Ultra-early surgery for aneurysmal subarachnoid hemorrhage: outcomes for a consecutive series of 391 patients not selected by grade or age


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Objective. This study was undertaken to determine the outcomes in an unselected group of patients treated with semielective surgical clipping of aneurysms following subarachnoid hemorrhage (SAH).

Methods. A clinical management outcome audit was conducted to determine outcomes in a group of 391 consecutive patients who were treated with a consistent policy of ultra-early surgery (all patients treated within 24 hours after SAH and 85% of them within 12 hours). All neurological grades were included, with 45% of patients having poor grades (World Federation of Neurosurgical Societies [WFNS] Grades IV and V). Patients were not selected on the basis of age; their ages ranged between 15 and 93 years and 19% were older than 70 years. The series included aneurysms located in both anterior and posterior circulations. Eighty-eight percent of all patients underwent surgery and only 2.5% of the series were selectively withdrawn (by family request) from the prescribed surgical treatment. In patients with good grades (WFNS Grades I–III) the 3-month postoperative outcomes were independence (good outcome) in 84% of cases, dependence (poor outcome) in 8% of cases, and death in 9%. In patients with poor grades the outcomes were independence in 40% of cases, dependence in 15% of cases, and death in 45%. There was a 12% rate of rebleeding with all cases of rebleeding occurring within the first 12 hours after SAH; however, outcomes of independence were achieved in 46% of cases in which rebleeding occurred (43% mortality rate). Rebleeding was more common in patients with poor grades (20% experienced rebleeding, whereas only 5% of patients with good grades experienced rebleeding).

Conclusions. The major risk of rebleeding after SAH is present within the first 6 to 12 hours. This risk of ultra-early rebleeding is highest for patients with poor grades. Securing ruptured aneurysms by surgery or coil placement on an emergency basis for all patients with SAH has a strong rational argument.

Key Words • subarachnoid hemorrhage • cerebral aneurysm • aneurysm surgery • rebleeding • outcome

The term “early surgery,” which applies to an operation performed within 3 days after onset of SAH, is, of course, somewhat misleading if we consider that the rebleeding rate in patients who have suffered this hemorrhage is highest within the first 24 hours, with up to 87.1% of rebleedings occurring within the first 6 hours after SAH. Therefore early surgery performed on the 2nd or 3rd day post-SAH would seem to be somewhat delayed, and would not be expected to have a major impact on the rebleeding rate. It is not surprising that major series in which the differences between early and late surgery have been compared have often not shown a marked difference in outcome. In the original cooperative study, only 49% of patients were admitted to the hospital on the day of SAH and patients with multiple incidences of rebleeding were excluded from the study (11% of exclusions).

The term “ultra-early” is used to describe rebleeding that occurs during the first 12 to 24 hours post-SAH; however, this term distracts us from the fact that this is the most common time for rebleeding, and securing the aneurysm within this time frame would seem a rational approach.

Although early surgery is now widely advocated, it is still unusual for aneurysmal SAH treatment to be undertaken other than on a semielective basis. Even those practitioners advocating emergency securing of the aneurysm tend to withhold treatment from patients with poor grades (those believed to have the highest risk of rebleeding) and elderly patients.

As a new specialized technology, endovascular coil placement has understandably developed in a controlled elective environment. There have been many comparisons between results of surgery and those of coil placement; however, such studies have focused primarily on the adequacy of aneurysm obliteration, procedural complications, and so forth, and have distracted discussion away from the main objective of either procedure: the prevention of rebleeding.

Given the known timing of the maximum risk of rebleeding, we believe that semielective securing of the aneurysm should be taken into consideration.

Clinical Material and Methods

Patient Population

This is the report of a clinical management outcome audit of 391 consecutive patients with aneurysmal SAH. The patient population included individuals of all grades and...
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all ages whose cases were managed with an aggressive ultra-early surgery policy by two neurosurgeons (J.D.L. and K.H.S.) at one institution (Alfred Hospital, Victoria, Australia) between 1991 and 2000. During this study period, this hospital was the major trauma institution in the state and, as such, had helicopter access and facilities for urgent reception, investigation, and surgery. Endovascular (coil placement) facilities were not available at the hospital during that time, and therefore, aneurysm treatment was surgical. During the treatment period patients requiring ventilation (those with a poor grade) were placed in a general intensive care unit, and all other patients were managed in a general ward environment.

During the 9.3-year period from January 1991 to April 2000 all patients with aneurysmal SAH who presented to our hospital were prospectively identified and data pertinent to their cases were collected by a continuous clinical audit. The audit data were also verified by a retrospective review of the medical records for all cases. A total of 775 patients were identified as having a diagnosis of nontraumatic SAH and/or intracranial aneurysm. Of these, 134 were excluded on the grounds that they did not experience a spontaneous saccular aneurysmal hemorrhage. The majority of patients who were excluded were those treated for unruptured aneurysms; also excluded were patients with nonaneurysmal SAH, dissecting aneurysms, and mycotic aneurysms.

Although seven different neurosurgeons treated patients at our institution during the study period (the patients are allocated according to an on-call roster), we selected only those 391 patients who were treated by the two of us for a number of reasons. First, we were the only neurosurgeons treating patients at that institution throughout the entire study period and, therefore, managed the majority of cases. Second, we managed cases by using a consistent, aggressive, standard treatment regime throughout the study period, whereas management of cases by other neurosurgeons differed (particularly with respect to patients with poor grades and elderly patients). We also excluded those patients who initially were treated by other neurosurgeons before being referred to us, usually for surgery, because this would introduce selection bias into this series (those patients often were referred late for surgery and disproportionately consisted of elderly patients and those with poor grades) and also because, by virtue of late referral, these patients were not able to be treated according to our early surgery regimen.

Grading of SAH

Clinical grading of patients was based on the neurological status of the individual at the time of presentation to our hospital in 86% of cases. Thirty-four percent of patients who required intubation before arrival at our hospital were graded according to the best reliable neurological assessment made before intubation. All patients with SAH were graded according to the WFNS grading scale (Table 1). The WFNS Grades I through III are associated with GCS Scores 13 through 15, and are collectively referred to as good grades; WFNS Grades IV and V are associated with GCS scores below 13 and are referred to as poor grades.

Case Management Regimen

During the study period we pursued an aggressive early surgery treatment regimen for all patients with aneurysmal SAH, regardless of their age or clinical status. The only exceptions to this approach were made for patients who had been clinically determined to be brain dead or whose nearest relative refused treatment (see later discussion of non-surgical cases).

We requested urgent transportation of patients from peripheral facilities, using air transportation when appropriate. On arrival at the emergency department, CT scanning was performed on an urgent basis. Four-vessel cerebral angiography was requested as soon as resuscitative measures had been instituted; this usually commenced within 2 to 3 hours after the patient’s arrival at the hospital. Most patients were transferred directly to the operating room from the angiography facility.

Patients were not routinely given sedatives. Small intermittent doses of intravenous narcotic agents were titrated on a regular basis for analgesia if required; this usually consisted of the equivalent of approximately 1 mg morphine delivered intravenously on an hourly basis. Only patients with poor grades (WFNS Grades IV and V) and those with compromised airways or respiratory failure were treated with immediate intubation and ventilation to achieve normocapnia (PaCO₂ 35–45 mm Hg) and mild hyperoxemia (PaO₂ > 100 mm Hg). Patients receiving ventilation were given sedatives to allow for endotracheal tube tolerance.

Central venous catheters were inserted in all patients before surgery so that fluid deficits could be optimally corrected and mild hypervolemia could be instituted. Hypervolemia therapy, designed to keep central venous pressure at 5 to 10 cm H₂O, was continued during the postoperative period throughout the presumed risk period of vasospasm (7–10 days or longer if indicated by clinical, transcranial Doppler ultrasonography, or angiography findings). Initially we had used colloid boluses (albumin solution) to maintain hypervolemia. Over the past 5 years, however, we have found that a crystalloid solution has the same effect in most patients and have only used albumin in patients who are hypoalbuminemic. Serum electrolytes were closely monitored and their levels were corrected as required.

Patients were maintained in a normotensive state preoperatively, with the exception of patients with poor clinical grades in whom we allowed moderate hypertension (to a maximum systolic pressure of 160–180 mm Hg) on the assumption that hypotension may compromise cerebral perfusion pressure. Postoperatively we ceased all routine antihypertensive medications, and tolerated hypertension up to a maximum of 180 mm Hg in all patients.

Intravenous infusion of nimodipine was commenced on the day of admission in all patients and continued during the

### Table 1

<table>
<thead>
<tr>
<th>WFNS Grade</th>
<th>GCS Score</th>
<th>Motor Deficit</th>
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<tbody>
<tr>
<td>I</td>
<td>15</td>
<td>absent</td>
</tr>
<tr>
<td>II</td>
<td>13–14</td>
<td>absent</td>
</tr>
<tr>
<td>III</td>
<td>13–14</td>
<td>present</td>
</tr>
<tr>
<td>IV</td>
<td>7–12</td>
<td>present or absent</td>
</tr>
<tr>
<td>V</td>
<td>3–6</td>
<td>present or absent</td>
</tr>
</tbody>
</table>

* Adapted from Drake. Motor deficit is defined as aphasia and/or hemiparesis or hemiplegia.
vasospasm risk period. Oral nimodipine was rarely used; it was only substituted for intravenous nimodipine after Day 10 post-SAH in some well patients still considered to have significant risk of vasospasm at that time (for example, persistently raised transcranial Doppler measurements in the absence of neurological deficit). Delayed neurological deficit due to symptomatic vasospasm was aggressively treated with hypervolemia and induced hypertension. Intraarterial papaverine was only used in refractory cases. Angioplasty was not available.

Calf compression stockings were used in all patients as a prophylaxis against venous thromboembolism and early mobilization was routinely practiced, with patients with good grades routinely walking within 24 hours after surgery. Low doses of heparin were used in patients whose postoperative neurological conditions prevented ambulation.

Preoperative ventricular drainage was not routinely used and was reserved only for those patients with poor grades with significant ventricular dilation. Although ventricular drainage was not uncommonly used for intraoperative brain relaxation, routine postoperative ventricular drainage was not practiced.

Surgical clipping of the aneurysm was the only method available for securing aneurysms at the hospital during the study period. We routinely used standard pterional craniotomy techniques to treat both anterior circulation and distal basilar aneurysms, and posterior fossa approaches to treat other more proximal vertebrobasilar aneurysms. We strongly adhered to the principles of small craniotomy, minimal brain retraction, and sharp microdissections performed with the aid of high-power magnification. Temporary clipping of proximal vessels was infrequently performed. Intraoperative dehydration and hypotension were avoided. Intraoperative micro-Doppler ultrasonography was commonly performed to assess the vessel’s patency postclipping, but intraoperative angiography was not available. Aneurysms were routinely punctured to determine the adequacy of the clip placement. Although we routinely performed postoperative angiography for aneurysms located in the posterior circulation, it was only performed in a few cases of anteriocirculation aneurysms in which we had concerns regarding clip placement.

Our commitment to ultra-early surgery and the absence of any full-time neurosurgeons at the hospital necessitated that more than 70% of surgeries were performed outside routine operating hours (not infrequently late at night), without a neurosurgery-trained surgical support staff. All patients were surgically treated within 24 hours after aneurysm diagnosis, with 85% of patients undergoing surgery within 12 hours after arrival at our hospital. In the 15% of patients in whom surgery was postponed more than 12 hours after arrival, most surgical deferments were due to diagnostic delays.

**Outcome Assessment**

Outcome was assessed according to the GOS (Table 2).

All patients participated in follow-up review for a minimum of 3 months postoperatively (unless death preceded this time period), and more than 80% of patients participated in clinical follow up for longer than 12 months. Although we did observe clinical improvement in some cases (particularly in patients who initially had poor grades) between 3 and 6 months postoperatively, there was rarely enough change to constitute an upgrade on the GOS. Therefore, to use 100% follow-up data, we report outcomes of patients at 3 months postoperatively.

For the purposes of simplified discussion in this paper, patients who were independent (GOS Scores 4 or 5, moderate disability and good recovery, respectively) are collectively referred to as having achieved good outcomes, whereas those patients who remained dependent (GOS Scores 2 or 3, persistent vegetative state and severe disability, respectively) are referred to as having poor outcomes; however, detailed ungrouped outcome data, with frequencies for each individual GOS score, are presented in Table 3.

**Incidences of Rebleeding**

For the purposes of this study, rebleeding has been defined as an observed abrupt deterioration in neurological status following documented SAH, in the absence of clinical seizure activity or primary cardiovascular instability. Intraoperative aneurysm rupture, even if it occurred early during the procedure, before the aneurysm was exposed (four cases), has not been included in this definition of rebleeding. Although not a primary requirement for the definition of rebleeding, more than two thirds of rebleeding incidents were confirmed on CT scans, and two cases of rebleeding had angiographic evidence.

**Intraoperative Technical Difficulties**

We have defined an intraoperative technical difficulty as one of the following: difficult access (as noted by the surgeon at the time of surgery) due to brain swelling; intraoperative aneurysm rupture; application of temporary clips for a period longer than 5 minutes; evidence of retraction injury (focal swelling or hemorrhagic contusion) on a postoperative CT scan; early postoperative infarction demonstrated on a CT scan; or a new, early postoperative neurological deficit.

We acknowledge that specific factors, such as aneurysm

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**TABLE 2**

**Glasgow Outcome Scale***

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Score</th>
<th>Description</th>
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<tbody>
<tr>
<td>good recovery</td>
<td>5</td>
<td>able to reintegrate into normal life &amp; can return to work; may have mild persistent sequelae</td>
</tr>
<tr>
<td>moderate disability</td>
<td>4</td>
<td>independent in activities of daily living &amp; in home &amp; community activities but has disability such as memory or personality change, hemiparesis, dysphasia, ataxia, seizures, major cranial nerve deficits</td>
</tr>
<tr>
<td>severe disability</td>
<td>3</td>
<td>conscious, but has a 24-hr dependency due to cognitive, behavioral, or physical disabilities, including dysarthria &amp; dysphasia</td>
</tr>
<tr>
<td>persistent vegetative state</td>
<td>2</td>
<td>persistent state characterized by reduced responsiveness associated w/ wakefulness; may exhibit eye opening, sucking, yawning, &amp; localized motor responses</td>
</tr>
<tr>
<td>death</td>
<td>1</td>
<td>death</td>
</tr>
</tbody>
</table>

* Adapted from Jennett and Bond.
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site and size, breadth of neck, atheroma or calcification, and aneurysm origin, have a major impact on the degree of difficulty encountered in successfully clipping an aneurysm. Because these factors do not relate to the timing of surgery, however, we deliberately did not consider them in this study. Therefore, the criteria for technical difficulties used in this study were essentially the same as unanticipated problems encountered when a similar aneurysm is clipped on an elective delayed basis.

Statistical Analysis

Analysis was performed using commercially available statistical software (SPSS version 9.0 for Windows; SPSS Inc., Chicago, IL). Chi-square tests and the Fisher exact probability test were used, where appropriate, to test differences in distribution probability between groups. Probability values lower than 0.05 were deemed statistically significant.

Results

Age and Sex Distribution

This series does not include pediatric cases (defined as < 15 years of age), which were not treated at our institution. The ages of the patients in our study ranged from 15 to 93 years, with a median age of 54 years. Seventy-four patients (19%) were age 70 or older. There was a slight female predominance (54%) in the study population.

Admission Grades

Using the WFNS SAH grading scale, the admission grades for patients were the following: Grade I, 31%; Grade II, 16%; Grade III, 8%; Grade IV, 9%; and Grade V, 36% (Table 3).

Management Outcome

Among the 391 cases that we managed, 214 (55%) patients had good grades, with 121 patients being assigned WFNS Grade I, 63 patients Grade II, and 30 patients Grade III. One hundred seventy-seven patients (45%) had poor grades, with 37 being assigned WFNS Grade IV and 140 Grade V (Table 3).

Of the 214 patients with good grades (WFNS Grades I–III) the 3-month postoperative outcome was good in 178 patients (83%), poor in 16 patients (7%), and death in 20 patients (9%). Of the 177 patients with poor grades (WFNS Grades IV and V) the 3-month outcome was good in 54 patients (31%), poor in 20 patients (11%), and 103 patients died (58%) (Table 3).

Nonsurgical Cases

Despite a consistent policy of aggressive surgical treatment for all cases, regardless of age or clinical grade, 48 (12%) of the 391 patients did not undergo surgery. Twenty-nine patients died preoperatively (clinical brain death on presentation in nine cases, no intracranial flow on angiography in 10 cases, cerebral perfusion pressure 10 mm Hg after emergency ventriculostomy and ventricular drainage in six cases, and in four patients asystolic cardiac occurring before surgery (all within 4 hours after presentation).

Eight patients were considered unsuitable for surgery on medical grounds (severe uncontrolled neurogenic pulmonary edema in three cases, cardiogenic shock in one case, massive intracerebral and brainstem hemorrhage in three cases, and coexisting cancer in one patient. All eight patients died within 4 days post-SAHA.

Ten elderly patients with poor grades (nine of whom were 80 years of age or older, and one 68-year-old patient with dementia) were not treated at the specific request of their families. Two of these patients still survived at 3 months postoperatively, although both were in completely dependent states (one was severely disabled and the other was in a persistent vegetative state).

In the remaining patient, no aneurysm was found on three separate angiograms. That patient was discharged home with no neurological deficit. She returned to the hospital 3 weeks later with a second SAH and was found to harbor a ruptured pericallosal artery aneurysm that was clipped. An excellent outcome was achieved in this case.

Coil Embolization of Aneurysms

During the study period the hospital did not have facilities for endovascular aneurysm obliteration, and, therefore, this is a study of surgical management of aneurysms. Nevertheless, there were three cases in which coil placement was specifically requested. The patients were transferred to other institutions for the coil embolization and returned to us following this procedure. One patient (WFNS Grade IV) suffered vessel occlusion, stroke, and death as a result of the coil procedure. One patient (WFNS Grade I) who harbored an aneurysm at the verteobasilar junction achieved excellent neuroimaging and clinical outcomes. The last patient (WFNS Grade II) who harbored a giant aneurysm at the trunk of the basilar artery underwent incomplete coil embolization of the lesion and required surgical clipping. An excellent outcome ensued in that case.

<table>
<thead>
<tr>
<th>Admission grade and 3-month outcome in 391 patients</th>
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<tbody>
<tr>
<td>WFNS Grade</td>
</tr>
<tr>
<td>I</td>
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<tr>
<td>II</td>
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<tr>
<td>III</td>
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<tr>
<td>IV</td>
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<tr>
<td>V</td>
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<td>total</td>
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<table>
<thead>
<tr>
<th>Surgical series</th>
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<tbody>
<tr>
<td>WFNS Grade</td>
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<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
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<tr>
<td>III</td>
</tr>
<tr>
<td>IV</td>
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<td>V</td>
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<tr>
<td>total</td>
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<table>
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<tr>
<th>Cases w/ intraop technical difficulties</th>
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<tbody>
<tr>
<td>WFNS Grade</td>
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<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
<tr>
<td>IV</td>
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<tr>
<td>V</td>
</tr>
<tr>
<td>total</td>
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Outcomes of Surgery

Of the 340 patients who underwent surgical clipping of an aneurysm, 208 (61%) were assigned good grades: 119 patients with WFNS Grade I; 59 with Grade 2; and 30 with Grade III. One hundred thirty-two patients (39%) were assigned poor grades: 33 patients with WFNS Grade IV and 99 patients with Grade V (Table 3).

The 3-month postoperative outcome for the 208 patients with good grades (WFNS Grades I–III) was good in 174 patients (84%), poor in 16 patients (8%), and death in 18 patients (9%). In the 132 patients with poor grades (WFNS Grades IV and V) outcomes were good in 53 patients (40%), poor in 20 patients (15%), and death in 59 patients (45%).

Incidence of Rebleeding

Using the clinical definition of rebleeding provided earlier, 47 patients (12%) in the total series and 37 patients (11%) in the surgical series experienced rebleeding. All patients in the nonsurgical group who experienced rebleeding died; rebleeding was the cause of sudden preoperative death in eight of these 10 patients. Every instance of rebleeding occurred within 12 hours after the initial SAH.

In the surgical series patients who experienced rebleeding were more commonly those initially assigned poor grades (28 [76%] of WFNS Grades IV or V, but only nine [24%] of 37 patients had WFNS Grades I, II, or III on admission). Despite this, outcomes in patients who experienced rebleeding and surgery were not uniformly poor; 46% achieved good outcomes, 11% poor outcomes, and 43% died.

Incidence of Vasospasm

Sixty-one patients (18%) in the surgical series experienced DINDs due to symptomatic vasospasm. Not surprisingly, there were no cases of DIND in the nonsurgical group (with only three of those patients surviving more than 4 days).

There was no correlation between admission grade and the development of DIND, which occurred in 41 (20%) of 208 patients with good grades who underwent surgery and in 20 (15%) of 132 patients with poor grades who underwent surgery.

Fisher grades were not recorded for all admission CT scans, although our impression is that severe vasospasm occurred more commonly in patients in whom there were large amounts of subarachnoid blood clot.

Outcomes at 3 months postoperatively in patients with good grades in whom vasospasm developed were good in 85%, poor in 5%, and death in 10%. In patients with poor grades in whom vasospasm occurred, outcomes were good in 55%, poor in 20%, and death in 25%.

Intraoperative Technical Difficulties

Intraoperative technical difficulties, as defined earlier, were encountered in 26 (8%) of the 340 surgical cases. Sixty-nine percent of these problems occurred in patients with poor grades (WFNS Grades IV and V) (Table 3).

When we separate the patients who underwent surgery into groups based on grades, technical difficulties were not ed in only eight (4%) of 208 patients with good grades, but in 18 (14%) of 132 patients with poor grades (p < 0.001).

Discussion

During this study period we had a deliberate policy of treating SAH on a semiurgent basis, and we report the results of this policy. Although we have only included cases that were treated by two surgeons for the methodological reasons previously discussed (see Patient Population), these patients were assigned to those surgeons according to an on-call roster over the 10-year period and have, therefore, not been subjected to clinical selection bias. Our regimen of ultra-early surgery is based on the now-well-documented risk of rebleeding, which is highest within the first 6 to 12 hours after SAH. Our series confirms that risk with a 12% ultra-early (≤ 12 hours post-SAH) rebleeding rate. This series cannot add to the debate between the relative merits of surgical and endovascular treatment of aneurysms, because the study period encompassed a time when we were unable to offer endovascular therapy routinely for aneurysms. Nevertheless, the optimal timing of surgery following SAH (particularly for patients assigned poor grades) is still a matter of debate, and endovascular treatment must address the same issue.

Many authors reviewing surgical treatment of ruptured aneurysms have presented selected surgical outcomes, rather than overall management outcomes, and thus the patient selection introduced bias. Because we have had a deliberate policy of nonselection of patients, offering aggressive ultra-early treatment to patients of all ages and grades, we have reported surgical outcomes believing that, in this series, they are relevant. Nevertheless, we accept the fact that bias was introduced into this series by the 10 cases in which families refused treatment (patients tending to be elderly and having poorer grades). Therefore, because we could not avoid this bias, we have reported both overall management and surgical outcomes.

This series differs from many previously reported series in that it contains a relatively high proportion of SAH patients with poor grades, with a total of 45% of patients with WFNS Grades IV or V. This reflects the fact that the hospital has rapid reception facilities and is able to receive patients with poor grades early after onset of SAH, patients who may have otherwise died if they had been transported to other facilities in a less urgent manner. It also reflects the fact that the hospital is a primary neurosurgical referral site, with less than 1% of cases being referred from other neurological or neurosurgical facilities, and more than 90% of cases being referred to us directly by emergency department physicians at the time of acute presentation. Very few patients (< 10%) were admitted to other hospitals before they were referred to our institution and, therefore, the effects of referral bias in this series should be minimal, with little selection having been made according to grade and presumed prognosis. This is also reflected in the relative high number of elderly patients in this series (19% of patients were ≥ 70 years of age).

There have been recent publications advocating a period of conservative treatment for patients with poor grades to allow selection of patients with improving clinical status. It has been established that some of these patients will improve clinically over a period of time, partic-
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ularly in response to ventricular drainage and aggressive medical therapy.1,6,7,19,29,46,71,77,79 We acknowledge that, in our series, some patients with poor grades probably would have improved to better grades over a period of conservative treatment. It is therefore difficult to compare our series with others in which clinical grading was applied in a more delayed manner, and it must be remembered that, in our series, grading was based on the patient’s clinical status on admission. This differs from most other series, in which patients with poor grades are usually those who remain in a poor neurological condition after some days of conservative treatment. Our ultra-early treatment strategy, however, necessitated ultra-early clinical grading and we cannot predict which patients with poor grades would have improved or suffered rebleeding during a period of conservative treatment. The main early risk to all patients with SAH is rebleeding, and the results in our series confirm previously reported findings that this risk is somewhat higher in patients with poor grades than in those with good grades.24,27,36,49,67,72,83 It is not a rational medical strategy—as opposed to a socioeconomic79 strategy—to leave a ruptured aneurysm unsecured in all patients with poor grades during the period in which the risk of rebleeding is highest so that those with a better prognosis can be selected.

We did not use routine preoperative ventricular drainage for patients with poor grades because our strategy dictated definitive intracranial decompression on a semiurgent basis. We considered that the delay caused by ventriculostomy and the risk of ventriculostomy-associated rebleeding22,67,71 would outweigh the potential benefits. Hypotensive therapy is still commonly advocated in the preoperative management of SAH.1,3,14,79,91 We did not use this routinely in cases of poor grades in which neurological assessment is less sensitive, autoregulation is more likely to be disturbed, and intracranial pressure is likely to be elevated.12,15,51,86,88,89,92 We had less reluctance to use hypotensive agents (although only to maintain normotension) in patients with good grades.

This study may be criticized because we did not insist on neuroimaging documentation of rebleeding (neuroimaging confirmation was only obtained in two thirds of the cases). Computed tomography scans do not always provide reliable confirmation of rebleeding; differences in slice levels make assessments of amounts of blood in the basal cisterns subjective and somewhat unreliable, particularly in cases in which there already is a large amount of blood in the basal cisterns. Our clinical requirements for an event to be categorized as rebleeding, namely an observed abrupt deterioration in neurological status following documented SAH in the absence of clinical seizure activity or primary cardiovascular instability, are likely to underestimate the incidence of rebleeding. It excluded those few cases in which deterioration was not actually observed by a reliable observer because we could not rule out the possibility of seizure activity. In our study we also excluded patients with poor grades who experienced a sudden cardiac event. Our clinical impression is that the cause of these events was most likely rebleeding, although again we could not be sure. Finally, patients with poor grades were treated by intubation and ventilation on arrival at the hospital, making neurological monitoring difficult, and we would therefore expect that we have probably underestimated the frequency of rebleeding in these patients. Despite this, our study still supports previous findings that the risk of rebleeding is significantly higher in patients with poor grades24,27,36,46,67,72,83 rebleeding occurred in 36 (20%) of 177 patients with poor grades (WFNS Grades IV or V), but in only 11 (5%) of 214 patients with good grades (WFNS Grades I–III) (p < 0.0001).

Typically, rebleeding is more severe than the initial SAH, with reported mortality rates ranging from 64.5%24 to 80%.65,72 Although the results of this series underscore the importance of rebleeding, demonstrating a 43% mortality rate in patients who experienced that event, it also demonstrates that, by applying aggressive treatment, rebleeding need not be associated with a bad prognosis because only 11% of patients who experienced rebleeding and were treated with ultra-early surgery had a poor outcome at 3 months. Forty-six percent of patients in whom rebleeding was aggressively treated in this series achieved independent outcomes at 3 months postoperatively. Rebleeding should therefore not be considered to be a contraindication for very early and aggressive treatment; in fact the opposite may be true.

Concerns that early surgery may precipitate or aggravate the development of vasospasm have been allayed by previous studies.53,70 There has been some suggestion that early clot removal may reduce the risk of developing subsequent vasospasm,34,45,56,59,70 although this effect has not been substantiated.37,53,82,94 Nevertheless, it is generally agreed that an aneurysm that has been secured (clipped or coiled) facilitates the safe treatment of vasospasm.5,8,22,65,73,75 In this series we used prophylactic and therapeutic measures for vasospasm that are widely practiced, although the efficacy of these measures is by no means proven. These include prophylactic hypervolemia,9,16,29,51,56,57,60,66,74 prophylactic nimodipine,10,16,17,20,21,25,26,31,32,39,62,68,70,90 and therapeutic hypervolemic hemodilution and hypertension therapy.8,16,30,40,43,52,55,59,61,85,86 When compared with previous reported series, the results of the present study indicate that the overall strategy would seem to be effective in that there was only an 18% rate of DIND and among those patients in the surgical series in whom DIND developed, 75% were independent (good outcome), 10% were dependent (poor outcome), and 15% had died at the end of the 3-month follow-up period. When viewed according to grade stratification and compared with the rest of the surgical series, however, these findings are perplexing. Among patients with good grades, there was almost an identical outcome for those with and without DIND. Among patients with poor grades who experienced DIND, good outcomes were achieved in 55%, whereas among similar patients who did not experience DIND, good outcomes were achieved in only 38%. This unexpected finding is not statistically significant (p = 0.14). We cannot explain this and we believe that this may be an anomalous finding in a relatively small series. Nevertheless, we do need to consider that only patients with established DIND, who are thus treated with induced hypertension, and patients with poor grades, who required ventilatory support, were treated in a general intensive care unit, whereas all other patients were treated in a general ward environment.

The determination of intraoperative technical difficulties is subjective and somewhat unreliable. Because one main argument against early surgery has been the degree of technical difficulty that is encountered, particularly when surgery is performed at unscheduled hours with an inexperi-
enced support staff, we consider this topic to be sufficiently important to make some attempt at assessment. The definition of intraoperative technical difficulties we used for this study is more inclusive than the array of surgical complications that are usually reported. Nevertheless, our findings that cases fulfilling any of these criteria occurred in only 4% of patients with good grades and 8% of those with poor grades would suggest that our series compares well with other series in which surgery has been delayed for some time. These results support previous findings that the selection of early surgery does not add to surgical morbidity.\(^{46}\) We stress that emergency after-hours aneurysm surgery without a good support team is very difficult and not optimal for either the surgeon or the patient. Nevertheless, our findings would indicate that the risk to the patient of rebleeding would generally outweigh that of nonselective surgery. Although surgical difficulties were more commonly encountered in patients with poor grades, there is a higher rebleeding rate in those patients, which is not likely to be helped by delaying surgery.

Some concerns have been raised concerning whether angiography performed within the first 6 hours post-SAH may actually precipitate rebleeding.\(^{24,47,93}\) An analysis of such reports and a review of the literature does show that, although the rebleeding rate might be higher during angiography performed during the first 6 hours compared with angiography performed later, there is no good evidence that the risk of rerupture of the aneurysm is higher within the first 6 hours if angiography is performed during that same period than if angiography was not performed.

The lack of availability of intraoperative angiography and our management strategy of not routinely performing postoperative angiography in all anterior circulation aneurysms during the study period means that we cannot, of course, comment accurately on the angiographically determined adequacy of the technique of surgical clipping in all cases. The adequacy of the surgical clipping technique, however, was assessed in each case by visual inspection, routine puncturing of the aneurysm after clipping, intraoperative vessel micro-Doppler ultrasonography, postoperative angiography in cases in which the aneurysm had not collapsed intraoperatively, and routine postoperative clinical and CT scanning studies to detect infarction. We consider this to be appropriate clinical management and find it difficult to justify routine postoperative angiography in all cases.

The ethical and economic considerations of aggressively treating patients of all ages and grades are important, and concerns are often raised about the appropriateness of treating elderly patients and those with poor grades. These value judgments can only be made, however, if we have an understanding of the results of these aggressive interventions, rather than simply denying those groups the treatment on the expectation that their outcomes will be poor. We believe that the results of the present study provide outcome data on which more informed ethical discussions can be based.

Finally, we should note that, despite our efforts to secure the aneurysm as soon as possible after most of the SAH, we still found a rate of rebleeding of 12%. Therefore, it could be suggested that the strategy itself has failed in its goal to prevent rebleeding. Whether the rate would have been much higher had we deferred surgery is not known; however, outcome figures for the overall series do compare very well with other more delayed treatments, particularly in patients in whom rebleeding has occurred and in those with poor grades. We do think that the rebleeding rate could be further reduced with even more prompt treatment, which would be quite feasible if the hospital community assigned SAH the urgent prioritization accorded to other similar life-threatening conditions (for example, ruptured abdominal aneurysm).

Conclusions

Rebleeding is the most threatening early complication facing a patient who survives an SAH, and its prevention must be a primary therapeutic goal. The risk of rebleeding is highest within the first 6 hours after an SAH has occurred and, even with ultra-early surgery (85% of patients treated within 12 hours), we found a 12% rebleeding rate. The rate is higher in patients with poor grades. This series raises a number of compelling hypotheses. 1) Securing a ruptured intracranial aneurysm (achieved either by clipping or coil embolization) on an urgent basis would reduce the rebleeding rate and improve patient outcome. 2) The benefit of ultra-early surgery would be even more marked for patients with poor grades than for those with good grades (a group that has a lower rebleeding rate). 3) Ultra-early surgery is as beneficial to elderly patients as to younger patients.

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References

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