Factors determining the best surgical exposure and safe clip positioning in surgical treatment of anterior communicating artery (AComA) aneurysms—particular significance of AComA complex rotation in the axial plane

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ABSTRACT:

Introduction: The aim of this study was to evaluate whether Anterior Communicating Artery (AComA) complex rotation in axial plane may influence the ease of surgical exploration in this region and safety of clip positioning when left vs right-sided approach is compared.

Materials and methods: This is a retrospective study based on analysis of patients operated due to AComA aneurysm, both ruptured and unruptured. AComA complex position in relation to coronal plane was evaluated using 3D-CTA VR reconstructions. Next, comparison between surgical approach from the side where A1-A2 junction (angle) was located anterior and posterior to coronal plane was performed in relation to surgical difficulties and intra- and postoperative complications.

Results: Subgroup statistical analysis revealed that there is a strong and statistically significant correlation between AComA complex rotation and surgical difficulties expressed by the need of repeated temporary clip application and brain transgression. When anterior vs posterior angle side approach was compared in relation to surgical difficulties and complications, there was a statistically significant difference with strong correlation (p < 0.05) in favour of posterior angle side approach. Interestingly, in 72.7% and 45.5% of patients that were operated from the side where A1-A2 junction was located posterior to coronal plane, the approach was performed form the side of a non-dominant A1 and aneurysm dome projection side, respectively.

Conclusions: Despite its limitations, our results suggest that microsurgical clipping strategy of AComA aneurysms should at least include AComA complex rotation in axial plane, besides well acknowledged factors, when deciding from which side these lesions will be approached.

KEYWORDS: computed tomography angiography, intracranial aneurysms, subarachnoid hemorrhage, vascular spatial orientation

ABBREVIATIONS

3D-CTA – three-dimensional computed tomography angiography
3D-DSA – three-dimensional digital subtraction angiography
ACA – Anterior Cerebral Artery
AComA – anterior communicating artery
aSAH – aneurismal subarachnoid hemorrhage
CTA – computed tomography angiography
VR – volume rendering

INTRODUCTION

The prevalence of cerebral aneurysms is estimated to be 1–3% and unruptured aneurysms appear to be identified with increasing frequency [1]. Most often these vascular abnormalities are nonsymptomatic lesions and the most common presentation is a subarachnoid hemorrhage which is a devastating form of stroke with a cumulative six months mortality of 50% [2, 3]. The distribution of aneurysms along different intracranial arteries is unequal, hence certain arteries and their segments present with aneurysms more often than others, possibly due to flow-related reasons. The AComA is one of the most common sites of intracranial aneurysms and the single, most frequent site for aneurysm rupture accounting for approximately 40% of aSAH.

Many factors should be taken into account when preparing for microsurgical exploration of the AcomA complex region, including hypothalamic perforators, numerous anatomic variants and other structures located in this region, such as olfactory and optic nerves. Although these aneurysms are preferably managed from the right side due to the preponderance of right-handedness and left hemisphere dominance for language functions, the dominancy of the A1 segment of ACA and dome projection are considered to be key factors in choosing the optimal side of approach to these vascular lesions. The position of the AComA complex in relation to the coronal plane, as a consequence of rotation in the axial plane, has been considered important in the preoperative decision-making process only by a few authors [6, 7, 10, 11]. The aim of this study was to evaluate if rotation of the AcomA complex in relation to the coronal plane may influence the ease of surgical exploration in this region and safety of clip positioning when left vs. right-sided approach is compared. Moreover, we performed virtual reconstructions of pre-operative images in order to determine if the spatial position of the AComA complex may be confirmed using CTA.

MATERIALS AND METHODS

This is a retrospective study based on an analysis of patients operated in the Department of Neurosurgery, Maria Skłodowska-Curie Hospital, Zgierz, Poland, due to AComA aneurysm, both
line that transects the body to anterior and posterior halves. For our purpose its projection in axial images was drawn between the two optic canals being a reference point when estimating any arterial rotation. To simplify our measurements, any deviation of A1-A2 junction from that line was considered as a rotation and no particular angle value between the line drawn along the AComA and coronal plane projection was considered necessary. Based on the position of this A1-A2 junction in relation to that reference point, the side of approach was called the “anterior angle side” or “posterior angle side” if that junction was located anteriorly or posteriorly, respectively (Fig. 2.).

Next, a comparison between AComA rotation, anterior angle side approach (A1-A2 junction anterior to the reference point discussed above) and posterior angle side approach were performed in relation to factors determining surgical difficulties and/or complications. These include:

- necessity of fixed brain retraction and/or temporary clip application which represents the possible difficulties in obtaining good visualization of local vascular topography (1 point each);
- brain transgression meaning the necessity of removing a small part of the brain in order to obtain better insight into the local vascular topography (2 points);
- intraoperative rupture (2 points);
- postoperative brain ischemia defined as any new focal neurological deficit encountered within the first 72 hours after surgery and confirmed in the brain CT scan (3 points).

These points were summed for each patient and as such used for further analysis on a scale of 0 to 5 points where 0 points means no surgical difficulties and 5 points meant a difficult surgical approach with postoperative complications. The results are presented in the graph (Fig. 3.).

Statistical analysis was performed using the IBM SPSS Statistics software. The correlation between surgical difficulties and/or postoperative complications represented as a scale of points (0–5) and a side of the surgical approach based on the position of the A1-A2 junction in relation to the coronal plane (anterior or posterior) was performed using Chi-Square test. Contingency tables were then designed in order to define the strength of that correlation. Similar measurements were made for rotation of the AComA complex itself and the aforementioned difficulties. A p value <0.05 was considered as statistically significant.

RESULTS

Among 52 patients, 16 had unruptured (Hunt-Hess Grade 0–30.8%) and 36 ruptured (69.2%) aneurysm. On admission, in the ruptured aneurysm group 44.4% of patients were Hunt-Hess Grade I, 11.1% of patients were Hunt-Hess Grade II, 27.8% of patients were Hunt-Hess Grade III and 16.7% of patients were Hunt-Hess Grade IV. The mean age in the ruptured and unruptured groups was 62.3 and 54.87 years, respectively (Tab. I.). In 65.4% of patients 3D-CTA models, the position of the AComA complex in relation to the coronal plane was evaluated. The coronal plane is an imaginary ruptured and unruptured during a 3-year period (2014–2017). All medical records were reviewed, including patient sex and age, initial clinical status (Hunt-Hess Grade), images, surgical reports and postoperative CT scans. Patients with a poor clinical grade (Hunt-Hess V) and those with AComA aneurysms clipped additionally during surgical management of another ruptured aneurysm were excluded from this analysis (Fig. 1.). Using CTA 3D VR models, the position of the AComA complex in relation to the coronal plane was evaluated.
the surgical difficulties encountered during surgery (phi coefficient = 0.69; Cramér’s V = 0.69; C-Pearson coefficient = 0.57; p < 0.05). When anterior vs. posterior angle side approach was compared in relation to surgical difficulties and complications, there was a statistically significant difference with a strong correlation (phi coefficient = 0.59; Cramér’s V = 0.59; C-Pearson coefficient = 0.51; p < 0.05), that was in favor of the posterior angle side approach (Fig. 3).

In other words, the patients operated from the side where the A1-A2 junction was located posteriorly in relation to the coronal plane developed brain ischemia less frequently and their surgery was easier (no brain transgression or temporary clipping required, as well as a better understanding of the local vascular anatomy resulting in less frequent intraoperative rupture due to manipulation of the aneurysm itself). These patients did not experience postoperative ischemia as opposed to those approached from the anterior angle side.

Interestingly, when these aneurysms were operated from the side where the A1-A2 junction was posterior (posterior angle side), the side of approach was contralateral to the A1 dominant segment in 72.7% (Tab. II.).

**DISCUSSION**

The final outcome of microsurgical treatment of cerebral aneurysms depends on many factors, among which we can distinguish surgeon-dependent aspects, as well as factors that are beyond our control (initial clinical status, severity of aSAH, complex vascular anatomy). These include a perfect understanding of the angioarchitecture of the aneurysm itself and its related vessels as well as obtaining an optimal surgical corridor allowing for safe microsurgical manipulation and definitive clip application. One of these important factors is also the side of approach. The selection of side of surgical approach has recently been receiving increasing attention. A list of the most important publications on this topic has been summarized in Tab. III.

Perlmutter and Rhoton were the first to describe the orientation of the AComA plane [4]. They found that AcomA is oriented in a strictly coronal plane with both A1s side by side as would be expected from anatomical descriptions in only 18% of cases. In many instances the AComA was found oriented in an oblique plane, being the left A1/A2 junction anterior to the coronal plane in 48% and fixed brain transgression as well as necessity of local brain transgression were significantly less common as compared with the anterior angle side approach.

Numerous articles have evaluated the use of 3D-CTA but only a few have specifically used the virtual evaluation by 3D-CTA of the spatial position of the AComA complex in preparation for microsurgical clipping. Futami et al. studied the simulation of clip positioning for cerebral aneurysms using 3D-CTA and concluded that this method can predict whether an aneurysm can...
be completely obliterated or will have any remnant [5]. Gonzalez-Darder and Dehdashti et al. evaluated the relevance of CTA in a preoperative simulation of surgical approach for AComA aneurysms according to the orientation of the AComA plane. They concluded that the angulation of the AComA plane along with the orientation of the aneurysm dome were critical in choosing the best side of surgical approach [6, 7].

Most of the vascular neurosurgeons recommend the right-sided approach for AComA aneurysms arguing that it is better for right-handed surgeons and most of all, that it avoids – in the majority of cases – the retraction of a dominant frontal lobe. Most authors suggest the left-sided approach only in selected cases, especially when there is a hematoma with mass effect in the left frontal lobe, the presence of an additional aneurysm on the left Internal Carotid Artery (ICA) or Middle Cerebral Artery (MCA) or a giant AComA complex aneurysm associated with left A1 dominance (in this case the aim is to obtain early proximal control and reach the neck early on) [8, 9].

The results of our retrospective study showed that the spatial orientation of the AComA plane can be easily determined using preoperative CTA 3D-VR reconstructions [Fig. 2]. Our data, although derived from a small group support the assumption that patients with rotation of the AComA complex make a distinct subgroup that is more surgically demanding in terms of understanding the local vascular topography and ease of surgical exposure. This rotation seems to be more important in planning the microsurgical approach than A1 segment dominance itself. As the position of the AComA plane indicates the ease with which the angioarchitecture of the complex will be explored and therefore the safety of clip application, we analyzed our results in relation to the position of the A1-A2 junction (anterior vs. posterior) that was located on the side of surgical approach. This analysis revealed that surgery from the side where the A1-A2 junction was situated posteriorly to the coronal plane provided a better surgical corridor; p < 0.05 (Fig. 3). Moreover, it should be outlined that the spatial disposition of the AComA complex can be accurately displayed preoperatively using 3D-CTA. 3D-DSA, which is considered to be a gold standard, is limited in showing both A1s on the same injection making the precise understanding of the AComA complex more difficult, especially with regard to the anterior and posterior displacement of the A1-A2 junctions.

Despite the limitations of this study, our results suggest that the microsurgical clipping strategy of AComA aneurysms should at least include rotation of the AComA complex, besides well-acknowledged factors, when deciding the approach to these lesions. It seems that this rotation may be more important than A1 segment dominance or aneurysm dome projection in this subgroup of patients when choosing the best surgical corridor. We demonstrated that patients with rotation of the AComA complex represent a more surgically demanding group in terms of understanding local vascular topography and ease of surgical manipulation. Therefore, we believe that the selection of side of surgical approach in patients with AComA aneurysm deserves thorough research as the number of patients in our study is too small to reach unequivocal conclusions.

REFERENCES: