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Ruptured giant intracranial aneurysms. Part II. A retrospective analysis of timing and outcome of surgical treatment

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Object. This retrospective study was made to determine the relationship between surgical timing and outcome in all patients with ruptured giant intracranial aneurysms undergoing surgical treatment at the Mayo Clinic between 1973 and 1996.

Methods. The authors studied 109 patients, 102 of whom were referred from other medical centers. The ruptured giant aneurysms were 25 to 60 mm in diameter. One hundred five of the patients survived the rupturing of the aneurysm to undergo operation, with direct surgery possible in 84% of cases. Excluding delayed referrals, the average time to surgery after admission to the Mayo Clinic was approximately 4 to 5 days. Patients admitted earlier tended to be in poorer condition, often undergoing earlier operation. On average, surgical treatment was administered later for patients with ruptured aneurysms of the posterior circulation than for those with aneurysms in the anterior circulation. Temporary occlusion of the parent vessel was necessary in 67% of direct procedures, with an average occlusion time of 15.5 minutes. Among surgically treated patients, a favorable outcome was achieved in 72% harboring ruptured anterior circulation aneurysms and in 78% with ruptured posterior circulation lesions.

Conclusions. The overall management mortality rate was 21.1%, and the mortality rate for surgical management was 8.6%. The authors believe that because of the technical difficulties and risk of rebleeding associated with ruptured giant intracranial aneurysms, timely referral to and well-planned treatment at medical centers specializing in management of these lesions are essential to effect a more favorable outcome.

KEY WORDS • **ruptured giant aneurysm** • **surgical treatment** • **timing of surgery**

ALTHOUGH still controversial,[4,5,13,14,21,30,33] the advantages and benefits of early surgical treatment for patients admitted in good neurological condition with ruptured small aneurysms have been well documented.[34] No such information is available for giant aneurysms. The determination of the optimum time for surgical treatment of giant aneurysms is considerably more complicated, partly because the risks and patterns of rebleeding for giant aneurysms have not been described. This problem has been compounded by the fact that many giant aneurysms are not readily amenable to clipping[6] and often require temporary, sometimes prolonged, intraoperative arterial occlusion[24,27] and perhaps permanent occlusion of the proximal vessel[7,23] for treatment. Thus, the risk of ischemic complications related to the management of giant aneurysms must be greater than with smaller lesions and, undoubtedly, is even more considerable in the acute phase after subarachnoid hemorrhage (SAH), when cerebrovascular autoregulation is disturbed.[18,28] The necessity for more planning, including additional studies (such as trials of balloon occlusion of parent arteries) or special provisions for surgery accomplished using profound hypothermia and circulatory arrest, makes early surgical treatment more difficult to perform. The overall outcome for management of giant aneurysms is poorer than that for smaller lesions[13–15,20,26,29,32,37] even in expert hands and has been an impetus to refer these cases to medical centers specializing in their management.

Because little information is available about the timing of surgical treatment of ruptured giant intracranial aneurysms, our study was aimed at delineating the relationship between surgical timing and outcome in our patients, who were predominantly a referred population.[36]

Clinical Material and Methods

Patient Population

We reviewed the medical records of all patients who had undergone surgical treatment at the Mayo Clinic for ruptured giant intracranial aneurysms between October 1973 and May 1996. The demographic and diagnostic data and aneurysm specifications for this population of patients have been described in detail in a companion paper.[16]

Clinical Characteristics

At the time of admission, patients were classified according to their neurological status based on a modified Botterell grading system (Table 1).[29] In this classification, Botterell Grade 1 corresponds to Hunt and Hess[11] Grade I or II. Where specified, good neurological condition corresponds to Botterell Grades 1 and 2 and poor condition to Botterell Grades 3 and 4.

Surgical Procedures and Timing

Detailed descriptions of management and operative techniques have been given elsewhere.[24–26] Time to surgi-

TABLE 1

Neurological status at time of admission in 109 patients with ruptured giant intracranial aneurysms

Grade*	No. of Patients (%) Entire Series	Subgroup Admitted After 1st Hemorrhage
1	42 (39)	35 (46)
2	31 (28)	21 (27)
3	28 (26)	17 (22)
4	8 (7)	4 (5)
total	109 (100)	77 (100)

* Neurological grading according to a modified Botterell classification (see text).

TABLE 2

*Operative procedures in 105 patients with ruptured giant intracranial aneurysms**

Procedure	No. of Patients (%)
direct	
clipping	75 (71)
repair w/ vessel reconstruction	7 (7)
SVG & clipping	6 (6)
total	88 (84)
indirect	
simple trapping	4 (4)
SVG & trapping	4 (4)
proximal ligation	4 (4)
STAA & proximal ligation	3 (3)
SVG & proximal ligation	2 (2)
total	17 (16)

* STAA = superficial temporal artery anastomosis; SVG = saphenous vein grafting.

cal treatment was defined according to three intervals: 1) early surgery refers to operations performed within 3 days after the presenting SAH; 2) intermediate surgery was performed within 4 to 9 days; and 3) delayed surgery was performed more than 9 days post-SAH.[3] Hospital admission is defined as admission to our Mayo Hospitals and the Neurology/Neurosurgery services and recognizes that the majority of the patients in our study were referred from other medical centers.

Data from the entire group of 109 patients varied with regard to history of SAH, including number and dates of previous hemorrhages. Therefore, to examine the effects of neurological condition and delay in admission on the timing of surgery in a more uniform population of patients, we identified a subgroup of 77 surgically treated patients who were admitted to our institution after their first SAH from a ruptured giant aneurysm and who did not experience a rehemorrhage preoperatively (Table 1). Twenty-three of these patients were admitted early (within 48 hours after the initial SAH). The other 54 patients, all referred from other medical centers, were admitted late to our institution (more than 48 hours after the initial SAH), with 24 of them admitted 7 days or more after their SAH. Where specified, delayed referral pertains to the 54 patients admitted late.

General Outcome

The results of treatment were assessed at the latest follow-up review, which was performed between 2 weeks and 15 years after discharge.[16] However, to allow statistical comparisons in a more uniform population of patients, analysis of outcome as a function of neurological condition, time of admission, and interval to surgery was performed for the subgroup of 77 patients, with assessment of outcome categorized at the time of discharge. Four categories of assessment were used: excellent, good, poor, and dead.[26,29] A "favorable" outcome refers to one that was excellent or good, whereas "unfavorable" refers to the last two assessment categories. Details of the method of assessment are presented elsewhere.[38]

Statistical Analysis

Statistical comparisons were made using rank-sum analysis, Student's paired t-test, or the chi-square test. Probability values of 0.05 or less were considered significant.

Results

Surgical Procedures

One hundred five of the patients in the study survived the rupture of their aneurysm to undergo operation. Of the four patients who died preoperatively, one suffered a fatal hemorrhage at the time of admission to the hospital and another died of rebleeding immediately after cerebral angiography. The third patient was an elderly woman whose compromised medical status precluded surgical intervention; she suffered a fatal rehemorrhage in the hospital 10 weeks after admission. In the fourth patient, surgery was delayed because of the mass effect and cerebral edema caused by a ruptured 4-cm aneurysm; this patient suffered a fatal rehemorrhage 7 days after admission. As summarized in Table 2, 88 aneurysms were repaired directly: direct clipping was used in 75, direct aneurysm repair and vessel reconstruction in seven, and saphenous vein grafting combined with clipping in six. Temporary occlusion of the parent vessel was necessary for 59 (67%) of the 88 aneurysms. For lesions repaired by direct clipping and for which occlusion time was specified, the average time was 15.5 minutes (range 3–40 minutes). Indirect procedures were necessary for 17 aneurysms (Table 2).

Timing of Surgery

Location of Aneurysm. In the 105 patients who survived to undergo operation, the average time to surgery after the initial SAH for the 78 patients with ruptured giant aneurysms of the anterior circulation was 9.1 days. This was not significantly different from the average of 11 days for the 27 patients with ruptured giant aneurysms of the posterior circulation. The average time to surgery after admission to our institution was 3.6 days for patients with ruptured giant aneurysms of the anterior circulation and 6.1 days for those with similar lesions in the posterior circulation; this difference was significant ($p < 0.02$).

Neurological Condition. Seventy-seven of the 105 surgically treated patients were admitted to the hospital after their first SAH and did not have an episode of rebleeding preoperatively. For this subgroup of patients, the average time to surgery was 10.2 days after initial SAH and 4.5

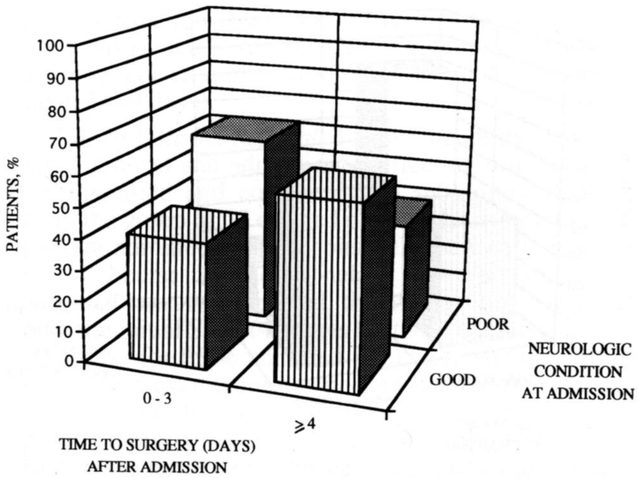

FIG. 1. Bar graph showing time to surgery after admission according to neurological condition at admission. All graphs depict data from the subgroup of 77 surgically treated patients who were admitted to our hospital after their first SAH from a ruptured giant aneurysm and who did not suffer preoperative rehemorrhage.

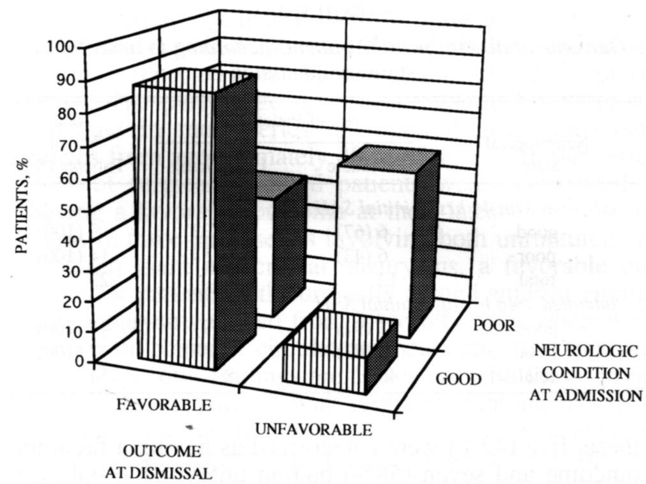

FIG. 2. Bar graph showing outcome at dismissal according to neurological condition at admission. See Fig. 1 for description of subgroup depicted.

days after admission. Fifty-six of the 77 patients were in good neurological condition at admission, and of these, 23 (41%) underwent surgical treatment within 3 days and the other 33 (59%) at 4 or more days after admission. The other 21 patients were admitted in poor neurological condition, and of these, 13 (62%) underwent surgical treatment within 3 days and the other eight (38%) at 4 or more days after admission (Fig. 1).

Time of Admission. Of the 77 patients admitted to our institution after their first SAH, 23 were admitted within the first 48 hours and 54 were admitted more than 48 hours posthemorrhage. The time to surgical treatment according to neurological condition at admission for these two subgroups is given in Table 3. For the subgroup of 23 patients admitted within 48 hours, the average time to surgical treatment after initial SAH was 4.8 days. This was significantly different ($p < 0.001$) from the average of 12.5 days for the 54 patients admitted more than 48 hours post-SAH. The average time to surgical treatment after admission was 4.4 days for the 23 patients admitted within 48 hours and 4.5 days for those admitted later; this difference was not significant.

TABLE 3
Time to surgery in 77 patients according to neurological status at admission

Neurological Status	No. of Patients (%): Days to Surgery 0–3	≥4	Total
admitted w/in 48 hrs of initial SAH			
good	2 (22)	7 (78)	9 (100)
poor	10 (71)	4 (29)	14 (100)
total	12	11	23
admitted >48 hrs after initial SAH			
good	21 (45)	26 (55)	47 (100)
poor	3 (43)	4 (57)	7 (100)
total	24	30	54

Surgical Outcome

Outcome as determined at the latest follow-up evaluation or at dismissal was studied with regard to the following categories.

Patient Age, Location of Aneurysm, and Effect of First Rehemorrhage. For the 105 surgically treated patients, a favorable outcome was noted in 72% of patients at their latest medical follow-up evaluation. Sixty-five percent of the 74 patients older than 45 years and 90% of those 45 years of age or younger (31 patients) were categorized as having a favorable outcome at latest follow-up review, as were 72% of patients with ruptured aneurysms of the anterior circulation and 78% of those with similar lesions in the posterior circulation. Of the nine patients in our study[16] who suffered their first rehemorrhage after admission, seven survived to undergo operation. Of these, five (71%) were categorized as having a favorable outcome at their latest follow-up evaluation.

Neurological Condition. Among the 77 surgically treated patients admitted to our hospital after their first hemorrhage, 56 were in good neurological condition at admission, and of these, 49 (88%) were categorized as having a favorable outcome at dismissal and seven (12%) had an unfavorable outcome. The other 21 patients were admitted in poor neurological condition, and of these, nine (43%) had a favorable outcome at dismissal and 12 (57%) had an unfavorable outcome (Fig. 2). There was a significant difference in outcome between these subgroups ($p < 0.001$).

Time of Admission. For the 23 patients admitted within the first 48 hours and the 54 patients admitted more than 48 hours posthemorrhage, outcome at dismissal according to neurological condition at admission is given in Table 4. The difference in outcome between those admitted within 48 hours compared with those admitted more than 48 hours posthemorrhage was not significant.

Interval to Surgery. Outcome at dismissal according to interval to surgery after initial SAH was analyzed in the 77 patients who presented after their first hemorrhage. In this group of patients, 12 underwent early surgery, and of

TABLE 4

Outcome at discharge in 77 patients according to neurological status at admission

Neurological Status	No. of Patients (%) Favorable	Unfavorable	Total No. of Patients (%)
admitted w/in 48 hrs of initial SAH			
good	6 (67)	3 (33)	9 (100)
poor	6 (43)	8 (57)	14 (100)
total	12	11	23
admitted >48 hrs after initial SAH			
good	43 (91)	4 (9)	47 (100)
poor	3 (43)	4 (57)	7 (100)
total	46	8	54

these, five (42%) were categorized as having a favorable outcome and seven (58%) had an unfavorable outcome. Sixty-five patients underwent intermediate or delayed surgery, and of these, 53 (82%) had a favorable outcome and 12 (18%) had an unfavorable outcome (Fig. 3). The statistical significance of the difference in outcome between these subgroups could not be determined because of the relatively low number of patients who underwent early operation.

Mortality Rate

Overall, the mortality rate directly due to SAH among the 109 patients in our series was 8.3%. The mortality rate due to surgical complications was 8.6%, with slightly more than half (56%) of these deaths attributed to ischemic complications of surgical treatment and the remainder to complicated ischemia including delayed ischemia of vasospasm.

Discussion

Technical and Planning Considerations

Although the purpose of this study was not to provide a detailed description of management and surgical techniques for treatment of giant aneurysms, it is appropriate in the context of the timing of aneurysm surgery to consider technical problems that may be posed by giant aneurysms and acknowledge the requirement for thorough surgical planning. First, in addition to appropriate preoperative radiological investigation, including cerebral angiography, parent artery trial occlusion studies may be indicated, especially for certain giant carotid aneurysms. Second, provision must be made for the possibility of extracranial–intracranial bypass surgery in some patients, whereas in others extracorporeal (cardiopulmonary) bypass may be indicated during the procedure.[6,17,24] Third, temporary occlusion of the feeding trunk is frequently necessary to define and soften the neck of a giant aneurysm for clipping, a process that can be expected to be more prolonged than with smaller aneurysms.[24] In the present study, temporary occlusion of the parent vessel was necessary in 67% of 88 directly repaired aneurysms, with an average occlusion time of 15.5 minutes. By comparison, in a series involving the entire range of aneurysm sizes, only 35.7% required temporary occlusion of the parent artery, with an average occlusion time of less than 7 minutes.[12] Fourth, many giant aneurysms cannot be clipped directly;[6] they often require permanent occlusion

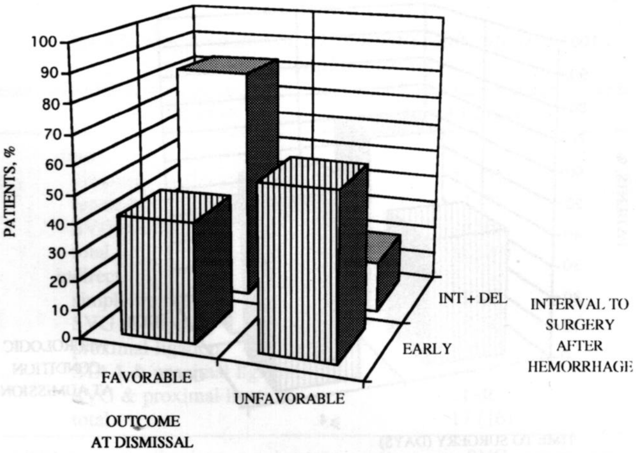

FIG. 3. Bar graph showing outcome at dismissal according to interval to surgery after initial SAH. See Fig. 1 for description of subgroup depicted. INT + DEL = intermediate and delayed operation.

of the parent trunk[7,23] (as in 16% of our surgically treated patients), a procedure that if performed early may compound the risks for delayed ischemia.[12] In our series, direct clipping was possible in 71% of aneurysms. This is a greater proportion than reported for many series involving both unruptured and ruptured giant aneurysms, in which the range was 38 to 70%,[6,17,31] but it reflects the bias of our cerebrovascular surgeons, who believe that direct obliteration of the aneurysm constitutes the most definitive treatment and, particularly in cases presenting with SAH, is preferable to indirect treatment such as occlusion of the parent trunk. Finally, the rate of rebleeding for ruptured giant aneurysms,[16] which is comparable to that for smaller aneurysms, must also be considered in the context of the planning and timing of giant aneurysm surgery.

Timing of Surgery

Average Time to Surgery. The intent of this study was to analyze our management of patients with ruptured giant aneurysms and the intervals to surgery to gain perspective on the optimum timing of intervention. Because of the variability of data from the entire population of 109 patients, especially with regard to the number and dates of previous hemorrhages, we found it helpful to focus on a more uniform group of 77 patients representing all patients admitted to our hospital following their first SAH from a ruptured giant aneurysm who did not experience rehemorrhage preoperatively. Data from this subgroup were used to calculate average times to surgery, which we found to be 10.2 days after the initial hemorrhage and 4.5 days after admission. It is evident from these findings that the average time to surgery posthemorrhage among our patients lies beyond the early range of 0 to 3 days that seems advantageous for patients with smaller ruptured aneurysms.[34] Recognizing that the vast majority of our patients were referred from other medical centers, and that there was often a considerable delay from the time of initial hemorrhage to the time of admission to our institution (one-third of patients in the subgroup of 77 were admitted 7 or more days after their initial SAH), we maintain that delayed referral[36] greatly accounts for the finding that our average time to surgery post-SAH is in the delayed range (> 9 days); and in the absence of referral delay, our true average time to surgery post-SAH lies in the intermediate range (4–9 days).

Role of Delayed Referral. To investigate the role of delayed referral and admission in affecting time to surgery, we identified and compared two subgroups of patients from the group of 77 defined previously: a subgroup of 23 patients admitted to the hospital relatively early post-SAH (< 48 hours; no referral delay) and a subgroup of 54 admitted later. As expected, the average times to surgery after the initial SAH (4.8 days for those admitted early and 12.5 days for those admitted late) were significantly different. However, there was no significant difference in the average times to surgery after admission for the two subgroups (approximately 4.5 days for both groups). These findings indicate that in the absence of delayed referral, as in the subgroup of 23 patients, the average time to surgery post-SAH (4.8 days) lies in the "in- termediate" range; overall, patients with ruptured giant aneurysms underwent surgery on average 4 to 5 days after admission, reflecting a preference for thorough evaluation of the aneurysm and planning for the procedure.

Role of Neurological Condition. Several studies have documented the advantages of early surgical treatment for patients in good neurological condition with ruptured small aneurysms.[34] In one series of large and giant aneurysms,[1] surgical repair within 72 hours after the presenting SAH was also recommended for patients in good neurological condition, although most of the surgically treated aneurysms in the series were nongiant lesions. This practice was not followed by surgeons at our institution: in the subgroup of 23 patients admitted early, only two (22%) of the nine in good neurological condition underwent surgical treatment within 3 days after admission. In analyses of management of ruptured nongiant aneurysms, several authors have advocated delayed operation for patients admitted in poor neurological condition.[34] In our series, 10 (71%) of the 14 patients admitted in poor neurological condition within 48 hours of the ictus underwent operation within 3 days of their admission. In some of these patients, the presence of a hematoma contributed to the poor neurological condition and motivated early surgical intervention. In others there was a perception that because of the already existent serious neurological deficits, there was little to be gained by a more extended, cautious preoperative evaluation.

Surgical Outcome

The outcome in patients undergoing surgical treatment for ruptured intracranial aneurysms has been studied in comprehensive aneurysm series[3,13,14,19,25] and in series of both ruptured and unruptured giant aneurysms[6,8–10,15,20,22,26,32,37] and has been found to be considerably poorer in patients with giant aneurysms.[13–15] In the International Cooperative Study on the timing of aneurysm surgery[13,14] researchers found that the overall management outcome for giant aneurysms was good in 39%, and fatal in 41% of cases; for smaller aneurysms these figures were 60% and 25%, respectively. Among patients with surgically treated giant aneurysms in the same study, investigators reported a good outcome in 52%, with a mortality rate of 21%; for those with smaller aneurysms the figures were 70% and 14%, respectively. In a series of 32 giant aneurysms, 26 of which had ruptured by the time of admission, Onuma and Suzuki[20] reported a favorable outcome in 62.5% of patients. The percentage of patients attaining a favorable outcome in most series of ruptured giant aneurysms ranges from approximately 30 to 85%.[17,31,37] In our series, 72% of surgically treated patients were categorized as having a favorable outcome at their latest follow-up review. In three large series involving both unruptured and ruptured giant intracranial aneurysms, a favorable outcome for patients with surgically treated anterior circulation aneurysms ranged from 79 to 89%,[6,17,27] whereas for those with posterior circulation aneurysms, the range was 65 to 74%. Our findings are consistent with these: in our series, 72% of patients with ruptured giant aneurysms of the anterior circulation and 78% with ruptured aneurysms of the posterior circulation demonstrated a favorable outcome at their latest follow-up evaluation. A greater proportion of favorable results occurred in the subgroup of patients younger than 45 years of age and among patients admitted in good neurological condition.[2,13,14,35] We could not measure any significant difference in outcome at discharge between the subgroups of patients with a single SAH who were admitted within 48 hours postictus compared with those admitted later. We did find a greater proportion of favorable results among patients with a single SAH who underwent intermediate or delayed surgery as compared with early surgery. Although the significance of this observation could not be determined, it is partly explained by the fact that a greater proportion of patients admitted in poor neurological condition (that is, with a worse prognosis)[2,25] underwent early surgery compared with those admitted in good neurological condition (62% compared with 41%).

Mortality Rate

In a series of 32 giant aneurysms, more than 80% of which had ruptured at the time of admission, Onuma and Suzuki[20] reported a patient mortality rate of 20.8%, with an overall poor outcome in 37.5% of patients. The mortality rates for patients with ruptured giant aneurysms reported in various series have ranged from 8[31] to 67%,[37] whereas in series composed of patients with both unruptured and ruptured lesions, the mortality rate approximates 15%.[6,27] We report an overall mortality rate of 21.1% and a surgical mortality rate of 8.6%, similar to that reported by Symon and Vajda.[32]

Principal Findings

The principal finding in the present study is that among patients referred to our institution for treatment of ruptured giant aneurysms over a 23-year span, the average time to surgery post-SAH lies beyond the early range of 0 to 3 days that seems advantageous for patients with smaller ruptured aneurysms. Allowing for delayed referral, our patients' average time to surgery was approximately 4 to 5 days after admission to our hospital, reflecting the cautious preference of our surgeons for thorough evaluation of the aneurysm and planning for the procedure. Overall, we achieved a favorable outcome in 72% of patients; good neurological condition at admission was significantly associated with the likelihood of a favorable outcome. Although we observed a greater proportion of favorable outcomes for operations performed 4 or more days postictus, we were unable to determine the statistical significance of this association.

Conclusions

Given the technical problems unique to the treatment of these lesions and the similarity in rebleeding patterns for ruptured giant aneurysms and smaller lesions, expeditious referral of patients to medical centers specializing in treatment of these lesions is indicated. We believe that whereas surgery for these lesions should be performed as early as possible, it should be preceded by thorough planning, because hasty treatment of ruptured giant aneurysms, whether by direct or indirect means, carries even higher risks for unsatisfactory outcome.

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