Time course of recovery following poor-grade SAH: the incidence of delayed improvement and implications for SAH outcome study design

Clinical article

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Object. Data regarding the time course of recovery after poor-grade subarachnoid hemorrhage (SAH) is lacking. Most SAH studies assess outcome at a single time point, often as early as 3 or 6 months following SAH. The authors hypothesized that recovery following poor-grade SAH is a dynamic process and that early outcomes may not always approximate long-term outcomes. To test this hypothesis, they analyzed long-term outcome data from a cohort of patients with poor-grade aneurysmal SAH to determine the incidence and predictors of early and delayed neurological improvement.

Methods. The authors reviewed outcome data from 88 poor-grade SAH patients enrolled in a prospective SAH treatment trial (the Barrow Ruptured Aneurysm Trial). They assessed modified Rankin Scale (mRS) scores at discharge, 6 months, 12 months, and 36 months after treatment to determine the incidence and predictors of neurological improvement during each interval.

Results. The mean aggregate mRS scores at 6 months (3.31 ± 2.1), 12 months (3.28 ± 2.2), and 36 months (3.17 ± 2.3) improved significantly compared with the mean score at hospital discharge (4.33 ± 1.3, p < 0.001), but they did not differ significantly among themselves. Between discharge and 6 months, 61% of patients improved on the mRS. The incidence of improvement between 6–12 months and 12–36 months was 18% and 19%, respectively. Hunt and Hess Grade IV versus V (OR 6.20, 95% CI 2.11–18.25, p < 0.001) and the absence of large (> 4 cm) (OR 2.76, 95% CI 1.02–7.55, p = 0.05) or eloquent (OR 5.17, 95% CI 1.89–14.10, p < 0.01) stroke were associated with improvement up to 6 months. Age ≤ 65 years (OR 5.56, 95% CI 1.17–26.42, p = 0.02), Hunt and Hess Grade IV versus V (OR 4.17, 95% CI 1.10–15.85, p = 0.03), and absence of a large (OR 8.97, 95% CI 2.65–30.40, p < 0.001) or eloquent (OR 4.54, 95% CI 1.46–14.08, p = 0.01) stroke were associated with improvement beyond 6 months. Improvement beyond 1 year was most strongly predicted by the absence of a large stroke (OR 7.62, 95% CI 1.55–37.30, p < 0.01).

Conclusions. A substantial minority of poor-grade SAH patients will experience delayed recovery beyond the point at which most studies assess outcome. Younger patients, those presenting in better clinical condition, and those without CT evidence of large or eloquent stroke demonstrated the highest capacity for delayed recovery.

Key Words • subarachnoid hemorrhage • poor-grade subarachnoid hemorrhage • cerebral aneurysm • outcome • stroke • vascular disorders

LONG-TERM clinical outcomes following poor-grade SAH have not been well studied. Most SAH studies assess outcome at a single time point, often as early as 3 or 6 months following SAH. Implicit in that study design is the notion that any improvement in clinical status following SAH quickly reaches a plateau beyond which no further improvement can be expected. In failing to account for delayed improvement, this “plateau” assumption carries important implications for the design and findings of SAH outcome studies.

We hypothesized that recovery following poor-grade SAH is a dynamic, long-term process and that early outcome measures are not always indicative of long-term outcome. To test this hypothesis, we analyzed outcome data obtained in poor-grade SAH patients enrolled in a prospective randomized SAH treatment trial, the Barrow Ruptured Aneurysm Trial, at multiple time points up to 3 years following SAH. We investigated the time course expected.
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of recovery among this cohort and identified clinical and radiographic predictors of early and delayed improvement following poor-grade SAH.

Methods

Patients

We reviewed hospital records, imaging studies, and prospectively collected outcome data of 472 SAH patients enrolled in a prospective ruptured aneurysm treatment trial, the BRAT,19 between 2003 and 2007. We included patients with confirmed aneurysmal SAH and a Hunt and Hess Grade of IV or V on presentation and who underwent definitive aneurysm treatment. Exclusion criteria were as follows: angiographically negative SAH, a Hunt and Hess Grade I–III on presentation, death before treatment, and no treatment due to the determination of medical futility at presentation.

This study was approved by the Institutional Review Board of St. Joseph’s Hospital and Medical Center (Phoenix, AZ).

Clinical and Radiographic Variables

We reviewed the following prospectively collected data: age, sex, ethnicity, Hunt and Hess grade at presentation, Fisher grade, presence of any intraventricular hemorrhage, presence of any intraparenchymal hemorrhage, medical history, aneurysm size, aneurysm location, and treatment modality (clip or coil). We retrospectively reviewed posttreatment, predischarge CT scans for the following features: presence of any ischemic stroke in an eloquent territory (defined as primary motor cortex, left frontal operculum, left posterior temporal lobe, deep white matter tracts, basal ganglia, thalamus, brainstem, or occipital pole), presence of stroke greater than 4 cm in maximum dimension, presence of bilateral strokes, and persistent ventriculomegaly.

Clinical Outcomes and Improvement

Clinical outcomes were prospectively assessed using the traditional version of the mRS at discharge, 6 months, 12 months, and 36 months after SAH. The evaluator was not blinded to prior mRS scores at the time of outcome assessment. We defined clinical improvement as a reduction in mRS score by at least one grade and calculated the incidence of improvement at each of the following 3 intervals: discharge to 6 months, 6 months to 1 year, and 1 year to 3 years.

Statistical Analysis

Using univariate contingency statistics (Fisher exact test), we analyzed the association between the following categorical variables and clinical improvement at each of the 3 intervals: age ≤ 65 years, Hunt and Hess grade (IV or V), Fisher grade, presence of intraventricular hemorrhage, presence of intraparenchymal hemorrhage, aneurysm location (anterior or posterior circulation), treatment modality (clip or coil), aneurysm size (< 10 mm or ≥ 10 mm), and mRS score at discharge (score dichotomized as 0–3 or 4–5). When the relationship between discharge mRS score and further clinical improvement was assessed, patients who died during hospitalization were excluded. The incidence of early improvement between hospital discharge and 6 months was included as a variable when the frequency of delayed improvement beyond 6 months was assessed.

The same analysis was applied for the following radiographic variables based on posttreatment, predischarge CT scans: presence of any stroke, eloquent stroke, large (> 4 cm) stroke, bilateral strokes, and persistent ventriculomegaly. The relationship between clinical improvement at each interval and the following continuous variables was also assessed with Student t-test: aneurysm size and mRS score at hospital discharge. Data are presented as mean ± SD.

Results

Patients

Eighty-eight patients with poor-grade SAH met the inclusion criteria. Fifteen patients with poor-grade SAH were excluded because they died before treatment or because of the determination that definitive aneurysm treatment was futile. Clinical characteristics and treatment variables of the 88 included patients are listed in Table 1.

Clinical Outcomes

The mean mRS score for the entire cohort, including 9 patients who died before discharge, was 4.33 ± 1.3 at discharge. Seventy-five patients (85%) were available for follow-up at 6 months, and their mean 6-month mRS score was 3.31 ± 2.1 (p < 0.001 compared with the mean discharge mRS score). Seventy-two patients (82%) were available for follow-up at 12 months, and their mean 1-year mRS score was 3.28 ± 2.2 (not significant compared with 6-month mRS score). Seventy-five patients (85%) were available for follow-up at 36 months, and their mean 3-year mRS score was 3.17 ± 2.3 (not significant compared with 6-month and 12-month mRS scores). Aggregate cohort outcome data are presented in Fig. 1. The breakdown of mRS scores in the entire cohort for each time point is summarized in Table 2.

Clinical Improvement

Between hospital discharge and 6 months, 46 (61%) of the available 75 patients improved at least one mRS grade. Between 6 months and 1 year, 13 (18%) of the 72 available patients improved at least one mRS grade. Between 1 year and 3 years, 14 (19%) of the 75 available patients improved at least one mRS grade (Fig. 2). When including the 15 patients in whom aneurysm treatment was deemed futile, the rate of neurological improvement between discharge and 6 months, 6 months and 1 year, and 1 and 3 years was 45%, 13%, and 14%, respectively. Over the 3-year follow-up period, a gross cumulative mRS score improvement of 73 grades occurred among the entire cohort. Forty-six (63%) of these improved mRS grades occurred between discharge and 6 months, 13 (18%) between 6 months and 1 year, and 14 (19%) between 1 and 3 years.
Six (46%) of 13 patients demonstrating improvement between 6 months and 1 year had no improvement from discharge to 6 months. Twelve of 14 (86%) of patients who improved beyond 1 year had no improvement in the preceding 6 months. Of patients who improved between 6 months and 1 year, 9 (69%) achieved a final “good” mRS score between 0 and 2, and of patients who improved beyond 1 year, 10 (71%) achieved a final “good” mRS score between 0 and 2.

Predictors of Early Clinical Improvement

Patients with Hunt and Hess Grade IV SAH were significantly more likely to improve between discharge and 6 months (OR 6.20, 95% CI 2.11–18.25, p < 0.001) as were patients with no evidence of eloquent stroke (OR 5.17, 95% CI 1.89–14.10, p < 0.01) or no evidence of large (> 4 cm) stroke (OR 2.76, 95% CI 1.02–7.55, p = 0.05) on CT scans before hospital discharge. Age, discharge mRS score, aneurysm location, aneurysm size, Fisher grade, whether treatment was by clipping or coiling, and presence or absence of any stroke on CT were not predictive of early clinical improvement (Table 3).

Predictors of Delayed Clinical Improvement

Patients ≤ 65 years of age were significantly more likely to manifest improvement beyond 6 months (OR 5.56, 95% CI 1.17–26.42, p = 0.02), but not beyond 1 year (OR 2.25, 95% CI 0.45–11.18, p = 0.49), than those > 65 years of age. An admission Hunt and Hess score of IV versus V was associated with clinical improvement beyond 6 months (OR 4.17, 95% CI 1.10–15.85, p = 0.03) and beyond 1 year (p = 0.02). The absence of a large (> 4 cm) stroke on CT scans before hospital discharge was associated with improvement beyond 6 months (OR 8.97, 95% CI 2.65–30.40, p < 0.001) and beyond 1 year (OR 7.62, 95% CI 1.55–37.30, p < 0.01). The absence of a stroke in eloquent territory was associated with improvement beyond 6 months (OR 4.54, 95% CI 1.46–14.08, p = 0.01). When investigating improvement specific to the time interval beyond 1 year, the association between absence of an eloquent stroke and improvement trended toward, but did not reach, statistical significance (OR 3.56, 95% CI 0.89–14.18, p = 0.07). A discharge mRS score less than 4 was associated with improvement occurring beyond 1 year (OR 4.90, 95% CI 1.20–19.93, p = 0.03). Treatment modality (clip vs coil), aneurysm size, and incidence of early improvement within 6 months were not associated and 6 months (OR 6.20, 95% CI 2.11–18.25, p < 0.001) as were patients with no evidence of eloquent stroke (OR 5.17, 95% CI 1.89–14.10, p < 0.01) or no evidence of large (> 4 cm) stroke (OR 2.76, 95% CI 1.02–7.55, p = 0.05) on CT scans before hospital discharge. Age, discharge mRS score, aneurysm location, aneurysm size, Fisher grade, whether treatment was by clipping or coiling, and presence or absence of any stroke on CT were not predictive of early clinical improvement (Table 3).

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### TABLE 1: Clinical characteristics of poor-grade SAH cohort*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>age in yrs (mean ± SD)</td>
<td>56.6 ± 12.3</td>
</tr>
<tr>
<td>male/female ratio</td>
<td>27:61</td>
</tr>
<tr>
<td>admission Hunt &amp; Hess grade</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>63 (72%)</td>
</tr>
<tr>
<td>V</td>
<td>25 (28%)</td>
</tr>
<tr>
<td>Fisher grade</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>2</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>3</td>
<td>85 (97%)</td>
</tr>
<tr>
<td>4</td>
<td>3 (3%)</td>
</tr>
<tr>
<td>aneurysm location</td>
<td></td>
</tr>
<tr>
<td>anterior circulation</td>
<td>67 (76%)</td>
</tr>
<tr>
<td>ACoA</td>
<td>22 (25%)</td>
</tr>
<tr>
<td>MCA</td>
<td>18 (20%)</td>
</tr>
<tr>
<td>ICA</td>
<td>9 (10%)</td>
</tr>
<tr>
<td>PCoA</td>
<td>13 (15%)</td>
</tr>
<tr>
<td>A1 segment</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>A2 and A3 segment</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>AChA</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>posterior circulation</td>
<td>21 (24%)</td>
</tr>
<tr>
<td>basilar apex</td>
<td>9 (10%)</td>
</tr>
<tr>
<td>PICA</td>
<td>6 (7%)</td>
</tr>
<tr>
<td>vertebral artery</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>VBJ</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>SCA</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>P2 segment</td>
<td>1 (1%)</td>
</tr>
<tr>
<td>aneurysm size in mm (mean ± SD [range])</td>
<td>7.5 ± 4.2 (2–18)</td>
</tr>
<tr>
<td>treatment</td>
<td></td>
</tr>
<tr>
<td>clip</td>
<td>61 (69%)</td>
</tr>
<tr>
<td>coil</td>
<td>27 (31%)</td>
</tr>
</tbody>
</table>

* AChA = anterior choroidal artery; ACoA = anterior communicating artery; A1-3 = A1-3 junction of anterior cerebral artery; ICA = internal carotid artery; MCA = middle cerebral artery; PCoA = posterior communicating artery; PICA = posterior inferior cerebellar artery; SCA = superior cerebellar artery; VBJ = vertebrobasilar junction.
† Unless specified otherwise, values indicate the number (percentage) of patients.
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TABLE 2: Percentage of patients stratified by mRS score at discharge, 6 months, 1 year, and 3 years

<table>
<thead>
<tr>
<th>mRS Score</th>
<th>Discharge</th>
<th>6 Mos</th>
<th>1 Year</th>
<th>3 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>10.3</td>
<td>28.0</td>
<td>30.6</td>
<td>29.3</td>
</tr>
<tr>
<td>5</td>
<td>46.6</td>
<td>4.0</td>
<td>1.4</td>
<td>2.7</td>
</tr>
<tr>
<td>4</td>
<td>26.1</td>
<td>16.0</td>
<td>15.3</td>
<td>13.3</td>
</tr>
<tr>
<td>3</td>
<td>5.7</td>
<td>9.3</td>
<td>13.9</td>
<td>12.0</td>
</tr>
<tr>
<td>2</td>
<td>6.8</td>
<td>14.7</td>
<td>8.3</td>
<td>12.0</td>
</tr>
<tr>
<td>1</td>
<td>3.4</td>
<td>21.3</td>
<td>18.1</td>
<td>14.7</td>
</tr>
<tr>
<td>0</td>
<td>1.1</td>
<td>6.7</td>
<td>12.5</td>
<td>16.0</td>
</tr>
</tbody>
</table>

Discussion

Our study suggests that recovery following poor-grade SAH is a long-term dynamic process and that delayed clinical improvement commonly occurs beyond the point at which most studies assess outcomes. In the present cohort of Hunt and Hess Grade IV and V patients, 19% improved at least one mRS grade between 1 and 3 years following SAH, and 37% of cumulative mRS improvement occurred after 6 months. Even assuming the worst-case scenario that all patients lost to follow-up subsequently declined, the incidence of improvement beyond 1 year remains above 15%. Clinical improvement within the first 6 months of hospitalization did not predict delayed improvement at any time interval beyond 6 months. Taken together, these results challenge the notion that early outcomes always approximate long-term outcomes and suggest that even patients whose recovery appears to plateau early may experience further clinical improvement over time.

Most SAH studies assess outcomes at a single time point as early as 3 or 6 months following SAH. Implicit in the design of these studies is the assumption that significant clinical improvement will not occur beyond the relatively early time point at which outcome was assessed. Our results suggest that a substantial minority of patients may improve as late as 3 years following SAH. In the ideal setting, the potential for delayed neurological recovery in this population would call for longer follow-up intervals in SAH studies. Longer studies, however, are most costly and difficult to conduct. Clinical trial design always involves a compromise between what is ideal and what is practical, and the most effective trials are those that successfully strike this balance. Regardless, our data do suggest that trials relying on early outcome measures may not capture the delayed improvement that occurs in nearly 20% patients who have suffered aneurysmal SAH.

Our data demonstrate the importance of distinguishing between aggregate cohort outcomes and individual patient outcomes. The mean mRS score of our entire cohort did not change significantly beyond the 6-month time point. This finding suggests that, as a whole, all statistically significant aggregate improvement occurred in the first 6 months following SAH. However, this finding does not imply that individual outcomes remain static after 6 months. Although the mean mRS score of the whole cohort did not significantly improve beyond 6 months, a substantial number of individual patients did improve beyond 6 months and up to 3 years following SAH. This finding reflects the variability that exists in clinical status with delayed improvement beyond 6 months or beyond 1 year (Table 4).

![Fig. 2.](image)

TABLE 3: Predictors of early improvement within 6 months of hospital discharge

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunt &amp; Hess grade (IV vs V)</td>
<td>6.20 (2.11–18.25)</td>
<td>&lt;0.001†</td>
</tr>
<tr>
<td>age ≥65 yrs</td>
<td>2.00 (0.70–5.74)</td>
<td>0.28</td>
</tr>
<tr>
<td>sex (female vs male)</td>
<td>0.95 (0.35–2.59)</td>
<td>1.00</td>
</tr>
<tr>
<td>aneurysm size (&lt;10 vs ≥10 mm)</td>
<td>2.32 (0.82–6.56)</td>
<td>0.18</td>
</tr>
<tr>
<td>clip vs coil</td>
<td>0.60 (0.22–1.64)</td>
<td>0.45</td>
</tr>
<tr>
<td>discharge mRS score (0–3 vs 4–5)</td>
<td>1.42 (0.34–5.91)</td>
<td>0.74</td>
</tr>
<tr>
<td>absence of any stroke</td>
<td>2.36 (0.68–8.19)</td>
<td>0.25</td>
</tr>
<tr>
<td>absence of eloquent stroke</td>
<td>5.17 (1.89–14.10)</td>
<td>&lt;0.01†</td>
</tr>
<tr>
<td>absence of large stroke</td>
<td>2.76 (1.02–7.55)</td>
<td>0.05†</td>
</tr>
</tbody>
</table>

* Fisher exact test used to calculate p values.
† Denotes statistical significance.
among the entire cohort over time. While some patients improved after 6 months, others deteriorated, such that the mean cohort mRS scores did not change significantly. The reasons for deterioration in some patients were not always clear but were mostly due to delayed medical complications that would be expected to occur in a portion of patients suffering severe SAH.

Despite the lack of overall cohort improvement beyond 6 months, almost 1 in 5 patients demonstrated improvement between 6 months and 1 year and, again, between 1 year and 3 years. Our results suggest that the capacity for delayed improvement beyond 6 months is higher in younger patients. This is consistent with prior studies demonstrating an association between younger age and more favorable outcomes following SAH.10,11,14,20,24,31 Although patients 65 years of age or younger had more than 5 times the odds of improvement beyond 6 months, when improvement specific to the time intervals beyond 1 year was analyzed, age was no longer a significant predictor. This finding suggests that while younger age has its benefits in recovery, the most delayed improvement is driven primarily by other factors.

In addition to supporting the well-accepted association between clinical grade at admission and outcome,2,9,20,24,31,38,41 our results demonstrate the impact of cerebral ischemia on delayed recovery at all time points. Although the presence or absence of any stroke was not predictive of a patient’s capacity to recover, the avoidance of a large (> 4 cm) stroke or ischemia in eloquent territory was highly predictive of delayed improvement. This association supports the notion that vasospasm and cerebral ischemia are significant contributors to early and late SAH-related morbidity.18,22,26,28,29,31,42,43 It also suggests that maneuvers to avoid cerebral ischemia during hospitalization are critical in optimizing the capacity for continued long-term clinical improvement.

The capacity for the brain to demonstrate delayed recovery more than 1 year after a cerebral insult is controversial. Most recovery following ischemic stroke is believed to occur in the first 6 months.36 Likewise, the greatest capacity for improvement after traumatic brain injury appears to occur in an early time window, typically 3–6 months following injury.32 However, some studies have demonstrated the potential for cerebral plasticity to allow for delayed recovery in select patients.1,32 The demographic, clinical, and genetic features underlying this capacity are not clear and have been the subject of several investigations.3,44 Our results do not refute the fact that most recovery occurs early, because the majority of improvement in our cohort did occur in the first 6 months following SAH.

Our results, however, do suggest that the mechanisms governing cerebral recovery following SAH may allow for delayed improvement in a substantial minority of patients. The pathogenesis of cerebral injury due to SAH is multifactorial and complex. Cerebral vasospasm,18,31,42 hydrocephalus,40 cortical spreading ischemia,39 elevated intracranial pressure,40 and cerebral metabolic dysfunction34 have all been implicated in cerebral injury following aneurysm rupture. Our results suggest that in select patients, particularly younger patients with no radiographic evidence of large or eloquent stroke, the potential for delayed improvement is greatest. This is consistent with studies that have demonstrated improvements in cognition and quality of life in some SAH patients beyond the immediate posthospitalization period.5,6,8,21 Beyond its implications for the design of outcome studies, this finding has important prognostic implications for families and caregivers. Decisions regarding how long to wait for a patient to improve following poor-grade SAH depend on the possibility of recovery of that individual, not on the entire cohort. For this reason, more accurate and individualized predictors are needed. The molecular mechanisms and genetic factors that govern the capacity for recovery following SAH are the subject of several current investigations.16,25,35

Interestingly, no difference in the incidence of delayed recovery was seen in the patients who underwent microsurgical clipping versus endovascular coiling. In the BRAT study,19,37 the difference in outcomes between the 2
treatment groups that was present at 6 months and 1 year disappeared at the 3-year time point. At 3 years, the rate of poor outcome among patients randomized to clipping or coiling in the BRAT did not differ significantly (35.8% vs 30%, OR 1.30, 95% CI 0.83–2.04, p = 0.25), suggesting that initial differences in outcomes between the 2 cohorts converged at a later time point. However, for the poor-grade subpopulation, treatment modality does not appear to be a determinant of the capacity of the brain to recover from a severe SAH.

Our study represents a cohort of poor-grade SAH patients treated at a high-volume cerebrovascular center enrolled in a prospective trial. Nevertheless, our review of the data was post hoc and therefore carries the limitations of most retrospective studies. Additionally, the relatively small size of the population and the 15% rate of loss to follow-up limit the strength of our study. Another limitation is the potential influence of inter- and intraobserver variability of the mRS. It is possible that some changes in mRS score may be artifactual due to the intrinsic inter- and intraobserver variability of the scale. However, rater variability is an issue with any scale, and this is a limitation of any study relying on mRS scores as an outcome measure. A recent review demonstrated moderate to strong inter- and intraobserver reliability of the mRS, with weighted kappa coefficients of 0.90 and 0.94, respectively. Therefore, individual variations in scoring are unlikely to account for the frequency of delayed improvement found in our study. Additionally, because the number of patients with improved mRS scores at 1 year and 3 years was more than twice the number of patients with worse mRS scores at these same time points, inter- and intrarater variability is unlikely to account for our findings. More subtle measures of outcomes, including neuropsychiatric testing, are likely necessary to clarify the nature of the improvement that occurs.

Conclusions

In our cohort of 88 patients with poor-grade SAH, 37% of the clinical improvement occurred beyond 6 months post-SAH and 19% of the patients demonstrated improvement between 1 and 3 years. Younger patients, those presenting in better clinical condition, and those without CT evidence of large or eloquent ischemic strokes demonstrated the highest capacity for delayed recovery. These results suggest that a substantial minority of poor-grade SAH patients will experience delayed recovery beyond the point at which most studies assess outcome.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following: Conception and design: Wilson, Nakaji. Acquisition of data: Wilson. Analysis and interpretation of data: Wilson. Drafting the article: Wilson. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Spetzler. Administrative/technical/material support: Wilson, Nakaji, Albuquerque, McDougall, Zabramski. Study supervision: Spetzler, Nakaji.

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Author contributions to the study and manuscript preparation include the following: Conception and design: Wilson, Nakaji. Acquisition of data: Wilson. Analysis and interpretation of data: Wilson. Drafting the article: Wilson. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Spetzler. Administrative/technical/material support: Wilson, Nakaji, Albuquerque, McDougall, Zabramski. Study supervision: Spetzler, Nakaji.

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Conclusions

In our cohort of 88 patients with poor-grade SAH, 37% of the clinical improvement occurred beyond 6 months post-SAH and 19% of the patients demonstrated improvement between 1 and 3 years. Younger patients, those presenting in better clinical condition, and those without CT evidence of large or eloquent ischemic strokes demonstrated the highest capacity for delayed recovery. These results suggest that a substantial minority of poor-grade SAH patients will experience delayed recovery beyond the point at which most studies assess outcome.

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