The relationship of subarachnoid hemorrhage and the need for postoperative shunting

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The incidence of chronic hydrocephalus requiring shunting after aneurysmal subarachnoid hemorrhage (SAH) is not precisely known. The authors investigated whether the need for ventriculoperitoneal (VP) shunting can be predicted by initial Hunt and Hess grade or Fisher computerized tomography score. One hundred eight patients who presented with SAH and underwent 116 surgical procedures for aneurysm clipping were evaluated retrospectively to determine the incidence of chronic hydrocephalus. Chronic hydrocephalus was defined as clinically and radiographically demonstrated hydrocephalus that lasted 2 weeks or longer after the original hemorrhage and that required shunting. All SAH patients were managed in a similar fashion with induced hypervolemia, relative hemodilution, and hypertension complemented by a course of calcium channel blockers. The majority of patients underwent perioperative extracranial ventricular drainage to allow intraoperative brain relaxation and to assist intracranial pressure management. The overall mortality rate of the study group was 17%. Of the surviving patients, 20% underwent VP shunt placement secondary to chronic hydrocephalus. There were no statistically significant relationships between chronic hydrocephalus and patient age or gender, aneurysm type and size, or use of a perioperative drain. There was a high clinical correlation between chronic hydrocephalus and admission Hunt and Hess grades and Fisher grades (p < 0.05). All of the patients who survived a second bleeding episode and almost 46% of the patients who presented with intraventricular hemorrhage required placement of a VP shunt. The authors present predictive tables of chronic hydrocephalus based on the patient’s admission Hunt and Hess grade and Fisher classification.

KEY WORDS • aneurysm • subarachnoid hemorrhage • ventriculoperitoneal shunt • hydrocephalus • Hunt and Hess scale • Fisher computerized tomography classification
Subarachnoid hemorrhage and postoperative shunting

defined as sustained pressure above 20 mm Hg lasting at least 30 minutes.

Statistical Analysis

The incidence of hydrocephalus was calculated in this population and statistical analysis was performed using chi-square, score (log-rank), and logistic regression tests. The variables taken into account were: Hunt and Hess grade, Fisher grade, type and size of the aneurysm, use of an ICP monitor (lumbar, cisternal, or ventricular), and patient age, gender, and race, which were all made available by means of a computerized aneurysm database established at our institution. The same statistical analyses were used to evaluate the relationship between outcomes involving the above variables. Outcome was defined as: 1) good, independent in all major activities (Glasgow Outcome Scale [GOS] score of 4–5); 2) poor, dependent in major daily activities (GOS score of 2–3); and 3) dead (GOS score of 1).

Results

One hundred sixteen surgeries were performed in the 108 patients reviewed. The patients' ages ranged from 1 to 92 years with a mean of 50.9 years. The population consisted of 36% males and 64% females. Approximately 58% of the patients were Caucasian, 41% were African American, and 1% were Asian. The follow-up period ranged from 7 to 32 months with a mean of 12.2 months. All patients presented with aneurysmal SAH. The most common location of the aneurysm was the anterior communicating artery (33%), followed by the posterior communicating artery (21.7%), the middle cerebral artery (16%), and the ophthalmic artery (8.8%); the location of the aneurysm in the remaining patients was divided almost equally between the posterior inferior cerebellar, pericallosal, basilar, and carotid bifurcation arteries. Most of the aneurysms were small (60%); however, some were large (30%) or giant (10%). Figure 1 left summarizes the clinical findings in patients on admission according to their Hunt and Hess grades. Approximately 55% of the patients presented with a Hunt and Hess grade of III or higher. Radiographic findings on admission showed that approximately 42% of the patients presented with evidence of intraventricular hemorrhage. Figure 1 right shows patients grouped according to their Fisher classification.

On admission all patients were transferred to the intensive care unit and underwent a four-vessel angiogram. Only 10% of the patients required aggressive ICP monitoring for depressed level of consciousness prior to surgical intervention. Almost 80% of the patients underwent placement of a ventriculostomy or lumbar drain at the time of the surgery. All patients underwent craniotomy for clipping of the aneurysm(s). More than 75% of the patients underwent craniotomy within 72 hours (95% had surgery within 7 days).

The mortality rate of this group of patients was 17%. All patients who presented with a Hunt and Hess grade of V died despite aggressive medical and/or surgical treatment. Chronic hydrocephalus was clinically evident in 17% of the total population. Of the surviving patients, 20% required placement of a VP shunt. Four patients who underwent shunt placement experienced a clinical course of multiple bleeding episodes prior to undergoing craniotomy for clipping of the aneurysm. The same four patients were the only ones to survive multiple hemorrhages. Of those patients requiring permanent CSF diversion, approximately 78% underwent shunt placement within 30 days. Of the remaining patients, one developed chronic hydrocephalus at 5 months and another at 6 months after the original hemorrhage. As of a 90-day follow-up period, 17% of the patients had died, 12% remained dependent in their usual daily activities (GOS score of 2 or 3), and 70% were graded as independent (GOS score of 4 or 5) in major daily activities (Fig. 2).

The distribution of patients who developed chronic hydrocephalus is depicted in Fig. 3 according to their admission Hunt and Hess and Fisher grades. Patients with an initial Hunt and Hess grade of III or higher represent almost 90% of the group that developed chronic hydrocephalus. In a similar manner, patients who presented with an initial Fisher CT grade of 4 (intraventricular hemorrhage) represent almost 46% of this group.

The individual associations between time until shunting and patient age, sex, and race, size of the aneurysm, type of ICP monitor, Hunt and Hess grade, and Fisher grade were tested using score (or log-rank) statistics. Each type of aneurysm was also tested for its association with the time until shunting. The analysis revealed that Hunt and
Hess and Fisher grades were individually significantly associated with the time until shunting \( (p < 0.05) \) and that a middle cerebral artery aneurysm approached significance with \( p = 0.0589 \). A regression analysis using the Cox proportional hazards model\(^4\) was conducted to determine any joint association between time until shunting and all variables listed above. Stepwise selection using Wald’s chi-square statistic resulted only in a significant association between Hunt and Hess grade and time until shunting.

Using logistic regression, predictive values for chronic hydrocephalus were obtained on the basis of admission Hunt and Hess grade and Fisher grade for at least a 6-month follow-up period (Table 1). A combined score depicting admission Hunt and Hess grade and Fisher grade allows patient categorization according to the relative risk of developing hydrocephalus. If the combined score is 3 or less the risk is less than 2%; for a score of 4 the risk will run between 3% and 8%; for a score of 5 the risk will be between 8% and 25%; for a score of 6, between 20% and 40%; for a score of 7, between 40% and 60%; and for a score of 8 or more, the risk is close to 70%.

Outcome was significantly affected by Hunt and Hess grade \( (p < 0.001) \), Fisher grade \( (p < 0.05) \), and the development of chronic hydrocephalus \( (p < 0.001) \). A better outcome was obtained in those patients who presented acutely with low Hunt and Hess and Fisher grades. Patients who did not develop chronic hydrocephalus had a better prognosis.

Survival analysis revealed that the probability of survival without the need of postoperative shunting was approximately 70% after 5 months (Fig. 4 upper). The survival rate was worse for patients with a higher Hunt and Hess grade. The difference was more pronounced in patients with Hunt and Hess grades of III or higher (Fig. 4 lower).

**Discussion**

It is known that acute hydrocephalus that appears after SAH may not develop into chronic hydrocephalus.\(^{11,17,22}\) The incidence of acute hydrocephalus ranges from 6 to 30% in the literature;\(^6,7,10,17–19,21,22,24\) however, the incidence of chronic hydrocephalus is not clearly established. Estimates range from 8 to 20%,\(^1,2,8,17,22,23,26\) but indications for shunting in these series are not well defined. In some series, patients underwent shunt placement prior to aneurysm clipping and in others the time frame between the onset of the original SAH and the surgical intervention for the hydrocephalus is not clearly demonstrated. To avoid ambiguities, our study represents a contemporary group of patients treated basically the same way by only one surgeon. All patients underwent aneurysm clipping prior to placement of the VP shunt. Only patients who had consis-
tently elevated ICP (regardless of CSF output) and had the clinical picture of hydrocephalus (confirmed by CT findings) after a minimum 2-week observation period underwent placement of a shunt system. The rationale for waiting 2 weeks before classifying someone as at risk of developing chronic hydrocephalus is based on our philosophy that at least 10 days are required to develop fibrosis of the meninges as a consequence of SAH.

Many factors have been associated with the development of chronic hydrocephalus; however, of the variables tested in this review, only the clinical picture on admission and the CT findings were statistically significant. Intraventricular hemorrhage seems to be the most consistent predictive finding. All patients with repeated hemorrhage who survived required placement of a VP shunt. Most of the patients initially were monitored with an external ventricular drainage system; however, the type of ICP monitor did not correlate significantly with the development of hydrocephalus. Cerebrospinal fluid drainage pressures were kept above 10 mm Hg in our series, because a continuous low-pressure gradient has been suggested as a cause of increased incidence of hydrocephalus.

The development of shunt-dependent hydrocephalus is not time specific, as has been demonstrated in this study and in one by Vassilouthis and Richardson. At times this requires up to 6 months to develop the appropriate clinical picture and characteristic radiographic findings. We realize that the present review could contain a bias because of the nature of referral at our tertiary institution, in which more complicated patients are transferred for management and definitive surgical intervention. A short-term bias could also be present in that some of our patients may eventually develop hydrocephalus that has not yet been discovered. However, for planning purposes (need for future CT scans, follow-up evaluations, and so forth) the time horizon of chronic hydrocephalus seems to be within a 6-month period after SAH (see Fig. 4), especially for patients with low Hunt and Hess grades. Outcome seems to be more related to clinical presentation (Hunt and Hess grade) on admission than any other factor. Patients who do not develop chronic hydrocephalus tend to experience less morbidity and have a better prognosis.

Conclusions

The development of chronic hydrocephalus should be strongly suspected in the setting of SAH in cases of patients who have intraventricular hemorrhage and a high Hunt and Hess grade on admission, and patients who have repeated hemorrhage. Close observation of these patients over a 6-month follow-up period is recommended.

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