The Outcome of Shunted Hydrocephalic Children

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Key Words hydrocephalus; reoperation; intelligence tests

Background. Neurological sequelae and mental retardation may result from different etiological types of hydrocephalus. The aim of our study is to determine the intellectual problems and the “shunt history” of these children with regard to complications and reoperation rates.

Methods. We reviewed the medical history of non-tumoral pediatric hydrocephalic patients who had received first shunt insertions between 1983 and 1997 and had been regularly followed up at the outpatient clinics of Taipei Veterans General Hospital. These patients were categorized into five different etiological groups. Their intelligence test scores and the surgical morbidity encountered over this period were used as the main outcome measures.

Results. Out of the seventy-three patients, post-meningitis hydrocephalic patients had the significantly highest shunt revision rate (2.50 ± 0.82, p = 0.01). They also showed retardation in IQ scores, but the difference was not significant when compared with other groups. The results of IQ tests were not related to either the age of initial shunt insertion (p = 0.461) or revision rates (p = 0.292). For physical disabilities, post-meningitis hydrocephalic patients showed highest incidence of epilepsy (40%) whereas hydrocephalic patients associated with myelomeningocele had the highest incidence of motor deficits (56.25%).

Conclusions. Childhood hydrocephalic patients had different long-term neuroimpairments with respect to different etiologies. This study provides information about the physical and mental outcome of post-operative hydrocephalic patients which is valuable to assist in counseling of their families. [Chin Med J (Taipei) 2001;64:47-53]
spina bifida. Aqueductal stenosis refers to a congenital narrowing of the aqueduct of Sylvius that can result in a blockage of CSF to disturb its circulatory pattern. Spina bifida or myelomeningocele consist of neuro-pathological changes in the hindbrain and cerebellum that create a barrier to CSF outflow from ventricular spaces to subarachnoid spaces. Postnatal causes consist of prematurity, post-meningitis and obstructions. Premature infants who suffer intra ventricular hemorrhage (IVH) can develop hydrocephalus because of the resulting blockage of CSF reabsorption. In meningitis, the purulent exudate accumulates in subarachnoid spaces, obstructs the foramina of Luschka and Magendie, and interferes with absorption of CSF by the arachnoid villi.

Because childhood hydrocephalus is a serious condition which entails a considerable risk of subsequent developmental impairments, evaluating the outcomes of shunting procedures has been come extremely important to physicians and families. The present study analyzes the physical and intellectual outcomes of the different etiological groups. The surgical complication rates were reviewed. The age at first shunt insertion, the number of shunt revisions, and their effects on intellectual development are also discussed.

**Methods**

All children under 3 years of age presenting to the Pediatric Neurosurgery Department who had been documented as non-tumoral hydrocephalus patients and had undergone their first shunt insertions between 1983 and 1997 were included in the study. These patients were followed regularly at the outpatient clinics of Pediatric Neurosurgery Department and Department of Physical Medicine & Rehabilitation after surgery.

The etiology of hydrocephalus was determined by clinical evaluation, CT scans and operative findings, and was categorized as follows: (1) premature type hydrocephalus, for those who were born with gestational age less than 36 months, (2) obstructive type hydrocephalus, for full-term individuals who had documented obstructive hydrocephalus by CT scans or experimental findings, (3) hydrocephalus occurring after meningitis, (4) hydrocephalus associated with congenital anomalies, for subjects with Arnold-Chiari I brain malformations, sub-tentorium arachnoid cysts, achondroplasia, Dandy-Walker cysts, dermoid sinus, parenchymal leukomalacia and megacephaly, and (5) hydrocephalus associated with myelomeningocele, for those who had defects of neural tube closure so as to be associated with spinal dysraphisms and the Arnold-Chiari II brain malformations.

The minimum postoperative follow-up was 2 years. Data in cluding age, sex, etiology of hydrocephalus, age at which the first shunt was inserted, causes of shunt revision, number of shunt revisions, presence of physical conditions and intelligence test results for each child were obtained from medical records. Intelligence was evaluated using the Wechsler Intelligence Scale for Children (WISC) for those who were older than five years of age, and the Leiter International Performance Scale and Binet-Simon Scale for the remainder of the subjects. In reviewing the causes for shunt re-insertions, we identified four major groups of complications related to shunt revisions: shunt obstructions, shunt infections, reservoir ruptures and other miscellaneous reasons (subdural effusions, ventriculostomy failures, slit ventricles and shunt malfunctions of other unknown causes).

Kruskal-Wallis test was used to measure relationships among IQ scores, initial shunt ing ages and revision rates in different etiological groups. A p-value of less than 0.05 was considered as being statistically significant.

**Results**

Based on the aforementioned criteria, 82 children with hydrocephalus were identified in our medical records. Eight patients were followed up completely. One patient died in the midst of follow-up. Statistical analysis was performed on the remaining seventy-
There were a total of 41 males and 32 females in the study. The mean age ± standard deviation at initial shunt insertion for each etiological group is shown in Table 1. The mean age at latest clinical visit was 9.46 ± 4.49 years.

Length of follow-up ranged from 2.2 years to 10.3 years (mean = 6.2 years). During that time, 32 patients required shunt reinsertions. Table 2 demonstrates the shunt revision rates in different etiological groups. Post-meningitis hydrocephalic group patients had significantly higher rate of revision (p = 0.01) by Kruskal-Wallis test.

Seventy-eight shunt revisions were performed. Thirty-five (44.9%) were secondary to shunt obstructions, 19 (24.4%) due to shunt infections; 9 (11.5%) for reservoir rupture, and 15 (19.2%) for other reasons.

The mean age at the latest IQ test was 5.69 ± 3.25 years. Fifty-five patients had WISC test results. The numbers of patients who had received WISC test and their full IQ (FIQ), performance IQ (PIQ), and verbal IQ (VIQ) scores in each group are presented in Table 3. Post-meningitis hydrocephalic patients showed moderate retardation in both FIQ (65.60 ± 37.91) and PIQ (57.80 ± 32.63) scores, and severe retardation in VIQ (47.50 ± 18.91) scores. The ranges and means of FIQ, PIQ and VIQ scores in each group are presented in Figs 1, 2 and 3 respectively. Using Kruskal-Wallis test, we found no significant statistical difference in either FIQ (p = 0.337), PIQ (p = 0.082) or VIQ (p = 0.081) scores among different diagnostic groups. Nei-

### Table 1. Initial shunting ages in different etiological groups of hydrocephalic patients

<table>
<thead>
<tr>
<th>Etiological group</th>
<th>Number</th>
<th>Age (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature type</td>
<td>12</td>
<td>5.43 ± 1.57</td>
</tr>
<tr>
<td>Obstructive type</td>
<td>26</td>
<td>8.04 ± 1.96</td>
</tr>
<tr>
<td>Post-meningitis</td>
<td>10</td>
<td>21.80 ± 13.93</td>
</tr>
<tr>
<td>Associated with congenital anomalies</td>
<td>9</td>
<td>10.44 ± 3.88</td>
</tr>
<tr>
<td>Associated with myelomeningocele</td>
<td>16</td>
<td>3.00 ± 1.59</td>
</tr>
</tbody>
</table>

### Table 2. Shunt revision rates in different etiological groups of hydrocephalic patients

<table>
<thead>
<tr>
<th>Etiological group</th>
<th>Numbers of revisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature type (n = 7)</td>
<td>1.56 ± 0.50</td>
</tr>
<tr>
<td>Obstructive type (n = 9)</td>
<td>0.48 ± 0.15</td>
</tr>
<tr>
<td>Post-meningitis (n = 7)</td>
<td>2.50 ± 0.82</td>
</tr>
<tr>
<td>Associated with congenital anomalies (n = 3)</td>
<td>0.22 ± 0.15</td>
</tr>
<tr>
<td>Associated with myelomeningocele (n = 6)</td>
<td>0.79 ± 0.33</td>
</tr>
<tr>
<td>Total (n = 32)</td>
<td>0.93 ± 1.51</td>
</tr>
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the number of revisions \((p = 0.292)\) nor the age at initial shunting \((p = 0.461)\) had significant effect on IQ scores.

Of those suffering from epilepsy, 25\% patients had FIQ scores above 90 and 44\% had FIQ scores below 60. Incidences of epilepsy and motor deficits by different etiological group are shown in Table 4.

### Discussion

Shunt obstruction is the major problem requiring...
shunt revision among post-operative complications, as validated by our observation that 44.9% shunt revisions were due to shunt obstructions. Although the reason remains unclear, a previous study has suggested the possibility of some unidentified biological factors cause after three or more revisions, the remaining choroid tissue remains in the ventricular system to normal size, although not sufficient to obstruct the catheter.

The data in Table 3 showed that except for the children with hydrocephalus associated with congenital anomalies and hydrocephalus with myelomeningocele, all other groups of hydrocephalic patients had FIQ scores less than the normal population. Obiously, the hydrocephalus itself has implications on the intelligence. According to previous studies, hydrocephalus thins the brain and distorts the brain. Although significant cell loss does not occur, the axons in the periventricular white matter are elongated, and the surrounding myelin is disrupted. Myelination of the corpus callosum is also delayed. This might contribute to the lower IQ of FIQ scores in most of the hydrocephalic patients.

In our study, two groups with high est FIQ scores were those having congenital anomalies and myelomeningocele. In all the series published, IQ scores are best in patients with myelomeningocele. Hirsch et al. proposed that the CSF leak age at the level of the cisterns and the brain is disrupted. Myelination of the corpus callosum is also delayed. This might contribute to the lower IQ of FIQ scores in most of the hydrocephalic patients.

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In conclusion, since childhood hydrocephalus may lead to severe neurological defects in the brain, postmeningiitis hydrocephalus is often poor. The highest incidence of epilepsy was found in those with posthemorrhagic and postinfectious hydrocephalus, etiologies known to be associated with complex brain pathology and low functional status. Acording to our study, 40% of post-meningiitis hydrocephalus patients suffered from epilepsy; only 25% of the children with epilepsy had an FIQ score above 90 and 44% of the cases had an FIQ score below 60.

In conclusion, as childhood hydrocephalus may lead to severe neurological defects in the brain, postmeningiitis hydrocephalus is often poor. The highest incidence of epilepsy was found in those with posthemorrhagic and postinfectious hydrocephalus, etiologies known to be associated with complex brain pathology and low functional status. Acording to our study, 40% of post-meningiitis hydrocephalus patients suffered from epilepsy; only 25% of the children with epilepsy had an FIQ score above 90 and 44% of the cases had an FIQ score below 60.
cephalic patients pose a serious problem. Patients should be informed of such high morbidity risk before surgery can be done. As parents are increasingly concerned about the academic performance when their hydrocephalic children reach school age, re searches on school performance will be come the next important issue for future studies.

References