Acutely hydrocephalus is a common sequel of aneurysmal SAH effectively treated with an EVD. Ultimately, a significant proportion of patients may need conversion of their EVD to a permanent VP shunt due to development of chronic hydrocephalus. Although it is a common neurosurgical practice to convert the EVD to a VP shunt, the available literature offers little guidance regarding the technique and site for the placement of the ventricular catheter. Some neurosurgeons prefer using the same EVD hole, whereas in some units it is common practice to use a new, “fresh” site. Each technique has its own pros and cons. Using the same site that had been used for the EVD provides atraumatic entrance of the proximal catheter into the ventricular system through an established track and minimizes the operative risks of hemorrhage and catheter malpositioning. However,
this technique has the disadvantage of using a potentially contaminated site that has accommodated an externalized catheter for a variable period of time. For this reason, such a practice raises the concern of increasing the risk of shunt infection. However, with the routine use of antibiotic-impregnated ventricular catheters and shunts, and the resultant decreased incidence of EVD and VP shunt infections, this old dilemma may not be relevant anymore.

Patients with aneurysmal SAH requiring conversion of an EVD to a VP shunt also have elevated protein and RBC counts in the CSF for protracted periods of time. Elevated protein and RBC counts at the time of VP shunt placement have traditionally been considered to affect shunt performance adversely. However, protein and RBC counts may not be so critically important in patients with hydrocephalus secondary to SAH who usually are shunt dependent for a short period of time after their SAH. In such patients, CSF hydrodynamics are often only transiently disturbed and tend to normalize 40 to 50 days after SAH in most instances. After this initial period of time, adequate shunt function may not be an important factor in many patients with SAH.

In patients with aneurysmal SAH, it has been our practice to convert an EVD to a VP shunt by routinely using the “old” EVD site. In addition, VP shunting in these patients has been performed irrespective of the RBC and protein counts in the CSF. In this report, we studied the effects of these practices on shunt infection and malfunction in a consecutive series of 80 patients requiring conversion of an EVD to a VP shunt after aneurysmal SAH.

### Methods

Data obtained in 80 consecutive adult patients who underwent conversion of an EVD to a VP shunt for post-SAH hydrocephalus between August 2002 and March 2007 were retrospectively reviewed. The study was approved by the local institutional review board. Patients were excluded from analysis if they suffered neurological deterioration from hydrocephalus after the EVD had been pulled out and underwent VP shunt placement after variable periods of time from discontinuation of the EVD. Seven patients died of SAH-related complications shortly after VP shunt placement and were excluded because inadequate follow-up was available to assess for shunt infection and/or malfunction.

Patients included in the study demonstrated clinical and radiographic signs of acute hydrocephalus treated with EVDs to allow monitoring of intracranial pressure and continuous CSF diversion for a period of at least 7 days from the initial SAH. All ventricular catheters used (Cook Spectrum; minocycline and rifampin) were antibiotic impregnated. All patients received a single dose of antibiotic (cefazolin or vancomycin) prior to EVD placement. The ventricular catheter was tunneled posterior and medial to the bur hole for a distance of ~5 cm using the tunneling device available in the EVD kit. After EVD placement, the site was covered with a Bioclusive tape (Ethicon, Inc.), which was changed every 96 hours. Every time the tape was changed, the site was cleaned with alcohol and Bioprep. No prophylactic antibiotics were used during external ventricular drainage. Intermittent demonstrated or suspected systemic infections were treated when clinically indicated.

Following the acute phase after SAH (usually 7–15 days), if progressive elevation of the EVD drip chamber and/or EVD clamping resulted in increased ventricular size or neurological deterioration, conversion of the EVD to a VP shunt was considered. All but one patient underwent surgical or endovascular treatment of their aneurysm before VP shunt insertion. Patients with an elevated systemic temperature (>101.5°F) underwent systemic fever workup, including CSF sampling for Gram staining and cultures. In these patients, VP shunt placement was performed if CSF cultures were negative, irrespective of recurrent fever.

All shunts (the ventricular and peritoneal catheter) were antibiotic-impregnated devices (Codman Bactiseal; rifampicin and clindamycin). All patients received prophylactic antibiotic treatment 30–60 minutes prior to placement of the VP shunt. Intravenous antibiotics were continued prophylactically for 48 hours postoperatively. Hair along the hypothetical shunt track was shaved. The entire surgical area was then scrubbed with Betadine for 5 minutes. In each patient, the previously used ventriculostomy site was used to cannulate the ventricular system. The original ventricular catheter remained in place until we were ready to exchange it for the permanent catheter. It was then sharply divided close to its emergence from the skull. At this point the anesthesiologist pulled the distal cut end of the original EVD. An antibiotic-impregnated proximal shunt catheter was introduced without a stylet through the entry site immediately after removal of the external drainage catheter. Approximately 10 ml of CSF were obtained through the new catheter and sent for analysis. The old ventricular catheter was not cultured. A medium-pressure PS Medical valve was used in the majority of the patients and connected to a distal catheter that was subcutaneously tunneled and implanted into the peritoneum. A minority of patients, especially the elderly ones, received a high-pressure PS Medical valve or a programmable valve. A head CT was usually performed within 48 hours after VP shunt insertion to confirm adequate catheter position, decompression of the ventricular system, and to rule out operative complications.

Data were obtained from medical records, office notes, and telephone follow-up interviews. The following parameters were transferred to a computerized database and analyzed: patient demographics; time period of external ventricular drainage prior to VP shunt placement; intraoperative protein and RBC counts in the CSF (or protein and RBC counts from a CSF sample obtained during the 48 hours preceding VP shunt placement in those few patients without an adequate intraoperative sample); and complications during follow-up.

### Results

A total of 80 consecutive patients (18 men and 62 women) with a mean age of 60.8 years (range 33–85 years) underwent direct conversion of an EVD to a VP shunt for SAH-related hydrocephalus. The mean period of external ventricular drainage before VP shunt placement was 14.1 days (range 3–45 days). No patient developed ventriculitis
Conversion of extraventricular drain to VP shunt after SAH
during the study period. The mean perioperative protein level in the CSF was 124 mg/dl (range 17–516 mg/dl), and the mean and median perioperative RBC values in the CSF were 14,203/mm³ and 4600/mm³ (range 119–290,000/mm³), respectively. No patient was lost to follow-up, and the mean follow-up duration was 24 months (range 1–53 months). Five patients required VP shunt revision for malfunction during the follow-up period. In 2 patients the revision was required shortly (within 1 week) after VP shunt placement. Based on radiological and intraoperative findings, shunt malfunction in these 2 patients was related to preperitoneal placement of the distal catheter in one and kinking of the catheter immediately distal to the valve in the other. Three patients (3.8%) had shunt malfunction related to obstruction of the shunt system after 15 days, 2 months, and 18 months, respectively. There were no shunt-related infections (Table 1). No patient suffered a clinically significant hemorrhage from ventricular catheter placement after VP shunt positioning.

Discussion

Protein and RBC Count and Shunt Malfunction in Patients With SAH

Patients recovering from SAH who have an EVD and are in need of a VP shunt present the treating physician with a clinical dilemma. Aggressive mobilization is important to prevent pulmonary and systemic complications associated with reduced mobility and a protracted intensive care unit stay. Adequate mobilization and full participation in physical rehabilitation are limited in a patient with an EVD. Prolonged external CSF drainage also results in increasing length of stay and higher costs. On the other hand, there is reluctance on the part of the treating neurosurgeon to convert the EVD to a VP shunt in a setting in which the CSF still has elevated protein and RBC counts, which may adversely affect the shunt function and survival.

Although proteinaceous and/or hemorrhagic CSF is common among patients needing permanent CSF diversion after intracranial hemorrhage or brain injury, there is relatively little information in the literature as to when such patients can safely have a shunt implanted. In general, conventional wisdom cautions against placing a shunt in patients with proteinaceous and/or hemorrhagic CSF. Derived from experiments in which a wide variety of valves were perfused with a series of protein and whole blood solutions for variable periods of time, the existing laboratory data support the suggestion that protein has little practical effect on valve performance, but solutions of diluted whole blood can cause valve malfunctions at concentrations as low as 5–10 RBCs/mm³ (whole blood in a healthy adult contains ~ 5 million RBCs/mm³). Analysis of our experience suggests that in adult patients with SAH, protein and RBC counts in the CSF are not that critical in affecting shunt performance. Despite the very high preoperative protein levels (mean 124 mg/dl) and RBC values (median 4600 RBCs/mm³) in the CSF, our revision rate related to occlusion of the shunt system was relatively low (3.8%). This revision rate is well within the reported range. Moreover, most patients with communi-

cating hydrocephalus secondary to aneurysmal SAH are shunt dependent only for a relatively short period of time. In such a situation, shunt malfunction related to obstruction of the system does not have clinical correlates if it occurs several weeks after the shunt placement procedure.

Conversion of an EVD to a VP Shunt After SAH: Is a “Fresh” Site for the Ventricular Catheter Necessary?

When converting an EVD to a VP shunt, it is routine in many neurosurgical units to use a new site for fear that subclinical contamination of the EVD site might increase the risk of shunt infection. The recent introduction of antibiotic-impregnated ventricular catheters, associated with local care of the EVD site, has significantly reduced the incidence of EVD-related infections in our as well other neurosurgical units. Thus, with the use of antibiotic-impregnated catheters, the risk of contamination of an existing EVD site might not be as high as in past decades. Our series suggests that the existing EVD site can be safely used when converting an EVD to a VP shunt. With the consistent use of antibiotic-coated catheters for both the EVD and the VP shunt, none of our patients developed a shunt infection after a mean follow-up period of 24 months. It remains to be determined whether the same experience can be extended to the use of nonantibiotic-impregnated catheters. Inserting the proximal catheter without a stylet through the EVD hole immediately after removing the existing EVD catheter minimizes the risks of hemorrhage and malposition, does not add additional parenchyma trauma or damage, and shortens the operating time.

Conclusions

This review of our experience supports the suggestion that in adult patients with aneurysmal SAH, conversion of an EVD to a VP shunt can be safely done using the same EVD site, provided there are no local signs of infection. In addition, in this specific population, protein and RBC counts do not seem to affect shunt survival adversely. Thus, conversion of an EVD to a VP shunt should not be delayed because of an elevated protein or RBC count.

Disclaimer

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