Acutely hydrocephalus occurs in up to two-thirds of patients with subarachnoid hemorrhage (SAH), and its treatment involves the placement of a ventriculostomy catheter. Around 6%–37% of patients ultimately require permanent CSF diversion usually treated through ventriculoperitoneal shunt (VPS) placement because of the development of chronic hydrocephalus.

It is common practice to use a new contralateral bur hole for placement of the VPS in SAH patients with an existing ventriculostomy. At Thomas Jefferson University and Jefferson Hospital for Neuroscience, the authors have primarily used the ventriculostomy site for the VPS. The purpose of this study was to compare the safety of the 2 techniques in patients with SAH.

**Object.** It is common practice to use a new contralateral bur hole for ventriculoperitoneal shunt (VPS) placement in subarachnoid hemorrhage (SAH) patients with an existing ventriculostomy. At Thomas Jefferson University and Jefferson Hospital for Neuroscience, the authors have primarily used the ventriculostomy site for the VPS. The purpose of this study was to compare the safety of the 2 techniques in patients with SAH.

**Methods.** The rates of VPS-related hemorrhage, infection, and proximal revision were compared between the 2 techniques in 523 patients undergoing VPS placement (same site in 464 and contralateral site in 59 patients).

**Results.** The rate of new VPS-related hemorrhage was significantly higher in the contralateral-site group (1.7%) than in the same-site group (0%; p = 0.006). The rate of VPS infection did not differ between the 2 groups (6.4% for same site vs 5.1% for contralateral site; p = 0.7). In multivariate analysis, higher Hunt and Hess grades (p = 0.05) and open versus endovascular treatment (p = 0.04) predicted shunt infection, but the VPS technique was not a predictive factor (p = 0.9). The rate of proximal shunt revision was 6% in the same-site group versus 8.5% in the contralateral-site group (p = 0.4). In multivariate analysis, open surgery was the only factor predicting proximal VPS revision (p = 0.05).

**Conclusions.** The results of this study suggest that the use of the ventriculostomy site for VPS placement may be feasible and safe and may not add morbidity (infection or need for revision) compared with the use of a fresh contralateral site. This rapid and simple technique also was associated with a lower risk of shunt-related hemorrhage. While both techniques appear to be feasible and safe, a definitive answer to the question of which technique is superior awaits a higher level of medical evidence.

**Key Words** • infection • subarachnoid hemorrhage • hydrocephalus • ventriculoperitoneal shunt • vascular disorders
Ventriculoperitoneal shunting technique

Methods

The study protocol was approved by the Thomas Jefferson University institutional review board. Consecutive patients with SAH undergoing VPS placement between May 2005 and July 2010 were identified from a prospectively maintained database. The study period was chosen to provide a sizable sample of patients while allowing adequate follow-up time. A total of 523 patients were identified and constituted our study population, comprising patients with ruptured aneurysms (n = 447), arteriovenous malformations (n = 19), and angiogram-negative SAH (n = 57).

Antibiotic-impregnated ventriculostomy catheters were used for all patients at our institution. In all patients, an attempt to wean off the ventriculostomy was not successful. Placement of the VPS was performed at a delayed time during initial hospitalization, usually between 7 and 21 days following SAH. The choice between the 2 approaches (same site vs contralateral site) was based primarily on operator preference and experience. When there was any suspicion of potential wound complication, the contralateral site was selected. The duration of ventriculostomy drainage before VPS placement did not affect the decision to choose one technique over the other. No antibiotic-impregnated shunts were used in the study.

Same-Site VPS Technique

The procedures were performed by 7 neurosurgeons. Intravenous antibiotics were given 20 minutes prior to skin incision and were continued prophylactically for 48 hours postoperatively. The ventriculostomy exit site was carefully prepared outside of the field, and the sutures were cut. The ventriculostomy catheter was then pulled by the anesthesiologist from under the sterile drapes and a new ventricular catheter was placed into the ventricle with a soft pass (that is, without a stylet) using the same track. The ventricular catheter was then connected to the valve, and the valve was pulled down under the skin. For a VPS placed using a fresh contralateral site, the standard technique used was as previously described in the literature.2–6 All wounds were copiously irrigated with normal saline. Head CT scanning and a shunt series were performed for all patients within 24 hours after VPS placement to confirm adequate catheter position and decompression of the ventricular system and to identify procedural complications.

Outcomes

Demographic and baseline characteristics were collected for the entire study population. The rates of VPS-related hemorrhage, infection, and proximal revision during the follow-up period were compared between the same-site group and the contralateral-site group. Postoperative CT scans of each study patient were reviewed to detect hemorrhages related to VPS placement. New hemorrhages that occurred along the track of the ventricular catheter were deemed to be related to VPS placement. Shunt infection was defined as follows: 1) identification of organisms on culture or Gram stain from CSF, wound swab, or pseudocyst fluid; 2) shunt erosion; or 3) abdominal pseudocyst. Proximal shunt revision was defined as the need for revision of the ventricular catheter, the valve, or both. (Total or distal shunt revisions are not included.) This variable was adopted because it reflects complications related to the proximal part of the shunt, which constitutes the subject of comparison in this study.

Statistical Analysis

Data are presented as mean and range for continuous variables and as frequency for categorical variables. Analysis was carried out using unpaired t-test, chi-square test, and Fisher exact test. Univariate analysis tested covariates predictive of the following dependent variables: shunt-related intracerebral hemorrhage, shunt infection, and proximal shunt revision. Interaction and confounding were assessed through stratification and relevant expansion covariates. Factors predictive in univariate analysis (p < 0.20) were entered into a multivariate logistic regression analysis. Probability values ≤ 0.05 were considered statistically significant. Statistical analysis was carried out with Stata 10.0 (StataCorp LP).

Results

Baseline Characteristics

Of 523 patients undergoing VPS placement, the same site was used in 464 (88.7%) patients and the contralateral site in 59 (11.3%). The 2 groups were comparable with regard to the distribution of vascular lesions (p = 0.6; Table 1). The percentages of female patients were 64% (296/464) in the same-site group and 53% (31/59) in the contralateral-site group (p = 0.1). Mean age did not differ significantly between the 2 groups (54.4 years for same site vs 53.7 years for contralateral site; p = 0.6). A higher percentage of patients had poor Hunt and Hess grades (III–V) in the same-site group (90%) than in the contralateral-site group (71%; p = 0.001). The average time from ventriculostomy insertion to VPS placement was 12.5 days in the same-site group and 12.7 days in the contralateral-site group (p = 0.8). Endovascular treatment (as opposed to open surgery) was undertaken in a higher percentage of patients in the same-site group (77% vs 63%; p = 0.02). The follow-up duration did not differ significantly between the 2 groups (23 months in the same site vs 24 months in the contralateral site; p = 0.8).

Outcomes

The rate of new VPS-related hemorrhage was significantly higher in the contralateral-site group (1.7%, 1/59) than in the same-site group (0%, 0/464; p = 0.006). The rate of VPS infection did not differ between the same-site group (6.5%, 30/464) and the contralateral-site group (5.1%, 3/59; p = 0.7). The following factors were tested as predictors of VPS infection: age, sex, type of lesion, Hunt and Hess grade, operator, type of treatment (endovascular vs open), VPS technique, and follow-up time. In the univariate analysis, male sex (p = 0.01), older age (p = 0.1), higher Hunt and Hess grades (p = 0.09), and open treatment (p = 0.07) predicted proximal VPS revision. In the multivariate analysis, higher Hunt and Hess grades (OR 1.9; 95% CI 0.99–3.4; p = 0.05) and open treatment (OR
The percentage of proximal shunt revision was 6% (28/464) in the same-site group and 8.5% (5/59) in the contralateral-site group (p = 0.4). The following factors were tested as predictors of proximal VPS revision: age, sex, type of lesion, Hunt and Hess grade, operator, type of treatment (endovascular vs open), and VPS technique. In the univariate analysis, male sex (p = 0.09) and open treatment (p = 0.05) predicted proximal VPS revision. In the multivariate analysis, open treatment was the only factor predicting proximal VPS revision (OR 2.1; 95% CI 1.0–4.8; p = 0.05). The VPS technique did not predict the risk of proximal revision even after controlling for all other variables (OR 1.5; 95% CI 0.5–4.0; p = 0.5).

Discussion

Placement of a VPS is one of the most common neurosurgical procedures. A significant proportion of SAH patients require VPS placement, as chronic hydrocephalus has adverse consequences for recovery from SAH. Although simple, the procedure carries the risk of complications, including intracerebral hemorrhage, shunt infection, wound breakdown, and catheter/valve obstruction, leading to frequent shunt revision. Intracerebral hemorrhage rarely occurs after shunt insertions (4% of cases) and is usually subclinical. Around 8%–10% of shunts become infected, requiring lengthy hospitalization for intravenous antibiotics, temporary ventriculostomy placement, and shunt revision. In a cohort of patients undergoing VPS placement after SAH, up to 29.6% required a subsequent revision procedure (usually within 6 months).

Measures to decrease the risk of shunt complications/failure are therefore particularly important in SAH patients.

At most institutions, a new site is used for the VPS in patients with SAH for fear that the ventriculostomy site is contaminated and might increase the subsequent risk of shunt infection. In contrast, however, the present study clearly shows that the rate of VPS infection is not increased when the ventriculostomy site is used for the VPS: the shunt infection rate was 6.5% in the same-site group and 5.1% in the contralateral-site group (p = 0.7). This finding might be related to the local care of the ventriculostomy site, as well as the use of antibiotic-impregnated ventriculostomy catheters in all patients in the present study, which likely reduced contamination of ventriculostomy sites. Indeed, Harrop et al. reported a dramatic decrease in ventriculostomy infection rates from 2.3; 95% CI 1.02–5.4; p = 0.04) predicted shunt infection, but the VPS technique was not a predictive factor (OR 1.0; 95% CI 0.2–3.5; p = 0.9).

The same-site technique may have advantages compared with the traditional contralateral-site technique. Inserting the ventricular catheter with a soft pass (that is, without a stylet) using the same track has the potential to minimize the risks of hemorrhage and malposition while also avoiding further parenchymal trauma. In our study, no patient had a new shunt-related hemorrhage in the same-site group, and the rate of new hemorrhagic complications was significantly higher with the contralateral-site technique. However, the contralateral-site technique is also very safe: only 1 of 59 patients developed a new hemorrhage postoperatively (subclinical complication).

Another advantage of the same-site technique is its simplicity and reduction of operative time.

Our study has identified interesting predictors of VPS infection and the need for proximal revision. Because higher Hunt and Hess grades predicted VPS infection, special attention should be paid to technique and sterility when placing the ventriculostomy catheter and later the VPS in patients with poor neurological grades. It is interesting that open surgical treatment was associated with shunt infections and proximal revision. These findings differ from those of O’Kelly et al., who found endovascular treatment to be a predictor of shunt revision. We suspect that the higher rate of infections in patients undergoing open surgery was caused by prolonged exposure of the ventriculostomy site during surgery, which may promote contamination and ultimately shunt infection. This observation requires confirmation in other studies.

Limitations and Generalizability

Our study is a retrospective, nonrandomized, single-center study. Because of the retrospective nature of the analysis, we could not determine variables such as number of passes, catheter malposition, and operative time to quantify brain damage from shunt insertion, all of which could have further favored the same-site approach. The groups were generally comparable with regard to baseline characteristics, although a greater proportion of the patients with the same-site shunt had undergone endovascular treatment (which was associated with a lower rate of shunt infection). A multivariate analysis was performed to account for any such potential confounding factors. Because we used a new hole in the presence of signs of infection of the ventriculostomy site, the same-site group may have been theoretically favored. Our findings may not be generalizable to non–antibiotic-impregnated ventriculostomy catheters. Despite these limitations, this is the first study to account for any such potential confounding factors.
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study to compare the 2 shunting techniques in a large cohort of SAH patients and to establish the feasibility and safety of the same-site technique. Our study was not designed to show superiority of one technique over the other, but rather to assess whether the same-site technique adds any morbidity compared with the standard technique.

Conclusions

The results of this study suggest that the use of the ventriculostomy site for VPS placement may be feasible and safe and may not add morbidity (infection or revision) compared with the use of a fresh contralateral site. This rapid and simple technique also was associated with a lower risk of shunt-related hemorrhage. While both techniques appear to be feasible and safe, a definitive answer to the question of which technique is superior awaits a higher level of medical evidence.

Disclosure

Dr. Tjoumakaris reports being a consultant for Stryker.

Author contributions to the study and manuscript preparation include the following. Conception and design: Jabbour, Chalouhi, Tjoumakaris, Gonzalez. Acquisition of data: Whiting, Anderson, Witte, Zanaty. Analysis and interpretation of data: Jabbour, Chalouhi, Whiting, Anderson, Witte, Zanaty, Gonzalez, Hasan, Starke, Hamm, Ghobrial. Drafting the article: Chalouhi, Whiting, Zanaty. Critical revision of the article: all authors. Review of submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Jabbour. Statistical analysis: Starke. Administrative/technical/material support: Jabbour, Chalouhi, Whiting, Anderson, Witte, Tjoumakaris. Study supervision: Jabbour, Chalouhi.

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