Factors determining the side of approach for clipping ruptured anterior communicating artery aneurysm via supraorbital eyebrow keyhole approach

Robin Bhattarai, Chao-Feng Liang, Chuan Chen, Hui Wang, Teng-Chao Huang, Ying Guo*

Department of Neurosurgery, Third Affiliated Hospital of Sun Yat-Sen University, Guangzhou 510000, China

ABSTRACT

Purpose: The purpose of this study was to review the microsurgical anatomy and clipping of ruptured anterior communicating artery (AComA) aneurysms and to plan and avoid complications before operation.

Methods: A total of 523 cases of cerebral aneurysms admitted to the neurosurgery department of the Third Affiliated Hospital of Sun Yat-Sen University from September 2010 to October 2018 were analyzed retrospectively. Among them, 85 patients had ruptured AComA aneurysms. This study was limited to 85 of these cases, whose satisfactory preoperative angiographic diagnostic films can be retrieved from the hospital database system because of the need for detailed review.

Results: We performed supraorbital eyebrow keyhole approach (SOEK) craniotomy in 85 patients to clip 85 AComA aneurysms, in the setting of subarachnoid hemorrhage (SAH). Patients’ mean age was (52.69 ± 9.94) years (range, 28–78 years). The proportions of small, medium and large aneurysms were 83.5%, 15.3%, and 1.2%, respectively. The average size of the aneurysms was (5.07 ± 2.36) mm. There were 77.8% of patients with inferior aneurysms and 81.3% of patients with superior aneurysms achieved good results. There was a significant correlation between A1 dominance and operation method (p < 0.001).

There was no significant relationship between surgical approach and aneurysm projection or A2 plane (p = 0.157 & p = 0.318).

Conclusion: Regardless of whether the A2 plane is open or closed, the A1 dominant side is still a better choice for accessing AComA aneurysms to avoid dangerous premature bleeding.

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Introduction

In order to achieve accurate clipping of the aneurysm, A1 dominance, the anatomy of the aneurysm neck with A1 and A2 segment, presence of perforators and other vascular abnormalities are very important.1 Magnetic resonance angiography (MRA), three dimensions (3D) computed tomography angiography (CTA), and 3D digital subtraction angiography (DSA) can easily observe the detailed anatomy around the anterior communicating artery (AComA) complex.2

The decision of the surgical approach is based on the relationship between A1 dominance with projection, and relation of the projection with the plane of both A2 vessels. According to Yasargil et al.,2 projection is the main anatomical factor.

In this study, we analyzed the microanatomical relationship between AComA complex and its adjacent vessels, and individualized the selection strategy of the surgical side to avoid or reduce the complications associated with the dissection and clipping of AComA aneurysms, and further clarified the importance of using the dominant A1 segment during the microsurgical clipping of AComA aneurysm via supraorbital eyebrow keyhole (SOEK) approach.

Methods

General data collection

From September 2010 to October 2018, 523 cases of cerebral aneurysms were treated in the Department of Neurosurgery of the Third Affiliated Hospital of Sun Yat-Sen University. Among them, 85 cases of AComA aneurysm with subarachnoid hemorrhage were included in our study. All 85 cases had complete cerebral vascular imaging data and clinical data before and after the operation. We...
collected the general data, clinical manifestations, imaging data, intraoperative findings and postoperative recovery of 85 patients.

Research and analysis

The general data and angiographic features of 85 patients, such as size, projection, multiplicity, lobulations, dominant blood supply, relationship between the aneurysm and A2 plane, and surgical complications were analyzed in detail. The open A2 plane is defined as the presence of A2 of the SOEK approach more posteriorly than the contralateral A2. The closed A2 plane is defined as the position where the ipsilateral A2 is located more anteriorly, which results in the A1-A2 junction and the A2 to hide the neck of the aneurysm (Fig. 1). At the same time, world federation of neurological surgeon (WFNS) score and Fisher grade of patients at admission were analyzed. All patients were assessed by the modified ranking scale (MRS) when they were discharged from the hospital.

Statistical analysis

Quantitative variables are expressed as mean ± SD and categorical variables are expressed as frequency distribution. Quantitative variables of the two groups were compared using an independent sample t-test. The correlation between categorical variables was analyzed by Chi-square test. SPSS software (version 21.0; IBM, SPSS, Chicago, IL, USA) was used for statistical analysis.

Results

The average age of 85 patients in this study was (52.69 ± 9.94) years (range, 28–78 years). There were 50 male patients (58.8%). All the patients presented with ruptured AComA aneurysm. Among ruptured aneurysms, 28 (32.9%) were WFNS grade I, 20 (23.5%) were WFNS grade II, 12 (14.1%) were WFNS grade III, 23 (27.1%) were WFNS grade IV, and 2 (2.4%) were WFNS grade V (Table 1). A number of 49 (57.6%) patients were operated within 48 h and 36 (42.4%) were operated after 48 h of initial symptoms.

For all ruptured aneurysms, the severity of bleeding was determined by Fisher classification. Of 85 ruptured aneurysms, 42 were Fisher II (49.4%), 13 were Fisher III (15.3%) and 30 were IV (35.3%). Preoperative infarction occurred in 5 patients (5.3%).

Preoperative CTA/DSA of 85 cases was analyzed to study the morphology of aneurysms. The average size was (5.07 ± 2.36) mm (range, 2–12 mm). There were 52 patients had dominant circulation, 36 of them had dominant left A1 and 16 had dominant right A1 circulation. A total of 33 cases (38.8%) were co-dominant. With 48 patients had superior projection (56.5%), 18 patients had inferior projection (21.2%), 16 patients (18.8%) and 3 patients (3.5%) had anterior and posterior projection respectively. We found that 24 cases had multiple projections due to multiple lobules, of which dominant projections were considered the main projections. The A2 plane was open in 37 cases (43.5%) and closed in 48 cases (56.5%).

Out of 85 patients, 84 AComA aneurysms were clipped and 1 was wrapped. Three patients (3.5%) had ruptured aneurysms during operation. Three patients (3.5%) had a perforator injury. Rectus gyrus aspiration was performed in 5 patients (5.3%). Twenty-five patients (29.4%) received temporary clipping of dominant A1. Temporary clipping duration of dominant A1 was 1–20 min (average 6.9 min).

Of the 85 patients, 2 (2.4%) had post-operative contusion and 17 (20.0%) had infarction. Of these 10 (11.8%) patients suffered from severe infarction. Postoperative hematoma and intraventricular hemorrhage occurred in 5 cases (5.9%) and which resolved in subsequent computed tomography (CT) scan. Nine cases (10.6%) underwent cerebrospinal fluid (CSF) diversion due to hydrocephalus.

We evaluated the MRS for 85 patients at discharge. Two patients who had preoperative Hunt & Hess grade V died. Sixty-nine patients (81.2%) had a good prognosis (Table 2).

Among 85 patients, 52 patients had A1 dominance and 33 patients had co-dominance. Thirty-six patients had left side A1 dominance and 16 patients had right A1 dominance. Of the 36 patients with left A1 dominance, 33 underwent left-sided surgery and 3 underwent right-sided surgery. All 16 patients with dominant right A1 underwent right-sided surgery. The 3 cases which underwent surgery from the non-dominant circulation, all were antero-inferiorly directing aneurysms (Table 3).

A total of 48 cases of superiorly projecting aneurysms, 3 (3.5%) had an intraoperative rupture (IOR), gyrus rectus aspiration was

| Table 1 | Demographics of the 85 patients with cerebral aneurysms. |
|---------|------------------|
| Patients | n (%) |
| Age (years) | |
| <40 | 4 (4.7) |
| 40–49 | 6 (7.1) |
| 50–59 | 10 (11.7) |
| >60 | 65 (76.5) |
| Gender | |
| Male | 50 (58.8) |
| Female | 35 (41.2) |
| WFNS score | |
| I | 28 (32.9) |
| II | 20 (23.5) |
| III | 12 (14.1) |
| IV | 23 (27.1) |
| V | 2 (2.4) |
| Total | 85 (100) |

WFNS: World Federation of Neurological Surgeon.
Table 2
Outcome assessment of the 85 patients with cerebral aneurysms.

| Modified rankin scale | n (%) | p value |
|-----------------------|-------|---------|
| 0                     | 11 (12.9) |         |
| 1                     | 24 (28.3) |         |
| 2                     | 34 (40) |         |
| 3                     | 3 (3.5) |         |
| 4                     | 3 (3.5) |         |
| 5                     | 8 (9.4) |         |
| 6                     | 2 (2.4) |         |

Table 3
A1 dominance, projection, A2 plane and side of the approach, n (%).

| Variables                  | Side of approach | Total (n = 85) | p value |
|----------------------------|-----------------|---------------|---------|
| A1 dominance               |                 |               | <0.001  |
| Left                       | 33 (76.7)       | 36 (42.4)     |         |
| Right                      | 0 (0)           | 16 (18.8)     |         |
| No dominance               | 10 (23.3)       | 33 (38.8)     |         |
| Projections                |                 |               | 0.157   |
| Superior                   | 26 (60.5)       | 48 (56.5)     |         |
| Inferior                   | 5 (11.6)        | 18 (21.2)     |         |
| Anterior                   | 10 (23.3)       | 16 (18.8)     |         |
| Posterior                  | 2 (4.6)         | 3 (3.5)       |         |
| A2 Plane                   |                 |               | 0.318   |
| Open                       | 21 (48.8)       | 37 (43.5)     |         |
| Closed                     | 22 (51.2)       | 48 (56.5)     |         |

Table 4
Proportion of aneurysm, operative complications and outcomes evaluated by the modified rankin scale, n (%).

| Complications                  | Projections | Superior (n = 48) | Inferior (n = 18) | Anterior (n = 16) | Posterior (n = 3) | Total (n = 85) | p value |
|-------------------------------|-------------|-----------------|-----------------|------------------|------------------|---------------|---------|
| Intraoperative rupture         |             | 1 (2.08)        | 1 (5.6)         | 1 (6.3)          | 0 (0)            | 3 (3.5)       | 0.793   |
| Gyrus rectus resection        |             | 3 (6.3)         | 2 (11.1)        | 0 (0)            | 0 (0)            | 5 (5.9)       | 0.554   |
| Perforator injury             |             | 1 (2.1)         | 1 (5.6)         | 0 (0)            | 1 (33.3)         | 3 (3.5)       | 0.002   |
| Temporary clipping            |             | 13 (27.1)       | 4 (22.2)        | 7 (43.8)         | 1 (33.3)         | 25 (29.4)     | 0.536   |
| Postoperative complication    |             |                 |                 |                  |                  |               |         |
| Contusions                    |             | 1 (2.1)         | 0 (0)           | 0 (0)            | 1 (1.2)          | 1 (1.2)       | 0.671   |
| Infarction                    |             | 8 (16.7)        | 5 (27.8)        | 3 (18.8)         | 1 (33.3)         | 17 (20.0)     | 0.680   |
| Hematoma                      |             | 6 (12.5)        | 1 (5.6)         | 0 (0)            | 0 (0)            | 7 (8.2)       | 0.857   |
| VP shunt                      |             | 6 (12.5)        | 2 (11.1)        | 1 (6.3)          | 0 (0)            | 9 (10.6)      | 0.834   |

Table 5

Outcome of the 85 patients with cerebral aneurysms.

| Variables                  | n (%) | p value |
|----------------------------|-------|---------|
| VP shunt: ventriculoperitoneal shunt. | | |
of the 36 patients with left A1 dominance, 33 patients had left side A1 dominance and 16 patients had right A1 dominance. Among them, 36 patients had A1 dominance. Yasargil et al3 found that 80% of patients with AComA aneurysms. Cohen and Samson8 reported that 57% of AComA patients had left A1 dominance. Sano10 pointed out that A1 was bilaterally secured before surgery. The 3 cases which underwent surgery from the non-dominant circulation, all were antero-inferiorly directing aneurysms.

In our study, there were no statistical differences in terms of operative strategy between different projections. There was no statistical difference in complications and outcomes.
Superiorly projecting aneurysm with closed A2 plane

Higher requirement for gyrus rectus aspiration and higher incidence of residual neck remnant in closed A2 plane was observed by Suzuki et al.11 but there was no significant difference in the related vascular injury. A significant difference in contusion was observed in patients with closed A2 plane (p < 0.0092). They believe that the open A2 plane has obvious advantages in approaching the superiorly projecting AComA aneurysms.

According to Hyun et al.1 the plane of the both A2 blood vessels was more important in selecting the approach side than the dominant side of A1. It has been suggested that the spatial distribution around AComA should be determined prior to the determining the approach side for superior projecting AComA aneurysms. Ten patients (52.6%) were approached from the A2 anterior displacement side (closed A2 plane). In these 10 cases, 2 (20%) had A1 dominance on the right side and 8 (80%) had A1 dominance on the left side. The right approach was selected in 3 patients (30%), while the remaining 7 were treated from the left side (70%). For patients with closed A2 plane (9 out of 10 patients, p = 0.041), the requirement of gyrus aspiration was higher. However, according to the Glasgow outcome scale score, there was no significant correlation between the surgical approach side and the outcome.

In our study, there was no significant difference between open and closed A2 plane in terms of operative, post-operative and outcomes at the time of discharge. In addition, the development of clipping technology and the use of fenestrated clips help surgeons approach from either side.

Our study focused only on ruptured aneurysms. These aneurysms need proximal control, so the AComA aneurysms were approached from the dominant side. In literature review, the A2 posterior displacement side (open A2 plane) approach in patients with superior projecting aneurysms enables neurosurgeons to secure the neck of the aneurysm and prevent postoperative complications. On the contrary, our study, where cases were operated based on dominant circulation showed no significant correlation between open and closed A2 plane in terms of operative, post-operative complications, and outcomes.

Therefore, regardless of whether the A2 plane is open or closed, the A1 dominant side is still a better choice for accessing AComA aneurysms to avoid dangerous premature bleeding.

The limitations of our study are mainly related to small sample size, retrospective design, lack of randomization, and outcome assessment by surgical surgeons. Finally, our results are related to the single-center experience of specific surgical techniques and schemes, which limits the generalization. Only large-scale prospective studies can overcome these weaknesses.

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Ethical Statement
This study has been approved by the local ethical committee.

Declaration of Competing Interest
No benefits in any form have been received or will be received from a commercial party-related directly or indirectly with regard to this article and there are no competing interests related to this article.

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