Early versus late intracranial aneurysm surgery in subarachnoid hemorrhage

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The management results in 244 patients admitted to one institution within 3 days of aneurysmal subarachnoid hemorrhage (SAH) from January, 1979, to December, 1985, were analyzed with respect to the timing of surgical intervention. Twenty-six patients died prior to surgery. Patients surviving to surgery were divided into three groups according to the interval between preadmission SAH and surgery: 0 to 3 days (85 cases), 4 to 9 days (83 cases), and 10 or more days (50 cases). Of the patients who were categorized neurologically into Botterell Grades 1 and 2 (Hunt and Hess Grades I to III) on admission, 87% had an excellent or good result on follow-up evaluation. Patients undergoing surgery 0 to 3 days after SAH had a statistically significant increase in the incidence of postoperative ischemic symptoms (p < 0.005), which was balanced by similar complications preoperatively in the 10-day post-SAH surgical group. Most rebleeds occurred before admission but delaying surgery did increase the risk of rebleeding in the hospital (p < 0.0005). Management morbidity and mortality occurred primarily as a direct result of a severe initial hemorrhage; thus, the measured benefits of early surgery were less than might have been predicted.

KEY WORDS • intracranial aneurysm • subarachnoid hemorrhage • timing of surgery • rebleeding

Since Walter Dandy performed the first direct intracranial aneurysm repair in 1938, the overall management results for aneurysmal subarachnoid hemorrhage (SAH) have improved significantly. Despite this, less than half of the patients surviving to hospital admission have a favorable outcome. Aside from the direct effects of the initial hemorrhage, most reported mortality and morbidity can be traced to vasospasm and rebleeding. These poor management results have focused interest on early intracranial operative repair of ruptured sacular aneurysms. Surgeons who advocate this approach cite a lower incidence of rebleeding, reduced vasospasm because of early removal of subarachnoid blood, and more effective management of delayed ischemia as potential advantages. Despite substantial investigation, the impact of early surgical intervention on the overall management outcome for aneurysmal SAH remains controversial. In an effort to determine how the timing of surgical intervention affects management outcome, the records of all patients from January, 1979, to December, 1985, who were admitted within 72 hours of their last documented aneurysmal SAH were reviewed. For the purposes of this study, management results were compared among three patient groups based on the timing of surgical intervention. The interval between the last SAH and surgery was based on the patient's most recent SAH prior to admission rather than on a recurrent SAH while in the hospital awaiting surgery, for the obvious reason that emergency surgery for a recurrent bleed would have prejudiced the early-hemorrhage group and failed to recognize the risk of a rebleed in the delayed-surgery group.

Clinical Material and Methods

The records of all patients from January, 1979, to December, 1985, who were admitted within 72 hours of their last documented aneurysmal SAH were reviewed. For the purposes of this study, management results were compared among three patient groups based on the timing of surgical intervention. The interval between the last SAH and surgery was based on the patient's most recent SAH prior to admission rather than on a recurrent SAH while in the hospital awaiting surgery, for the obvious reason that emergency surgery for a recurrent bleed would have prejudiced the early-hemorrhage group and failed to recognize the risk of a rebleed in the delayed-surgery group.

The patients were divided into the following groups: Group 1 received intracranial aneurysm repair within 3 days of the last preadmission SAH; Group 2 underwent intracranial aneurysm repair 4 to 9 days after the
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last preadmission SAH; and Group 3 had intracranial aneurysm repair 10 or more days after the last preadmission SAH. The patients were further divided according to their admission neurological function, based on a modification of the Botterell grading system as follows:

Grade 1: with or without mild headache, alert and oriented, with no motor or sensory deficits
Grade 2: severe headache and major meningeal signs, mild alteration in sensorium or minor focal deficit
Grade 3: major alteration in sensorium or major focal deficit
Grade 4: semicomatose with or without major laterализing findings.

Further patient subdivision was made on the basis of aneurysmal site, age, and plurality of bleeding episodes.

Management results were assessed at discharge and at last medical follow-up review, and patients were allotted to one of four categories: 1) excellent: normal employment with normal mentation and little or no neurological deficit; 2) good: neurological deficit but with normal mentation and employment; 3) poor: anything less than full activity (including patients with personality or mental changes, a disabling focal deficit, or both); and 4) dead. Results in the three treatment groups were based on the patient's grade on admission to the hospital rather than the grade immediately prior to surgery in order to place in perspective the risks of rebleeding or deterioration from vasospasm while awaiting surgery.

The details of management and operative techniques are described in detail elsewhere. Briefly, initial management consisted of administering phenobarbital for sedation and codeine for analgesia. Antihypertensive drugs were used cautiously. Steroids were used sparingly early in the series but later, after further experience, high-dose steroids were used according to the protocol described previously. Epsilon-aminocaproic acid (EACA) was used only in a minority of instances and usually only after a rebleed had occurred. Statistical comparisons were made using the chi-square test of independence.

The case material is summarized in Table 1. Age and sex distribution were similar in all groups, but posterior circulation aneurysms and high-risk cases were more common in Groups 2 and 3 than in Group 1. On admission, 93 patients (38%) were in Grade 1; 71 (29%) in Grade 2; 40 (16%) in Grade 3; and 40 (16%) in Grade 4 (Table 1). Among the 80 patients who were in Grade 3 or 4 at the time of admission to the hospital, 26% did not survive to surgery, 26% were operated on 0 to 3 days following their preadmission SAH, 20% underwent surgery 4 to 9 days post-SAH, and 28% were operated on 10 days or more following the SAH. In contrast, among 164 patients in Grade 1 or 2 on admission, only 3% did not survive to surgery, 39% underwent surgery 0 to 3 days post-SAH, 41% 4 to 9 days post-SAH, and 17% 10 days or more post-SAH.

### Table 1

<table>
<thead>
<tr>
<th>Aneurysm Location</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACA</td>
<td>29/26</td>
<td>10/10</td>
<td>13/13</td>
<td>52/52</td>
</tr>
<tr>
<td>MCA</td>
<td>8/8</td>
<td>2/2</td>
<td>1/1</td>
<td>11/11</td>
</tr>
<tr>
<td>ICA</td>
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<td>11/11</td>
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<td>1/1</td>
<td>1/1</td>
<td>6/6</td>
</tr>
<tr>
<td>V-B</td>
<td>0/1</td>
<td>4/4</td>
<td>0/1</td>
<td>4/5</td>
</tr>
<tr>
<td>Other</td>
<td>2/2</td>
<td>1/1</td>
<td>0/1</td>
<td>3/3</td>
</tr>
</tbody>
</table>

* SAH = subarachnoid hemorrhage. For definition of neurological grade on admission see text.

### Table 2

<table>
<thead>
<tr>
<th>Admission Grade</th>
<th>No. of Cases</th>
<th>Excellent</th>
<th>Good</th>
<th>Poor</th>
<th>Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>93</td>
<td>79 (86%)</td>
<td>3 (3%)</td>
<td>3 (4%)</td>
<td>8 (6%)</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>41 (58%)</td>
<td>12 (17%)</td>
<td>6 (10%)</td>
<td>12 (15%)</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>12 (30%)</td>
<td>5 (13%)</td>
<td>9 (28%)</td>
<td>14 (35%)</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>1 (3%)</td>
<td>2 (5%)</td>
<td>14 (35%)</td>
<td>23 (58%)</td>
</tr>
</tbody>
</table>

* SAH = subarachnoid hemorrhage. For definition of neurological grade on admission see text.

### Results

**Overall Management Results**

Fifty-four (22%) of the 244 patients died, 26 prior to and 28 following surgery. Of the 26 patients not surviving to surgery, 20 died as a result of their initial or recurrent hemorrhage prior to admission, four from a rebleed while awaiting surgery, and two from other causes. The causes for postoperative and follow-up deaths are delineated below for each surgical group. Sixty-four patients rebled at some time prior to surgery. However, only 23 of these rebled after admission to our institution. Preoperative neurological deterioration due to ischemia from vasospasm occurred in 13 patients. These are detailed below under the heading Complications. The overall management results, including deaths prior to surgery are summarized according to grade at time of admission in Table 2. One hundred fifty-five or 64% of all patients had an excellent or good result.
Among the 218 patients who survived to surgery (Table 3), 71% had an excellent or good result.

**Outcome in Patients Surviving to Surgery**

**Surgery 0 to 3 Days Post-SAH.** Eighty-five patients underwent surgery 0 to 3 days post-SAH. The results of surgery in these cases are summarized in Table 4. Forty percent of this group were in Grade 1 on admission and of these 91% had an excellent result and 3% a good result. Thirty-five percent were in Grade 2 on admission and of these 73% had an excellent result and 10% a good result.

Eight patients died during the postoperative period. One patient died as a result of the initial bleed; this patient was in Grade 4 prior to surgery and underwent emergency craniotomy and lobectomy with no improvement. The other seven patients died because of vasospasm with edema; preoperatively, two were in Grade 1 (one of whom rebled postoperatively from a second aneurysm), two in Grade 2, two in Grade 3, and one in Grade 4. No patients died in the follow-up period.

**Surgery 4 to 9 Days Post-SAH.** Eighty-three patients underwent surgery 4 to 9 days post-SAH. The results of surgery in these cases are summarized in Table 5. Fifty-seven percent of this group were in Grade 1 on admission and of these 87% had an excellent result and 2% a good result. Twenty-four percent were in Grade 2 on admission and of these 65% had an excellent outcome and 25% a good outcome.

There were six postoperative deaths in this group. These were attributed to vasospasms in two cases (one in Grade 3 and one in Grade 4 preoperatively) and myocardial infarction in two cases (one in Grade 1 and one in Grade 3 preoperatively). The other two patients who had giant aneurysms: one, who was preoperatively in Grade 2, was unable to tolerate internal carotid artery ligation and suffered an infarct; the ninth patient was preoperatively in Grade 1 with a giant aneurysm at the junction of the vertebral and basilar arteries, rebled when cardiopulmonary bypass was instituted for profound hypothermia, and then had multiple complications. Nine deaths in the follow-up period were due to: myocardial infarction in three cases (two in Grade 1 and one in Grade 3 preoperatively); pneumonia in one patient (Grade 3); stroke other than SAH in one case (Grade 1); hepatitis in one case (Grade 2); suicide in one case (Grade 2); and two from unknown causes (both Grade 1).

**Surgery 10 or More Days Post-SAH.** The 50 patients operated on 10 or more days post-SAH tended to be in poorer condition with only 22% being in Grade 1 on admission (Table 6). Of these, 73% had an excellent result and 9% a good result. Thirty-four percent were in Grade 2 on admission and of these 35% had an excellent outcome and 24% a good outcome.

Nine patients died postoperatively; three (one in Grade 3 and two in Grade 4 preoperatively) from vasospasm; three from the effects of a rebled (one Grade 2 patient at the induction of anesthesia and two postoperatively from a source other than the aneurysm repaired); one (Grade 2) from a myocardial infarction; one (Grade 3) from a pulmonary embolism; and one (Grade 4) following emergency craniotomy with resection of necrotic tissue and ventricular drainage. There were three deaths in the follow-up period: one patient died in a motor-vehicle accident (Grade 1); one from septic shock due to a urinary tract infection (Grade 3); and one from an unknown cause (Grade 3).

**Statistical Analysis of Results**

No significant difference in treatment results could be identified related to timing of surgical intervention when due consideration was given to differences in aneurysm size and location. The more difficult aneurysms appeared in the groups with later surgery.

**Complications**

Rebleeding. Sixty-four (26%) of all patients had more than one bleed (53 had two bleeds, nine had three, and two had four) but only 23 rebled after admission to this hospital. Of the rebleds in our hospital, six were fatal and the patients did not survive to surgery. The effects of a rebled could be further ascertained by the observation that of four patients who rebled and subsequently underwent surgery within 3 days, two had an excellent outcome but two had poor results. Similarly, in the patients undergoing surgery 4 to 9 days after their preadmission SAH, five rebled after admission: two
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**TABLE 5**

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Cases</th>
<th>Results at Last Medical Follow-Up†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Admission</td>
<td>At Op</td>
</tr>
<tr>
<td>1</td>
<td>47</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>3</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

* SAH = subarachnoid hemorrhage. For definition of neurological grade see text.
† Results according to admission grade.

**TABLE 6**

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. of Cases</th>
<th>Results at Last Medical Follow-Up†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Admission</td>
<td>At Op</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
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<tr>
<td>3</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

* SAH = subarachnoid hemorrhage. For definition of neurological grade see text.
† Results according to admission grade.

died, one had a poor result, one had a good outcome, and one had an excellent result. In the group undergoing surgery 10 days or more after preadmission SAH, there were eight rebleeds prior to surgery; postoperatively, two had excellent results, one a good result, three poor results, and two died. Delaying surgery 10 or more days did statistically increase the risk of rebleeding (p < 0.005). In two patients with multiple aneurysms, rebleeding occurred after aneurysm repair, suggesting that the wrong lesion had been treated initially.

Epsilon-aminocaproic acid was administered to 32 patients (13%). Most patients treated in this fashion had rebled at least once and were not judged as candidates for immediate surgical repair. Five patients (16% of all the patients treated with EACA) rebled after therapy had been started.

Ischemic Complications. Preoperative symptoms of vasospasm occurred in 13 patients: three were treated with volume expansion and improved in neurological status; and 10 were treated with Isuprel (isoproterenol), of whom six responded and four did not. These complications occurred primarily in the delayed-surgery group (p < 0.001). Of these patients one was in Grade 1 at admission, five were in Grade 2, and seven were in Grade 3.

Of the 218 patients surviving to surgery, 58 (27%) had a temporary or permanent deterioration postoperatively judged to be due to ischemia from vasospasm. Of these patients, 35 showed only a minor deterioration or had a major deterioration that was reversible with volume expansion and/or vaspressors (13 patients in Grade 1, 17 in Grade 2, one in Grade 3, and one in Grade 4 preoperatively); 10 had a partially reversible deficit (two patients in Grade 1, three in Grade 2, four in Grade 3, and one in Grade 4 preoperatively); 10 had a partially reversible deficit (two patients in Grade 1, three in Grade 2, four in Grade 3, and one in Grade 4 preoperatively); and 13 had a major deterioration which did not respond (one patient in Grade 1, two in Grade 2, six in Grade 3, and four in Grade 4 preoperatively).

The incidence of postoperative vasospasm was affected by the timing of surgery. The 85 patients operated on 0 to 3 days after their last preadmission SAH had a statistically significant increase in the incidence of postoperative ischemic symptoms (p < 0.005). Of these patients, 35 (41%) had a postoperative deterioration thought to be due to vasospasm, which was reversible in 22 patients, partially reversible in seven, and in six resulted in major irreversible deterioration.

In the 83 patients operated on 4 to 9 days after their last preadmission SAH, 15 (18%) suffered postoperative deterioration thought to be due to vasospasm. Twelve patients recovered with treatment, but in the other three this represented a major irreversible change. In the 50 patients operated on 10 or more days following preadmission SAH, ischemic deterioration occurred in eight patients (36%). Only one of these patients had reversible symptoms; symptoms were partially reversible in three, and caused a major irreversible change in four.

Operative Complications. Surgical timing did not significantly affect the incidence or severity of operative complications. No operations were abandoned because of poor exposure or insufficient brain relaxation. Preoperative aneurysmal bleeding during induction of anesthesia, exposure, or aneurysm dissection occurred in 48 patients (22%). This usually represented a minor leak and was of no clinical significance. Bleeding was uncontrollable in one patient operated on within 3 days following SAH. Perioperative bleeding occurred at equal frequency regardless of the surgical timing. Unwanted operative major vessel occlusion occurred in two patients operated on within 3 days and in two patients undergoing surgery 10 or more days following SAH. Subcortical hematomas or edema due to retraction requiring reoperation occurred in one patient operated on in the first 3 days and in one patient operated on 10 or more days after SAH.

Postoperative seizures occurred in 13 patients: three patients undergoing surgery 0 to 3 days post-SAH, four patients being operated on 4 to 9 days post-SAH, and six patients with surgery 10 or more days following SAH. Other complications such as myocardial infarction, pulmonary embolism, gastrointestinal hemorrhage, deep venous thrombophlebitis, and postoperative meningitis occurred with equal frequency in all three surgical groups.
Age and Aneurysm Location. Analysis of management results with respect to age and aneurysm location failed to demonstrate any difference in outcome among patients treated within 3 days, 4 to 9 days, or 10 days or more after SAH.

Discussion

Since the pioneering efforts of Hunt and Hess to relate the timing of surgical intervention to patient grade following aneurysmal SAH, the traditional wisdom, at least in North America, has been to delay surgery for at least 1 week following the last SAH. Recent reports of improved management results with early surgery have renewed interest in early operative intervention.\textsuperscript{1,6-8,11,12,17}

Timing Versus Outcome

In the present study, the overall management results for patients admitted shortly after their last SAH compare favorably with those previously reported by others. Management results for Grade 1 patients were uniformly good regardless of the timing of surgical intervention. Grade 2 patients, although not doing quite as well as Grade 1 patients, had similar favorable outcomes regardless of whether surgery was performed early (within 3 days after their last SAH) or later (4 to 9 days after). Although several causes unfavorably influenced the outcome in these patients, direct effects of the initial hemorrhage were responsible in nearly half of these cases. Grade 3 and 4 patients did poorly regardless of timing of surgical intervention.

Timing Versus Rebleeding

Elimination of the risk of rebleeding has been suggested as a potential advantage of early surgery. In this series most episodes of rebleeding occurred before admission to this institution and, therefore, could not have been prevented by early surgery. However, delayed surgery did result in a statistically significant increase in the rate of rebleeding after hospital admission and thus early surgery did lessen the risk of a second or third hemorrhage.

Timing Versus Vasospasm

Although other authors have found that early surgery reduces the incidence and severity of delayed ischemia from vasospasm, our data show that patients operated on within 3 days of their SAH had more vasospasm than those operated on four or more days after hemorrhage, thus failing to confirm this observation. However, the incidence of preoperative deterioration from vasospasm in this study was lower than that previously reported from this institution during a period when surgery was routinely delayed for 10 days or more.\textsuperscript{4} This has been ascribed to early surgical intervention. It cannot be determined from our data if the overall risk of complications from vasospasm is decreased by early surgical intervention. The increased incidence of complications from vasospasm in the early surgical group did not result in a statistically significant increase in morbidity, as most of these were reversible.

Conclusions

The results of the present study confirm the observations of others that early aneurysm surgery is technically feasible. Our experience suggests that most management morbidity and mortality can be traced directly to the effects of the initial hemorrhage and, because of this, the measured benefits of early surgery were less than might have been predicted. Based on these observations, early surgical intervention is recommended in "good-grade" patients in order to capitalize on the benefits provided by a reduced risk of rebleeding. Surgery should probably be delayed in "poor-grade" patients until their condition has stabilized or improved unless intracranial hypertension (due to an intracranial hemorrhage, for example) is contributing to the patient's poor neurological condition.

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References

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