Factors Associated with Poor Outcome in Patients with Major Intraoperative Rupture of Intracranial Aneurysm

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Abstract-

Purpose: This clinical study was conducted to evaluate factors affecting outcome in the cases following major intraoperative rupture (MIOR) of the intracranial aneurysms.

Methods: Thirty cases with MIOR in a series of 467 surgeries for ruptured aneurysms were enrolled in this study. Clinical parameters, including: age, Hunt-Hess grading, Fisher grading, aneurysm size, aneurysm contour, operative timing, aneurysm location, and rupture timing were studied and compared with the prognosis in this particular cohort. The outcome was evaluated using the Glasgow Outcome Scale at least 3 months after surgery. Severe disability, vegetative survival, and death were classified as poor outcome.

Results: Among the 30 cases with MIOR, 11 resulted in poor outcomes (36.7%). Age was an important prognostic factor in this cohort. Those patients with poor outcome after MIOR were significantly older than those with good outcome (mean age: 64.6 vs 51.4 years, P=0.006). In this study, a trend toward poor outcome was observed in cases with MIOR on internal carotid artery aneurysms (8/14, 57.1% vs 2/9, 22.2% and 1/6, 16.7% on middle cerebral artery and anterior communicating artery aneurysms, P=0.197, after adjustment for age factor). There was a higher incidence of a poor outcome when MIOR occurred during clip application (5/6, 83.3% vs 1/5, 20.0% and 5/19, 26.3% when MIOR happened during brain retraction and aneurysm dissection, P=0.041 after adjustment with the factor of age).

Conclusion: Although a larger sample population is required for a more conclusive result, MIOR occuring in older age, during clip application, or on an internal carotid artery aneurysm possibly has the trend to bear a worse outcome in the cohort of patients with MIOR during aneurysm surgery.

Key Words: intraoperative rupture, intracranial aneurysm, outcome, risk factor

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INTRODUCTION

Progresses in neurosurgical instrumentation and surgical technique have continuously improved the surgical result for intracranial aneurysm over the past several decades. Nevertheless, intraoperative rupture (IOR) is still an undesirable but unavoidable danger in microsurgery for intracranial aneurysm. In literature, the incidence of IOR and its impact on outcome varied greatly [1-6]. Such inconsistencies may be because the microsurgery for a ruptured aneurysm possibly has a different incidence of IOR compared with that for an unruptured or remotely ruptured aneurysm [5]. Moreover, the different definition for IOR also leads to a dissimilar incidence and disparate impact on outcome [1-3,5-7]. In literature, some IOR studies included those minor leaks which apparently do not interfere with the microsurgical procedure and are unlikely to have much clinical significance. Consequently, the prognosis is no doubt better [5,6]. In this study, we investigated major intraoperative rupture (MIOR) in surgeries for ruptured intracranial aneurysms and excluded those trivial IOR unlikely to have any relation to the prognosis. All possible factors that might lead to a worse outcome in the MIOR cohort were investigated. This information, which is surprisingly lacking in literature, may be helpful for clinical care and practice.

METHODS

Patient population and rupture timing

In a five-year period, 30 cases of major intraoperative rupture (MIOR) in a series of 467 surgeries for ruptured intracranial aneurysms performed in our institute were enrolled for this study. The sample contained 12 male and 18 female patients. Ages ranged from 25 years to 78 years, with an average of 56.2 years. We excluded those cases with minor IOR which didn't interfere with the operation and had no implication for outcome. The timing of intraoperative rupture was categorized into 5 distinct operative stages: 1. anesthetic induction, 2. extradural procedure, 3. brain retraction, 4. aneurysm dissection, and 5. aneurysm clipping. Managements for the MIOR in this series included the judicious use of temporary clip, large bore suction, local tamponade, and brain protective regimen (thiopental and mannitol). No profound hypotension was used in the treatment of MIOR. Clinical parameters, including age, Hunt-Hess grading, Fisher grading, aneurysm size, aneurysm contour, operative timing, aneurysm location, and rupture timing were obtained and their correlation with the prognosis in this particular cohort was studied.

The outcome was evaluated using the Glasgow Outcome Scale at least 3 months after surgery. Severe disability, vegetative survival, and death were classified as poor outcome.

Statistical analysis

Differences in various variables were compared using student t, chi-square, or Fisher exact tests, with the type I error set at 0.05. All analyses were performed using the statistical packages SPSS for Windows, release 10.0 (SPSS Inc, Chicago Ill).

RESULTS

Effect of clinical factors on outcome

Among the 30 cases of MIOR, 5, 19, and 6 cases occurred during brain retraction, aneurysm dissection, and aneurysm clipping, respectively. No MIOR occurred during anesthetic induction and extradural procedure in this series. Eleven patients had poor outcomes. The mean age of poor outcome patients was 64.6 years, which was significantly older than the average of 51.4 years for good outcome patients (P=0.06).

Regarding patient's Hunt-Hess grading in patients with MIOR, 4 out of 15 cases with better grades (grades 1 or 2) had poor outcome (26.7%). On the other hand, patients with worse grades (grades 3, 4, 5), 7 of 15 cases resulted in poor outcome (46.7%). Patients with worse Hunt-Hess grading had the tendency toward unfavorable outcome, but the difference was not sufficient to be statistically significant (P=0.449) (Table 1).

Comparison between patients' Fisher grading and the eventual outcome revealed that MIOR patients with Fisher grades of 3 or 4 tend to have a greater chance of poor outcome than those with Fisher grades of 1 and 2

(8/18, 44% vs 3/12, 25%), but the difference again was not statistically significant (P=0.442) (Table 1).

Effect of aneurysm factors on outcome

Aneurysm size was not a factor of poor outcome in the cohort of patients with MIOR in this study. Three out of eight MIOR patients with aneurysms larger than 15 mm had poor outcome (37.5%), compared to eight out of 22 with aneurysms equal to or smaller than 15 mm (36.3%) (P=1.000) (Table 1).

Similar results were also found for the factor of aneurysm contour. Whether the aneurysm was lobulated or not did not interfere with the eventual outcome in the cohort of patients with MIOR. Five of 14 patients with lobulated aneurysms and 6 of 16 patients with non-lobulated aneurysms had poor outcome (35.7% vs 37.5%) (P=0.919) (Table 1).

Unlike both the size and contour of aneurysm, the location of aneurysm in cases of MIOR correlated more with the eventual outcome. In this cohort of MIOR, one patient whose MIOR occurred on distal anterior cerebral artery (ACA) aneurysm resulted in a more favorable outcome. Of the rest of 29 patients with MIOR, 8 out of 14 patients with internal carotid artery (ICA) aneurysms

Table 1. Correlation between various factors and poor outcomes in 30 cases with MIOR

Factor	Mean Age (yrs)	Total Cases	Poor Outcome No. (%)	P value
Hunt-Hess grading				0.449
1, 2	51.5	15	4 (26.7%)	
3, 4, 5	61.0	15	7 (46.7%)	
Fisher's grading				0.442
1, 2	57.9	12	3 (25.0%)	
3, 4	55.1	18	8 (44.0%)	
aneurysm size				1.000
< 15 mm	56.1	22	8 (36.3%)	
> 15 mm	56.6	8	3 (37.5%)	
lobulated aneurysm				0.919
no	56.6	16	6 (37.5%)	
yes	55.9	14	5 (35.7%)	
aneurysm location				0.039*
ICA	62.2	14	8 (57.1%)	0.197* adjusted
MCA	54.1	9	2 (22.2%)	with age
AcomA	50.5	6	1 (16.7%)	
operative timing				0.280**
< 3 days	57.4	13	7 (53.8%)	
4-13 days	57.5	12	4 (33.3%)	
> 14 days	50.2	5	0 (0 %)	
rupture timing				0.016***
brain retraction	42.4	5	1 (20.0%)	0.041*** adjusted
aneurysm dissection	58.0	19	5 (26.3%)	with age
aneurysm clipping	62.2	6	5 (83.3%)	

*The outcome following ICA aneurysm rupture was compared with that following intraoperative rupture of MCA and AcomA aneurysms. **The outcome of early operation (< 3days) was compared with that of both intermediate and late operations (> 4days). ***The outcome following rupture during aneurysm clipping was compared with that of rupture in both stages of brain retraction and aneurysm dissection.

(57.1%), 2 of 9 patients with middle cerebral artery (MCA) aneurysms (22.2%), and 1 of 6 patients with anterior communicating artery (AcomA) aneurysms (16.7%) displayed a poor outcome (P=0.039). Nevertheless, further analysis with the adjustment of age showed that outcome of MIOR on ICA aneurysm tended to be worse than that on MCA and AcomA aneurysms, but the difference was not statistically significant (P=0.197) (Table 1).

Effect of operative factors on outcome

Comparison between operation timing and outcome revealed that the incidence of poor outcome tended to be higher when MIOR of aneurysm occurred in early operations (< 3 days) (53.8%), in contrast with those occurred in intermediate (4-13 days) and late (> 14 days) operations (33.3% and 0%, respectively). However, the difference was not statistically significant (P=0.280).

Regarding the correlation between the timing of MIOR and the eventual outcome, 5 of the 6 patients with MIOR during clip application resulted in poor outcomes (83.3%). On the contrary, MIOR during brain retraction and aneurysm dissection gave rise to poor outcome in 1 out of 5 (20.0%) and 5 out of 19 (26.3%) patients, respectively (P=0.016). Upon further adjustment with the factor of age, MIOR during clipping still displayed a worse outcome than other rupture timings, and the difference was still statistically significant (P=0.041). Moreover, if aneurysm location and rupture timing were considered together in evaluating their correlation with outcome, all 5 patients with MIOR of ICA aneurysm during clip application resulted in poor outcome (100%). This pattern was significantly worse than that with different aneurysm locations or rupture timings, in which just 6 of 25 (24%) cases resulted in poor outcome (P=0.003).

DISCUSSION

In the last decade, endovascular treatment with coils largely replaced the microsurgery as the first-line treatment of certain intracranial aneurysm mainly in developed countries [8-10]. Even so, microsurgery will remain one of the major treatment options for a long time in many areas of the world. This is mainly because endovascular treatment with coils is too expensive. In addition, interventional treatment is not clearly superior to the microsurgery for certain intracranial aneurysms such as small, wide neck, and unruptured aneurysms [5,11]. Nevertheless, a MIOR happening during an intracranial aneurysm surgery is frequently a nightmare for a neurosurgeon. It often leads to a disastrous consequence and can compromise the outcome [1-3,12]. Therefore every effort should be made to reduce its occurrence. In addition, knowing better about this cohort of MIOR patients, such as factors associated with worse outcome, is helpful in clinical care and practice.

Age is a risk factor of poor outcome in MIOR patients

Age is widely regarded as a risk factor of poor prognosis in intracranial aneurysm [13-18]. However, the impact of age on outcome in cases with MIOR has not been clearly described previously. This study demonstrated that age clearly was a predictor of poor outcome in the cohort of patients with MIOR. The mean age of poor outcome patients was significantly older than that of good outcome patients.

MIOR on ICA aneurysm possible is a risk factor of poor outcome

In intracranial aneurysm surgeries, adequate application of temporary clip has been demonstrated to be useful for both reducing the incidence of IOR and for bleeding control during MIOR [1,12,19-24]. Nevertheless, it may be more difficult to handle and apply the temporary clip when a MIOR occurs on an ICA aneurysm because intracranial ICA is partially obscured by the skull base. Furthermore, major branches of intracranial ICA, such as the ophthalmic artery and posterior communicating artery, are either concealing or deep-seated and are more difficult to be controlled during MIOR. In this study, MIOR on ICA aneurysm did show a trend towards a worse outcome comparing with that on MCA and AcomA aneurysms after adjustment with the factor of age.

MIOR during aneurysm clipping is a risk factor of poor outcome

In this study, MIOR during clip application displayed the worst outcome compared with that during brain retraction and aneurysm dissection. In general IOR during clip application can happen with the bleeding from the dome or a rupture around the aneurysmal neck. Bleeding from the aneurysmal dome typically abates when the blades of the clip are approximated, which were excluded from this study because they didn't interrupt the procedure. On the other hand, a MIOR occurring close to the neck of an aneurysm during clip application usually leads to profound bleeding and compromises the outcome. A premature clipping without adequate dissection of the aneurysm is perceived as the major cause of aneurysm rupture during clip application [1,12]. Obviously, inappropriate clip application also further increases the risk of IOR. Therefore, we urge that a clip should never be applied before an adequate and complete dissection of the aneurysm is accomplished.

As for IOR during brain retraction, it can happen in the early or late stage of retraction. An IOR in the early stage of brain retraction generally leads to a catastrophic outcome but fortunately is rarely encountered. On the other hand, it is easier to obtain the parent vessel control if an IOR happens in the late stage of brain retraction, and therefore the outcome is better. In this study, all 5 cases with MIOR during brain retraction involved the late stage. Consequently, the prognosis was relatively good with only one resulting in poor outcome.

IOR during aneurysm dissection usually comes from inadequate dissection such as blunt and rough dissections. Fortunately when IOR happens in this stage, it is easier to control bleeding with temporary clipping on the parent vessels. Consequently the prognosis can be better.

In conclusion, older age and MIOR during clip application might be factors leading to a poor outcome following MIOR in ruptured aneurysm surgery. An MIOR on ICA aneurysm tended to have a worse outcome in this study. The major drawback of this study is the relatively small sample size for this particular cohort of MIOR patients. Further studies with larger sample population may be required to gain a more decisive result.

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REFERENCES

1. Batjer H, Samson D. Intraoperative aneurysmal rupture: incidence, outcome, and suggestions for surgical management. Neurosurgery 1986;18:701-707.
2. Giannotta SL, Oppenheimer JH, Levy ML, Zelman V. Management of intraoperative rupture of aneurysm without hypotension. Neurosurgery 1991;28:531-536.
3. Graf CJ, Nibbelink DW. Randomized treatment study: intracranial surgery. In Sahs AL, Nibbelink DW, Torner JC, editors. Aneurysmal Subarachnoid Hemorrhage: Report of the Cooperative Study. Baltimore, MD: Urban and Schwarzenburg; 1981. p.145-p202.
4. Lawton MT, Du R. Effect of the neurosurgeon's surgical experience on outcomes from intraoperative aneurysmal rupture. Neurosurgery 2005;57:9-15.
5. Leipzig TJ, Morgan J, Horner TG, Payner T, Redelman K, Johnson CS. Analysis of intraoperative rupture in the surgical treatment of 1694 saccular aneurysms. Neurosurgery 2005;56:455-468.
6. Sandalcioglu IE, Schoch B, Regel JP, Wanke I, Gasser T, Forsting M, Stolke D, Wiedemayer H. Does intraoperative aneurysm rupture influence outcome? Analysis of 169 patients. Clin Neurol Neurosur 2004;106:88-92.
7. Houkin K, Kuroda S, Takahashi A, Takikawa S, Ishikawa T, Yoshimoto T, Itamato K. Intra-operative premature rupture of the cerebral aneurysms. Analysis of the causes and management. Acta Neurochir 1999;141:1255-1263.
8. Luo CB, Mu-Huo Teng M, Chang FC, Lin CJ, Guo WY, Chang CY. Intraprocedure aneurysm rupture in embolization: Clinical outcome with imaging correlation. J Chin Med Assoc 2012;75:281-285.
9. Molyneux A, Kerr R, Stratton I, Sandercock P, Clarke M, Shrimpton J, . International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. Lancet 2002;360:1267-1274.
10. Pierot L, Cognard C, Anxionnat R, Ricolfi F, CLARITY Investigators. Ruptured intracranial aneurysms: Factors

affecting the rate and outcome of endovascular treatment complications in a series of 782 patients (CLARITY study). Radiology 2010;256:916-923.

11. Sundt TM Jr, Kobayashi S, Fode NC, Whisnant JP. Results and complications of surgical management of 809 intracranial aneurysms in 722 cases. Related and unrelated to grade of patient, type of aneurysm, and timing of surgery. J Neurosurg 1982;56:753-765.
12. Batjer HH, Samson DS. Intraoperative aneurysm rupture. In: Wilkins RH, Rengachary SS, editors. Neurosurgery Update II. New York: McGraw-Hill; 1991. p.100-p.105.
13. Fortuny LA, Adams CB, Briggs M. Surgical mortality in an aneurysm population: effects of age, blood pressure and preoperative neurological state. J Neurol Neurosurg Psychiatry 1980;43:879-882.
14. Artiola i Fortuny L, Prieto-Valiente L. Long-term prognosis in surgically treated intracranial aneurysms: part 1. mortality. J Neurosurg 1981;54:26-34.
15. Deruty R, Pelissou-Guyotat I, Mottolese C, Amat D, Bognar L. Level of consciousness and age as prognostic factors in aneurysmal SAH. Acta Neurochir (Wien) 1995; 132:1-8.
16. Ogilvy CS, Carter BS. A proposed comprehensive grading system to predict outcome for surgical management of intracranial aneurysms. Neurosurgery 1998;42:959-968.
17. Shephard RH. Ruptured cerebral aneurysms: early and late prognosis with surgical treatment. A personal series, 1958-1980. J Neurosurg 1983;59:6-15.
18. Yoshimoto Y, Kwak S. Age-related multifactorial causes of neurological deterioration after early surgery for aneurysmal subarachnoid hemorrhage. J Neurosurg 1995;83:984-988.
19. Ades PE, Graftieaux JP. Peroperative aneurysm rupture: role and consequences of temporary clamping. Agressologie 1990;31:351-356.
20. Bellotti C, Oliveri G, Allegra G, Arrigoni M, Regalia F, Voci A, Bellotti E. Temporary clipping in the surgery of endocranial aneurysms. J Neurosurg Sci 1998;42:77-79.
21. McDermott MW, Durity FA, Borozny M, Mountain MA. Temporary vessel occlusion and barbiturate protection in cerebral aneurysm surgery. Neurosurgery 1989;25:54-61.
22. Samaha E, Rizk T, Nohra G, Mohasseb G, Okais N. Temporary occlusion in surgical management of intracranial aneurysm. Report of 54 cases. Neuro-chirurgie 1999; 45:24-28.
23. Samson D, Batjer HH, Bowman G, Mootz L, Krippner WJ Jr., Meyer YJ, Allen BC. A clinical study of the parameters and effects of temporary arterial occlusion in the management of intracranial aneurysms. Neurosurgery 1994;34:22-28.
24. Taylor CL, Selman WR, Kiefer SP, Ratcheson RA. Temporary vessel occlusion during intracranial aneurysm repair. Neurosurgery 1996;39:893-905.