analysis was used to search for a set of covariates that might have an impact on the duration of shunt function. The covariates for the logistic regression were the following: patient's age, cause of hydrocephalus, insertion site, catheter position, surgeon, and presence or absence of infection. Age was the only covariate that was a continuous variable. The probabilities to enter and remove variables in the stepwise regression procedure were 0.15 and 0.10, respectively. Life-table methods were used to obtain "survivorship" curves that would display duration of shunt function. The time to the first malfunction was used as "survival" time in the life tables and in the logistic regression. Statistical significance was defined as a p value of 0.05 or less in all statistical tests.

Results

Shunts had been inserted frontally in 62 children and parietally in 52. The duration of function was significantly different in the two groups, with frontal shunts functioning longer than parietal shunts (Wilcoxon, p = 0.0008; Savage, p = 0.0015) (Fig. 1). This difference held true for subsequent shunts in children whose first shunts had malfunctioned (chi-square, p = 0.02).

The children's age at shunt insertion ranged from 1 day to 10.9 years, with a median age for the entire group of 0.12 years and a mean age of 0.6 years. There was no significant difference in ages between the two groups (Table 1). Causes of hydrocephalus in the entire group were as follows: myelomeningocele 31%, aqueductal stenosis 16%, intraventricular hemorrhage 27%, and other causes 26%. There was no significant difference in causes between the groups (chi-square, p = 0.45) (Table 2). Infection occurred with similar frequency in the two groups: in 11% of children with frontal shunts and in 8% of those with parietal shunts (chi-square, p = 0.721).

Three variables were selected by the regression analysis as important predictors of duration of function: insertion site, catheter position, and infection. Infection had the greatest influence on duration of function because all infected shunts were removed; insertion site and catheter position were approximately equal in their impact. The relationship between insertion site and catheter position is shown in Table 3 and in Fig. 2.
TABLE 3

<table>
<thead>
<tr>
<th>Catheter Position</th>
<th>Frontal Group</th>
<th>Parietal Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>good</td>
<td>26 (55%)</td>
<td>12 (33%)</td>
</tr>
<tr>
<td>fair</td>
<td>20 (43%)</td>
<td>19 (53%)</td>
</tr>
<tr>
<td>poor</td>
<td>1 (27%)</td>
<td>5 (14%)</td>
</tr>
</tbody>
</table>

* Data are given for the 83 patients for whom computerized tomography scans were available. Numbers in parentheses are percentages of each group in each shunt position. For a description of shunt position see text. Data in each shunt group are compared statistically: chi-square = 6.506; df = 2; p = 0.0386.

had ventricular catheters in a good position, compared to 12 (33%) of 36 with parietal shunts (chi-square, p = 0.04). Frontal shunts in good position had a long-term (5-year) function rate of 70%, significantly better than the 40% rate of parietal shunts in good position.

The distribution of patients by group and surgeon is listed in Table 4. The particular surgeon had no significant effect on the other variables according to survival analysis with covariates. Only Surgeon A had inserted enough shunts into each group to allow comparison of shunt function between groups; the long-term function rate achieved by this surgeon was 40% for frontal shunts and 20% for parietal shunts (Savage, p = 0.11).

The number of shunts placed at each institution was not sufficiently large to allow a comparison of institutions.

Discussion

These data support the statement by Hoffman and Smith 3 that "the ventricular catheter functions best when it is in the frontal horn of the ventricle, remote from choroid plexus." Ultrasound can be used intraoperatively to guide and confirm ideal catheter placement. 3,7 The low (25%) long-term function rate for parietal shunts is similar to the rate reported by Fernell, et al., 4 for Scandinavian children with ventriculoperitoneal shunts and to the 19% function rate at 12 years for 1719 children from the Toronto Hospital for Sick Children and the Paris l'Hôpital des Enfants-Malades (C Sainte-Rose, personal communication, 1988).

The definitive answer to the question about ventricular catheter placement would come from a randomized prospective clinical trial. Our study has the usual deficiencies of any retrospective trial, primarily the question of comparability of the two groups; however, children in the two groups were analogous in age, cause of hydrocephalus, and infection rate. The causes were similar to those reported in other series. 4 Although the surgeons differed somewhat between the two groups and there was some variation in shunt hardware (approximately 80% were medium-pressure Cordis shunts), we believe that the two groups are comparable enough to apply the study results to a larger population.

![Fig. 2. Left: Life-table analysis of duration of shunt function for ventricular catheters in good position (solid line) and fair or poor position (broken line), as defined in the text. The curves are significantly different (Wilcoxon, p = 0.03; Savage, p = 0.02). Right: Life-table analysis of duration of shunt function for ventricular catheters by site of insertion and position in the ventricle. Solid line = frontal, good position; dashed line = frontal, fair or poor position; dotted line = parietal, good position; dotted and dashed line = parietal, fair or poor position. The curves are significantly different (Wilcoxon, p = 0.006; Savage, p = 0.008).](image)
Although Becker and Nulsen\(^1\) recognized the importance of parietally inserted shunt catheters lying anterior to the foramen of Monro, we found that parietal shunts in good position did not function as long as frontal shunts in good position. In fact, poorly positioned frontal shunts and well-positioned parietal shunts seemed to have approximately equivalent duration curves (Fig. 2 right). The difference in function in well-placed shunts can be attributed to the fact that, although the tip of a parietally inserted shunt may lie in the frontal horn, the catheter proximal to the tip frequently lies near choroid plexus, which eventually obstructs it.

Duration of function was defined as the time from shunt insertion to latest follow-up evaluation or to revision. That definition assumes that the criteria for shunt revisions were similar for surgeons in the two groups, and that the proportion of “arrested” hydrocephalus (if any) would be equal in the two groups. We did not distinguish ventricular from peritoneal obstruction, because 1) the site of obstruction was not specified in several operative notes; 2) in previous series and in our experience, proximal obstruction occurred far more commonly than distal obstruction; and 3) we knew of no reason to expect any difference in the frequency of distal obstruction between the two groups.

In the regression analysis, the operating surgeon did not significantly affect the other variables; that is, a shunt’s insertion site and position in the ventricle predicted the duration of shunt function, but the surgeon who inserted it did not. The analysis showed that some surgeons were more likely to insert a shunt into the ideal site, but the numbers were too small to compare surgeons with each group.

This study strongly supports frontal insertion of shunts because of their longer function, and it conflicts with the statement by Dan and Wade\(^2\) that “… the frontal locus should be avoided whenever possible,” a conclusion they arrived at after finding a 6.6% frequency of epilepsy in 168 patients with parietal shunts and a 54.5% frequency in 11 patients with frontal shunts. In our opinion, the relationship between shunt site and epilepsy cannot be adequately evaluated in 11 patients, especially if several of their patients who developed epilepsy had disorders commonly associated with seizures (encephalitis, trauma, and supratentorial tumors). Any study of the relationship between shunt insertion site and post-shunt epilepsy must include in the frontal and parietal groups equal numbers of patients with features known to be associated with epilepsy: brain damage in premature infants, the cortical malformation of myelomeningoceles, shunt infections, and the number of shunt revisions. The high epilepsy rate reported by Dan and Wade for frontal shunts was determined mainly in adults. Venes and Dauser\(^8\) subsequently reported that only five (7.2%) of 69 children who were seizure-free preoperatively developed seizures after insertion of frontal shunts. Leggate, et al.,\(^6\) found that epilepsy developed in only 16% of 56 children with both frontal ventriculostomies and parietal shunts. In the present study post-shunt epilepsy was present in 30% of children with frontal shunts; we were unable to determine the frequency for children with parietal shunts because most parietal shunts were ultimately changed to the frontal location.

**References**


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Address reprint requests to: A. Leland Albright, M.D., Department of Neurosurgery, Children’s Hospital of Pittsburgh, 3705 Fifth Avenue at DeSoto, Pittsburgh, Pennsylvania 15213.