Complications of preoperative embolization of cerebral arteriovenous malformations

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Object. Preoperative embolization is viewed by the authors as a useful adjunct in the surgical management of cerebral arteriovenous malformations (AVMs). This study was performed to determine the rate of significant complication in patients undergoing this procedure.

Methods. Demographic, anatomical, and procedure data were collected prospectively. The treating physician reported complications. In addition, a review of medical records including procedure reports, operative reports, and discharge summaries was performed. Univariate statistical analysis was performed to determine if any of the variables was predictive of a poor outcome of embolization (death or permanent neurological deficit).

Endovascular procedures for embolization were performed 339 times in 201 patients during an 11-year period. Female patients comprised 53.7% of the study group and 85.6% of the AVMs were supratentorial. Embolization was performed using polyvinyl alcohol particles, N-butyl cyanoacrylate, detachable coils, and/or the liquid polymer Onyx. Analyzed by procedure, a poor result of embolization occurred in 7.7%. Analyzed by patient, 11% died or had a permanent neurological deficit as a result of the embolization. None of the demographic, anatomical, or procedure variables identified were predictive of a poor outcome.

Conclusions. Preoperative embolization may gradually reduce flow to an AVM, reduce intraoperative blood loss, and reduce operative time. The risks of this procedure, however, are not insignificant and must be considered in planning treatment for patients with AVMs.

Key Words • arteriovenous malformation • brain • embolization • endovascular therapy • outcome analysis

Among the many factors that must be considered when planning surgery for a patient with an AVM is the anticipated benefit of preoperative embolization compared with the risk of that procedure. Endovascular embolization of cerebral AVMs has been performed for several decades and is often a useful adjunct to the surgical management of these lesions. Despite advances in materials and methods, however, intracranial embolization still carries the risk of significant complications including death. Furthermore, because of the complex anatomy of many AVMs treated surgically, multiple embolization sessions are often required, potentially increasing the risk of complications. To aid in the analysis of the risks and benefits of preoperative embolization, we reviewed complications documented in patients treated over the past 11 years. Demographic, anatomical, and procedure variables were analyzed to determine if they were predictive of a poor result of embolization.

Clinical Material and Methods

Patient Selection

Patients with the diagnosis of cerebral AVM who underwent angiography for the purpose of preoperative embolization were included in this study. No patient at our institution underwent the embolization procedure as the only form of treatment. Patients with a dural arteriovenous fistula, a facial AVM, or a spinal AVM were excluded. Two hundred one patients were originally selected for embolization and 339 procedures were performed in these patients. There were 108 female (53.7%) and 93 male (46.3%) patients with a mean age of 36 years (range 8 months–67 years). In 172 (85.6%) of these patients the AVM was supratentorial and in 29 (14.4%) it was infratentorial. Data were maintained prospectively in an electronic database from June 22, 1992, through May 27, 2003. Some patients in this study who were treated before 1996 were included in an earlier report from this institution.2 Demographic data, AVM location, and the embolic materials used in the procedure were recorded. The patient’s presenting symptoms (hemorrhage, seizure, and so forth) and preoperative neurological condition were not recorded. Anatomical details including the size of the AVM, the pedicles embolized, and the location of the lesion with respect to areas of eloquence are currently entered prospectively, but are not included in the entire database and are not a subject of this report. The treating physician reported complications. In addition, the hospital chart, which contained procedure reports, operative reports, and the discharge summary, was reviewed for each patient to ensure that no identified complication was missed.

In patients who had not recently experienced an intracranial hemorrhage, intravenous heparin was given at the beginning of the procedure. In patients who had experienced

Abbreviations used in this paper: AVM = arteriovenous malformation; NBCA = N-butyl cyanoacrylate; PVA = polyvinyl alcohol.
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recent bleeding, heparin was given immediately before embolization. Using standard coaxial technique, a guide catheter was positioned in the carotid or vertebral artery. Superselective catheterization with a microcatheter was used to access vessels supplying the AVM. Vessels with branches supplying the normal brain were not embolized. Before embolization of vessels in eloquent regions, the patient while still awake received a selective amobarbital injection and underwent neurological testing. Patients undergoing multiple embolization sessions were usually scheduled for these procedures at 2-day intervals. Surgery was generally performed within several days after the final embolization session, unless contraindicated by a complication.

Complications were defined as follows. An outcome of death was assigned to a death that occurred after embolization and before surgery or a death that occurred after emergency surgery prompted by a complication that had occurred during or after the embolization procedure (for example, intracerebral hemorrhage). A permanent neurological deficit was defined as a new neurological deficit that persisted for more than 72 hours after embolization or until the time of surgery. Worsening of a preexisting deficit (for example, a loss of visual field in a patient with a preexisting visual field deficit) was considered a new deficit. A temporary neurological deficit was defined as a new neurological deficit that resolved completely within 72 hours after onset. A vascular complication without neurological deficit included a vessel perforation, subarachnoid hemorrhage, intracerebral hemorrhage, intraventricular hemorrhage, or unintentional vessel occlusion that did not result in a new neurological deficit, did not require surgical intervention, and did not produce symptoms other than headache.

Complications were analyzed by patient and procedure. In the analysis by patient, only the most severe complication was recorded, regardless of the number of embolization sessions or complications. For example, in the patient analysis, if a permanent deficit occurred after the first embolization and death occurred after the second embolization, the complication was reported as a death and the permanent deficit was not counted.

**Statistical Analysis**

For statistical analysis a poor outcome was defined as death or permanent neurological deficit. To determine the probability of a poor outcome, categorical data were entered into contingency tables and were compared using the Fisher exact test. Continuous data were compared using the two-tailed t-test. Statistical analysis was performed using appropriate software (JMP IN software [version 4.0.4]; SAS Institute, Inc., Cary, NC).

**Results**

During the 11-year study period, 339 procedures were performed in 201 patients. A majority of patients (118 [58.7%]) underwent only one procedure; however, 50 (24.9%) underwent two procedures, 16 (8%) three, 14 (7%) four, two (1%) five, and one (0.5%) seven procedures.

During a 7.5-year period within the study (between January 1, 1995 and June 30, 2002) at our institution we treated a total of 230 adult patients with the diagnosis of AVM. In that period 130 patients (56.5%) underwent embolization prior to conventional surgery, 68 patients (29.6%) under-
additional risk is assumed by the patient who undergoes embolization? This study was designed to answer that question in a meaningful way for both patients and their surgeons, that is, to determine the risk of death or permanent neurological deficit. This is not to say that temporary deficits are unimportant. Furthermore, some of the vascular complications that occurred without neurological deficit in this study caused a delay in surgery and extended hospital stays, and are best avoided. In the decision whether to treat an AVM, however, it is the risk of long-term disability that is most important both to patients and their surgeons. We found that preoperative embolization resulted in death in 2% of our patients and a permanent neurological deficit in another 9%.

Other investigators have reported that death occurs in 0 to 3% and permanent disability in 2 to 20% of patients undergoing embolization.1–6,8–10 One of the most detailed assessments of complications was made recently by the n-BCA Trial Investigators. They compared NBCA with PVA embolization in 104 patients. At least one complication was reported in 51% of the patients who were treated.7 In this study, however, the complications were assigned to a variety of categories including “occluded catheter,” “provocative test failure,” and “uncooperative patient.” This type of analysis is useful in a direct comparison of two different embolic agents, but some of the reported complications are irrelevant in the decision about whether to perform preoperative embolization. The overall death rate in the study was 3.9%.

None of the demographic, anatomical, or procedure variables that we studied were predictive of a poor result of embolization. Some of the factors that we consider important, although not addressed in this study, include the following: AVM size and flow characteristics; location of the lesion in eloquent cortex, feeding vessels that also supply normal brain, particularly the eloquent cortex; small caliber of feeding vessels; lack of collateral blood supply; and vascular tortuosity. Nevertheless, Dowd, et al.,1 reported that despite having many of these characteristics, the anterior choroidal artery was effectively embolized in 15 patients with only a 13% incidence of symptomatic complications. A limitation of this study is our lack of detailed anatomical data. In practice, each patient’s AVM must be evaluated individually with respect to all the aforementioned factors.

The benefit gained by AVM embolization is somewhat more difficult to describe objectively. Some surgeons believe that preoperative embolization decreases the risk of postoperative hyperperfusion and hemorrhage. Wallace, et al.,10 addressed this issue in a study in which NBCA embolization was compared with that performed using PVA particles. Outcome measures in that study included the following: probability of complete AVM resection; patient eligibility for radiosurgery after incomplete resection; intraoperative blood loss; duration of the surgical procedure; and duration of hospitalization. There was no difference in these parameters between the two embolic agents. A control group was not available and we are not aware of any studies providing a direct comparison of results in patients with and without embolization. We have no plans to undertake such a study because in our experience embolization has proved to be beneficial and often indispensable for gradually reducing AVM flow before surgery and for limiting intraoperative blood loss and operating time.

Conclusions

In this series, preoperative embolization was associated with a 1.2% death rate and a 6.5% permanent neurological deficit rate per procedure. Overall, death occurred in 2% and permanent neurological deficit in 9% of patients. Although improvements in materials and methods have been made over the past decade, the relatively low number of complications and the small number of procedures performed prevent any statistically valid conclusions regarding changes in the safety of this procedure. These complication rates must be considered in the overall management plan for patients undergoing resection of AVMs.

Disclosure

Dr. Purdy is a consultant to Boston Scientific Target.

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References


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