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# Multiple ruptured cerebral aneurysms at the National Hospital of the Kyrgyz Republic between 2008 and 2014: a departmental summary

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## ABSTRACT

Despite the rapid progress of vascular neurosurgery with the development of microsurgical and endovascular techniques, the optimal strategy for surgical treatment of multiple cerebral aneurysms has not yet been developed. The indications for choosing one-stage or multi-stage surgery remain unsolved. This is a summary of the departmental routine reports at the Clinic of Neurosurgery, National Hospital of the Kyrgyz Republic. Subjects were 235 patients (124 males and 111 females) with ruptured multiple cerebral aneurysms admitted to the hospital. Their ages ranged from 18 to 72 years (average and standard deviation: 44.3 ± 9.7 years) and 48.1% of patients had 3 or more aneurysms. Among aneurysms that ruptured, 20.4% were a giant aneurysm (>25 mm) and 43.0% of patients had grade IV or V according to the Hunt-Hess Scale. Among 228 patients who were operated on, 147 were treated by single-stage surgery and 81 by multi-stage surgery. Microsurgical operations with clipping of the aneurysm neck were performed in 141 (61.8%) patients (97 single-stage and 44 multi-stage), while 40 (17.5%) patients (16 single-stage and 24 multi-stage) were operated using the endovascular technique. The number of palliative surgeries (trapping, ligation of the internal carotid artery, and reinforcement of the aneurysm wall) was significantly less (p=0.011) with multi-stage surgery (9 out of 81 cases, 11.1%) than with single-stage surgery (38 out of 147 cases, 25.9%). Among 600 aneurysms, 583 (97.2%) were treated by either single-stage surgery (n=296) or multi-stage surgery (n=287). There were no differences in prognosis at discharge between single-stage and multi-stage surgery.

Keywords: multiple cerebral aneurysms, subarachnoid hemorrhage, multi-stage surgery, microsurgical technique, endovascular technique



## INTRODUCTION

Cerebral aneurysms are the main cause of nontraumatic subarachnoid hemorrhages (SAH), accounting for 70–80% of all SAH cases.[1] Untreated ruptured cerebral aneurysms are associated

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with high mortality due to rebleeding.[2-5] Microsurgical clipping and endovascular coil embolization are the two main treatment strategies for obliteration of ruptured and unruptured aneurysms.[6] While a single cerebral aneurysm can be successfully treated, surgical treatment of patients with multiple aneurysms (MA), which occurs in about 20% of patients with cerebral aneurysm,[7] is very difficult. The difficulty in treatment of such patients is derived from the need of surgery at multiple vascular regions of the brain, as well as the accurate diagnosis of the ruptured aneurysm.

The widespread use of modern noninvasive imaging such as magnetic resonance angiography (MRA) and spiral computed tomography angiography (SCT-AG) for cerebral vessels leads to an increase in the number of patients with cerebral aneurysms.[8-11] Despite the rapid progress of vascular neurosurgery with microsurgical and endovascular techniques, the optimal strategy for surgical treatment of cerebral vascular MA has not been developed. Different versions of microsurgical and endovascular MA exclusions have been proposed, but criteria allowing a surgeon to choose the optimal treatment does not exist.[12-14] The question of using a one-stage or multi-stage surgery remains unsolved. Options of combining microsurgical operations with endovascular operations and the sequence have not been established.[15-17]

This was the first report on clinical features and prognosis at discharge of patients with ruptured MA in Kyrgyz Republic. The data were derived from the departmental summary without their identifications at a tertiary hospital. Although observational studies cannot provide conclusive evidence, they may provide fundamental information to develop new surgical treatment tactics for cerebral MA in the future.

## MATERIALS AND METHODS

*Subjects*

Subjects were patients with ruptured MA aged 18 years or older, who admitted and treated at the Clinic of Neurosurgery, National Hospital of the Kyrgyz Republic from 2008 to 2014. This is a tertiary hospital with 1,500 inpatient beds and the largest neurosurgery department with 140 inpatient beds in the Kyrgyz Republic.

*Diagnosis*

Cerebral angiography (CAG), computed tomography angiography (CTA), and magnetic resonance angiography (MRA) were used to diagnose SAH and its bleeding site. Aneurysm sizes were classified as small (<10 mm in diameter), large (10–24 mm), and giant (>25 mm or larger).

*Treatment methods*

Operations (single-stage or multi-stage surgery) were conducted in an acute period (within 72 hours after rupture) or in a cold period (72 hours to 7 days after rupture). No clear guidelines regarding operation period and method (clipping, trapping, ligation, reinforcement, and endovascular occlusion) existed in the Kyrgyz Republic. Therefore, these decisions were made by the doctors in charge, based on their experiences, taking into account the location, size, and complexity of the aneurysms. The conceptual general rules for treatment were as follows. The second operation was scheduled based on a careful assessment of the neurological and physical status of the patient, including CT images taken after the first operation. The duration between the two operations ranged from 1 day to 4 months. Among patients operated in the cold period of the SAH, the subsequent operation was performed 1 to 2 weeks later. Patients treated in the acute phase of the SAH had the second operation 1 month or later.

The surgical approach to aneurysms were divided into two; 1) anterior or anterio-lateral access

to aneurysms of the internal carotid artery (ICA), middle cerebral artery (MCA), anterior communicating artery (Acom), anterior cerebral artery (ACA), posterior communicating artery (Pcom), distal segments of the basilar artery (BA), and posterior cerebral artery (PCA), and 2) posterior or postero-lateral approach to aneurysms of caudal parts of vertebra-basilar circulation (VBC).

*Prognosis*

The severity was assessed with the Hunt-Hess Scale[18] upon admission to the hospital. Surgical treatment outcome was evaluated with the Glasgow Outcome Scale[19] at the time of hospital discharge.

*Data source and statistical analysis*

Data were obtained from routine summaries at the department without the patient identification. All statistical analyses were performed with IBM SPSS Statistics version 21 for Windows. Mean and standard deviation (SD) were calculated for continuous variables. Mean age between two groups was tested with Student's t-test. Contingency tables were tested with a Pearson $\chi^2$ test. In case of less than 5 in the smallest cell, Fisher's exact test was applied. A P value less than 0.05 was considered statistically significant.

## RESULTS

*Clinical characteristics of patients with multiple aneurysms*

During 2008 to 2014, 235 patients (111 males and 124 females) with ruptured MA were listed in the reports of the clinic. Their ages ranged from 18 to 72 years with a mean ± SD of 44.3 ± 9.7 years. There was no significant difference in the mean age between men and women; 44.6±10.1 years in males and 45.3±9.2 years in females. Seven patients out of 235 did not have operations; 2 refused the operation and 5 died before surgery. The remaining 228 (97.0%) patients underwent surgical interventions for their aneurysms. The number of aneurysms per patients ranged from 2 to 8 (Table 1), with approximately half (51.9%) having 2 aneurysms. The largest aneurysm of each patient was less than 10 mm for 128 (54.5%), and 25 mm or more for 48 (20.4%). The severity of the patients according to the Hunt-Hess Scale was as follows; 14 (5.9%) in grade I, 49 (20.9%) in grade II, 71 (30.2%) in grade III, 75 (31.9%) in grade IV, and 26 (11.1%) in grade V. These percentages were similar between men and women with no significant difference.

*Characteristics of aneurysms*

Out of 600 total aneurysms from 235 patients, 476 (79.3%) were saccular aneurysms, 55 (9.2%) were fusiform aneurysms, 62 (10.3%) were aneurysmal bulging, and 7 (1.2%) were funnel extensions of the arterial wall (Table 2). Two thirds (405 aneurysms) were found in anterior circulation. Selective CAG was used for 209 (88.9%) patients. CTA was used for 52 (22.1%) cases because of micro- and small aneurysms suspected by CAG data, and MRA was used in 25 (10.6%) patients. Most of imaging tests were conducted in the cold period. MRA was rarely used for acute SAH, because the presence of blood around the aneurysm substantially distorts the image, making diagnosis difficult. In 13 (52.0%) out of the 25 cases with MRA, selective CAG was further needed to confirm the diagnosis. Selective CAG found additional small aneurysms in 4 (6.2%) of these 13 patients. No significant differences in the morphology were observed between men and women. Anterior circulation was significantly higher in men than in women (p=0.003). A chi-square test for 8 locations between men and women provided p=0.033.

**Table 1** Number and size of aneurysms in 235 patients according to sex

| Characteristics | Men (%) | Women (%) | Total (%) |
|---|---|---|---|
| **Age in years** | | | |
| 18–39 | 13 (11.7) | 16 (12.9) | 29 (12.3) |
| 40–59 | 67 (60.4) | 73 (58.9) | 140 (59.6) |
| 60–72 | 31 (27.9) | 35 (28.2) | 66 (28.1) |
| **Number of aneurysms** | | | |
| 2 | 57 (51.3) | 65 (52.4) | 122 (51.9) |
| 3 | 33 (29.8) | 36 (29.1) | 69 (29.4) |
| 4 to 8 | 21 (18.9) | 23 (18.5) | 44 (18.7) |
| **Largest aneurysm** | | | |
| Small (<10 mm) | 59 (53.2) | 69 (55.6) | 128 (54.5) |
| Large (10–24 mm) | 29 (26.1) | 30 (24.2) | 59 (25.1) |
| Giant (25 mm<) | 23 (20.7) | 25 (20.2) | 48 (20.4) |
| **Severity in the Hunt-Hess Scale*** | | | |
| I | 6 ( 5.4) | 8 ( 6.4) | 14 ( 5.9) |
| II | 24 (21.6) | 25 (20.2) | 49 (20.9) |
| III | 34 (30.6) | 37 (29.8) | 71 (30.2) |
| IV | 36 (32.5) | 39 (31.5) | 75 (31.9) |
| V | 11 ( 9.9) | 15 (12.1) | 26 (11.1) |
| **Total** | **111 (100)** | **124 (100)** | **235 (100)** |

* I: Asymptomatic, mild headache, slight nuchal rigidity, II: moderate to severe headache, nuchal rigidity, no neurologic deficit other than cranial nerve palsy, III: drowsiness, confusion, mild focal neurologic deficit, IV: stupor, moderate-severe hemiparesis, V: coma, decerebrate posturing.

**Table 2** Morphological features and location of aneurysms (N=600)

| Aneurysm | Men (%) | Women (%) | Total (%) |
|---|---|---|---|
| **Morphology** | | | |
| Saccular | 241 (78.2) | 235 (80.5) | 476 (79.3) |
| Fusiform | 30 ( 9.7) | 25 ( 8.6) | 55 ( 9.2) |
| Bulging | 33 (10.7) | 29 ( 9.9) | 62 (10.3) |
| Funnel extension | 4 ( 1.4) | 3 ( 1.0) | 7 ( 1.2) |
| **Location*** | | | |
| **Anterior circulation** | **225 (73.1)** | **180 (61.6)** | **405 (67.5)** |
| ICA | 94 (30.5) | 77 (26.4) | 171 (28.5) |
| MCA | 35 (11.4) | 21 ( 7.2) | 56 ( 9.3) |
| ACA | 21 ( 6.8) | 15 ( 5.1) | 36 ( 6.0) |
| Acom | 32 (10.4) | 31 (10.6) | 63 (10.5) |
| Pcom | 43 (14.0) | 36 (12.3) | 79 (13.2) |
| **Posterior circulation** | **83 (26.9)** | **112 (38.4)** | **195 (32.5)** |
| VA | 29 ( 9.4) | 30 (10.3) | 59 ( 9.8) |
| BA | 36 (11.7) | 42 (14.4) | 78 (13.0) |
| PCA | 18 ( 5.8) | 40 (13.7) | 58 ( 9.7) |
| **Total** | **308 (100)** | **292 (100)** | **600 (100)** |

ICA: internal carotid artery, MCA: middle cerebral artery, ACA: anterior cerebral artery, Acom: anterior communicating artery, Pcom: posterior communicating artery, VA: vertebral artery, BA: basilar artery, PCA: posterior cerebral artery.

**Table 3** Number and size of aneurysms among 228 patients according to type of surgery

| Characteristics | Single-stage | | Multi-stage | | P* |
|---|---|---|---|---|---|
| | N | % | N | % | |
| **Age in years** | | | | | 0.011 |
| 18–39 | 24 | 16.3 | 3 | 3.7 | 0.005 |
| 40–59 | 80 | 54.4 | 56 | 69.1 | 0.030 |
| 60–72 | 43 | 29.3 | 22 | 27.2 | NS |
| **Number of aneurysms** | | | | | NS |
| 2 | 78 | 53.1 | 40 | 49.4 | NS |
| 3 | 44 | 29.9 | 23 | 28.4 | NS |
| 4 to 8 | 25 | 17.0 | 18 | 22.2 | NS |
| **Largest aneurysms** | | | | | NS |
| Small (<10 mm) | 83 | 56.5 | 41 | 50.6 | NS |
| Large (10–24 mm) | 34 | 23.1 | 24 | 29.6 | NS |
| Giant (25 mm <) | 30 | 20.4 | 16 | 19.8 | NS |
| **Severity in the Hunt-Hess Scale*** | | | | | 0.083 |
| I | 8 | 5.4 | 4 | 4.9 | NS |
| II | 38 | 25.9 | 10 | 12.4 | 0.017 |
| III | 39 | 26.6 | 30 | 37.0 | 0.098 |
| IV | 49 | 33.3 | 25 | 30.9 | NS |
| V | 13 | 8.8 | 12 | 14.8 | NS |
| **Total** | **147** | **100** | **81** | **100** | |

* P values of 3 by 2 or 5 by 2 table for each variable and those of each level (2 by 2 table). In case of N less than 5, Fisher's exact test was applied. NS means P value more than 0.1.

*Surgical treatment of multiple aneurysms*

Among 228 patients, 100 (43.9%) were operated during the acute period of hemorrhage (within 72 hours after rupture), and 128 (56.1%) in the cold period (72 hours to 7 days after rupture). As shown in Table 3, single-stage surgery was performed for 147 (64.5%) patients, and multi-stage surgery was performed for 81 (35.5%) patients; twice for 51 (62.9%) patients, three times for 28 (34.6%) patients, and four times for 2 (2.5%) patients. Clinically compensated patients (grade I or II of the Hunt-Hess Scale) were 31.3% among single-stage surgery group, while 17.3% were among the multi-stage group ($p<0.001$).

As shown in Table 4, microsurgical operations with clipping of the aneurysm neck were performed in 141 (61.8%) patients (97 single-stage and 44 multi-stage), while 40 (17.5%) patients (16 single-stage and 24 multi-stage) were operated on by the endovascular technique. Among 600 total aneurysms, 583 (97.2%) were treated; 296 by single-stage surgery and 287 by multi-stage surgery. Among those 583 aneurysms, 400 (68.6%) were operated by means of microsurgical access, and 95 (16.3%) were treated with an endovascular technique. The remaining 88 (15.1%) underwent palliative surgery; trapping for 9, ligation of the ICA for 19, and reinforcement of aneurysm wall for 60.

The total exclusion of aneurysms by clipping and endovascular technique was achieved in 109 (74.1%) cases of single-stage surgery and in 72 (88.9%) cases of multi-stage surgery ($p=0.008$). Reinforcement of the aneurysmal wall was performed for 32 (21.8%) patients in single-stage surgery and 7 (8.6%) patients in multi-stage surgery, ($p=0.012$). Although not significant, the total number of excluded aneurysms in multi-stage surgery (85.7% of 287 aneurysms) was slightly more than in single-stage surgery (84.1% of 296 aneurysms). Meanwhile, the number of palliative

**Table 4** Type of surgery for cerebral aneurysms among 228 patients

| Type of surgery | Single-stage | | Multi-stage | | P* |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Ruptured aneurysm in 228 patients | | | | | <0.001 |
| Clipping of aneurysm neck | 97 | 65.9 | 44 | 71.6 | 0.083 |
| Trapping-clipping | 1 | 0.7 | 2 | 2.5 | NS |
| Ligation of ICA | 1 | 0.7 | 4 | 4.9 | 0.055 |
| Reinforcement of aneurysm wall | 32 | 21.8 | 7 | 8.6 | 0.012 |
| Endovascular occlusion | 16 | 10.9 | 24 | 17.3 | <0.001 |
| **Subtotal** | **147** | **100** | **81** | **100** | |
| Aneurysms including the unruptured (N=583) | | | | | <0.001 |
| Clipping of aneurysm neck | 233 | 78.7 | 167 | 58.2 | <0.001 |
| Trapping-clipping | 3 | 1.0 | 6 | 2.1 | NS |
| Ligation of ICA | 4 | 1.4 | 15 | 5.2 | 0.010 |
| Reinforcement of aneurysm wall | 40 | 13.5 | 20 | 7.0 | 0.009 |
| Endovascular occlusion | 16 | 5.4 | 79 | 27.5 | <0.001 |
| **Subtotal** | **296** | **100** | **287** | **100** | |

ICA: internal carotid artery

* P values of 5 by 2 table followed by those of each level (2 by 2 table) for patients and aneurysms. In case of N less than 5, Fisher's exact test was applied. NS means P value more than 0.1.

**Table 5** Prognosis of operated patients in terms of the Glasgow Outcome Scale

| Scale | Single-stage | | Multi-stage | |
|---|---|---|---|---|
| | N | % | N | % |
| I: Good recovery | 134 | 91.2 | 73 | 90.1 |
| II: Moderate disability | 5 | 3.4 | 3 | 3.7 |
| III: Severe disability | 3 | 2.0 | 1 | 1.2 |
| IV: Vegetative state | 2 | 1.4 | 2 | 2.5 |
| V: Death | 3 | 2.0 | 2 | 2.5 |
| **Total** | **147** | **100** | **81** | **100** |

surgeries (trapping, ligation of the ICA, and reinforcement of aneurysm wall) was significantly less (p=0.011) in multi-stage surgery (9 out of 81 cases, 11.1%) than in single-stage surgery (38 out of 147 cases, 25.9%).

Among 147 single-stage surgery patients, 32 (21.8%) had fusiform aneurysm(s) reinforced with surgical gauze, while only in 7 (8.6%) of 81 multi-stage surgery patients (p=0.012). In cases with saccular aneurysms and aneurysmal protrusions, the percentage of palliative surgery was also higher in the single-stage surgery group.

*Outcome at discharge*

The outcomes of single-stage and multi-stage surgeries is demonstrated in Table 5. Among 147 patients who received the single-stage surgery, 134 (91.2%) had a good recovery (Glasgow Outcome Scale I), while poorer outcome (Glasgow Outcome Scale III to V) was observed in 8 (5.4%) cases, including 2 deaths. Among 81 patients operated by multi-stage surgery, 73 (90.1%) were Glasgow Outcome Scale I, and 5 (6.2%) were Glasgow Outcome Scale III to V. The differences between the single-stage and multi-stage operations were not significant.

## DISCUSSION

Based on the summary in the hospital use, this article reported the characteristics and prognosis of 235 patients with ruptured MA, including 147 patients operated by single-stage surgery and 81 patients operated by multi-stage surgery at the Clinic of Neurosurgery, National Hospital of the Kyrgyz Republic from 2008 to 2014. Microsurgical operations with clipping of aneurysm neck were performed in 141 (61.8%) patients, while 40 (17.5%) patients had operations using the endovascular technique.

In this hospital, 113 (48.1%) patients had 3 or more aneurysms. A study from China reported that 13.1% of 183 MA patients had 3 or more than aneurysms.[2] Since the number of detected aneurysms can be influenced by several factors including the diagnostic methods, the higher percentage in this report should be interpreted carefully.

The locations of aneurysms have been reported in several countries. In a report from China, the main locations were Pcom (34.9%), Acom (29.5%), and MCA (14.5%) among 1,073 ruptured aneurysms.[2] In Korea, they were Acom (27.6%), MCA (25.5%), and Pcom (21.8%) among 239 ruptured aneurysms.[20] In Japan, they were ACA including Acom (34.3%), ICA (27.8%), and MCA (24.4%) among 1,448 patients with a ruptured saccular aneurysm.[21] In the present patients, ICA (28.5%) was the most common, while Pcom (13.2%), Acom (10.5%), and MCA (9.3%) were less common and BA was relatively frequent (13.0%).

Clinical results of operations in the acute period of SAH of patients in both single-stage and multi-stage surgery groups are similar. However, the distribution of severity according to the Hunt-Hess Scale revealed that clinically compensated patients (grade I or II) were 31.3% among the single-stage surgery group and 17.3% among the multi-stage group ($p<0.001$). Although a relatively worse outcome was expected in the multi-stage group, there was no substantial difference.

Since the information in this article was derived from a single tertiary hospital, these findings should be carefully generalized to the whole country. Another limitation was the precision of the data. This summary was based on data gathered for clinical practice, not for a research purpose. The comparison in the outcome between single-stage surgery and multi-stage surgery may be biased, because the allocation to either single or multi-stage surgery was not randomly assigned. The type of surgery (clipping, endovascular technique, or others) was determined by the doctor in charge.

In conclusion, this departmental summary demonstrated that for 235 MA patients that had operations 1) 48.1% had 3 or more aneurysms, 2) 20.4% had giant aneurysm, 3) 43.0% were grade IV or V on the Hunt-Hess Scale, 4) 147 patients were treated by single-stage surgery and 81 patients by multi-stage surgery, and 5) good recovery measured by the Glasgow Outcome Scale was found in 90.8% of patients. There were no differences in prognosis at discharge between single-stage and multi-stage surgery.

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## COMPETING INTERESTS

The authors have declared that no competing interests exist.

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