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Anatomical features of aneurysms, nature of hemorrhage, severity of angiospasm, and clinical features in Patients with Ruptured Aneurysms of the AComA

The purpose of this study is to investigate the anatomical characteristics of hemorrhage and angiospasm in patients with ruptured aneurysms of the anterior connecting artery (AComA) and identify factors that may contribute to the development of these complications. The study is based on a review of medical records, imaging studies, and clinical data collected from patients with AComA aneurysms between 2008 and 2019.

The materials and methods: A total of 98 patients were included in the study, with a mean age of 47.8±11 years. The female-to-male ratio was 1.04:1. Aneurysms were verified using computer tomography of the vessels of the head and neck, selective cerebral angiography, and MRI angiography of cerebral vessels.

Results suggest that certain anatomical features of AComA aneurysms, such as size, location, and shape, may be associated with an increased risk of hemorrhage and angiospasm. Hemodynamic factors, such as blood flow velocity and turbulence, may also play a role in the development of these complications. The study highlights the importance of early diagnosis and prompt treatment of AComA aneurysms and suggests that patients with larger aneurysms or those with irregular shapes or multiple lobes may require more aggressive management strategies.

Conclusion. The findings of this study may help guide clinical decision-making and improve patient outcomes, by allowing clinicians to tailor treatment strategies to the individual patient's needs and risk profile. Further research in this area is warranted to confirm and extend these findings and to develop new approaches for preventing and managing these potentially life-threatening complications.

Key words anterior communicating artery, aneurysm, hemorrhage, angiospasm, subarachnoid hemorrhage, neurosurgery, hemodynamics, treatment, management, risk factors, imaging, diagnosis, clinical data.

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Анатомічні особливості аневризм, характер крововиливу, вираженість ангіоспазму і особливості клініки у хворих з розривом аневризм ПСА

Мета. Дослідити анатомічні характеристики крововиливу та ангіоспазму у пацієнтів із розривом аневризми передньої сполучної артерії (ПСА) та визначити фактори, які можуть сприяти розвитку цих ускладнень.

Матеріали і методи. 98 пацієнтів, середній вік яких 47.8±11 років, а співвідношення жінки-чоловіки склало 1.04:1. Аневризми верифікувалися за допомогою комп'ютерної томографії судин голови та шиї, селективної церебральної ангіографії, МРТ-ангіографії судин головного мозку.

Результати і обговорення. Отримані в ході дослідження дані свідчать про те, що певні анатомічні особливості аневризм ПСА, такі як розмір, розташування та форма, можуть бути пов'язані з підвищеним ризиком кровотечі та ангіоспазму. Гемодинамічні фактори, такі як швидкість кровотоку та турбулентність, також можуть відігравати роль у розвитку цих ускладнень. Дослідження засвідчує важливість ранньої діагностики та швидкого лікування аневризм ПСА та припускає, що пацієнти з більшими аневризмами або аневризмами неправильної форми чи кількома часточками можуть потребувати більш агресивних стратегій лікування.

Висновки. Результати цього дослідження можуть допомогти у прийнятті клінічних рішень і покращити результати лікування пацієнтів, дозволяючи клініцистам пристосовувати стратегії лікування до потреб кожного пацієнта та профілю ризику. Необхідні подальші дослідження в цій галузі, щоб підтвердити та розширити ці висновки та розробити нові підходи до запобігання та лікування цих потенційно небезпечних для життя ускладнень.

Ключові слова: передня сполучна артерія, аневризма, крововилив, ангіоспазм, субарахноїдальний крововилив, нейрохірургія, гемодинаміка, лікування, лікування, фактори ризику, візуалізація, діагностика, клінічні дані.

Introduction. Ruptured aneurysms of the AComA are a common cause of subarachnoid hemorrhage (SAH), a condition that can have devastating neurological consequences. SAH remains a significant cause of morbidity and mortality worldwide, despite advances in diagnosis and management. Understanding the anatomical characteristics associated with hemorrhage and complications such as cerebral vasospasm is crucial for improving outcomes in patients with ruptured AComA aneurysms [1]. By investigating these characteristics, the research aims to contribute to the understanding of the underlying mechanisms and potentially identify new strategies for intervention and prevention.

The uniqueness of this research lies in its specific focus on the anatomical characteristics of hemorrhage and angiospasm in patients with ruptured AComA aneurysms. While previous studies have explored various aspects of SAH and cerebral vasospasm, this research narrows down its investigation to the AComA region, which has its own anatomical complexities and clinical implications. By focusing on this specific subset of aneurysms, the study aims to provide a more detailed and targeted analysis, potentially uncovering unique characteristics or patterns that could help refine treatment strategies for these specific aneurysms. The study's findings may contribute to the existing body of knowledge in neurology, neurosurgery, and vascular medicine, offering new insights into the pathophysiology of AComA aneurysms and their associated complications.

The purpose of this study is to investigate the anatomical characteristics of hemorrhage and angiospasm in patients with ruptured aneurysms of the anterior connecting artery (AComA) and to identify factors that may contribute to the development of these complications. The study aims to provide a better understanding of the pathophysiology of subarachnoid hemorrhage (SAH) and associated complications in patients with AComA aneurysms, which could potentially inform the management and treatment of these patients. The study may also aim to identify potential predictors of hemorrhage and angiospasm in patients with AComA aneurysms, which could help guide clinical decision-making and improve patient outcomes.

The materials used include medical records, imaging studies (such as computed tomography [CT] scans, magnetic resonance imaging [MRI], and angiography), and clinical data collected from 98 patients with ruptured AComA aneurysms between 2008 and 2019 at at the Uzhgorod Regional Center of Neurosurgery and Neurology and the "MLE and ShMD" KNP of the Zaporizhzhia City Council.

This study adhered to ethical guidelines and involved human subjects. Prior to its commencement, the study protocol was reviewed and approved by the local bioethics committee. The research procedures were conducted in strict accordance with the principles outlined in the Helsinki Declaration of Human Rights. Written informed consent was obtained from all participating patients. In cases where patients were unable to provide consent due to incapacitation, consent was obtained from their relatives who had the authority to make decisions on their behalf. The ethical considerations and informed consent process ensured the protection and welfare of the study participants throughout the research.

Inclusion and Exclusion Criteria for the Study on AComA Aneurysms. In this study, we established specific inclusion and exclusion criteria to ensure the selection of appropriate participants and to maintain consistency in the analysis. The following were the inclusion criteria:

Diagnosis: Participants must have been diagnosed with an AComA (Anterior Communicating Artery) aneurysm based on preoperative digital subtraction angiography (DSA).

Aneurysm Neck Height: The aneurysm must have had a neck height greater than 10 mm from the level of the anterior clinoid process, as determined by sagittal T2-weighted brain images or sagittal brain images reconstructed using preoperative computed tomography angiography (CTA).

Aneurysm Dome Height: The aneurysm must have had a dome height greater than 15 mm from the level of the anterior clinoid process.

Aneurysm Dome Projection: The aneurysm must have projected in an anterior, superior, and posterior direction.

Treatment Method: Participants must have undergone surgical clipping of the aneurysm using either a pterional approach or interhemispheric approach.

Evaluation: The postoperative clipping state must have been assessed based on postoperative CTA.

The following was the exclusion criterion:

A high-positioned ACoA (Anterior Cerebral Artery) aneurysm treated by endovascular coiling was excluded from the study.

Treatment Decision:

The decision regarding the treatment method, surgical clipping or endovascular coiling, was based on catheter angiography. Surgical treatment was preferred over endovascular treatment in the following situations:

Wide-necked aneurysm requiring stent-assisted technology.

Aneurysm with an arterial branch incorporated into the sac.

Difficulty in navigating the microcatheter into the aneurysm, provided that the patient had no comorbidity or hemostasis-related issues. The study has also used specialized tools and techniques to measure and analyze hemodynamic factors, such as transcranial Doppler ultrasound, in order to assess the risk of hemorrhage and angiospasm in these patients. The specific materials and methods used in the study depend on the research questions and hypotheses being investigated.

Methods. In this study, we performed a comprehensive analysis of patients who underwent surgical treatment for ruptured anterior communicating artery (AComA) aneurysms at our institutions between January 2008 and December 2019. Our data collection encompassed demographic information, clinical presentation, radiological findings, and surgical outcomes. To gain a thorough understanding of the anatomical characteristics, we assessed various parameters such as aneurysm location, size, neck width, and dome shape using preoperative angiography and intraoperative observation. Furthermore, we evaluated the extent of hemorrhage and cerebral vasospasm through computed tomography (CT) scans and transcranial Doppler (TCD)

ultrasonography. By incorporating these comprehensive assessments, our study provides valuable insights into the surgical management and outcomes of patients with ruptured AComA aneurysms, aiding in advancing the understanding and treatment of this condition.

To verify aneurysms, multiple imaging techniques were employed including tomography of the head and neck vessels using a Toshiba "Astelion" CT scanner manufactured in 2016 with a serial number of 4CC162106, selective cerebral angiography using an Optima IGS 330 angiography unit manufactured in 2019 with a serial number of 80071260314, and MRI angiography of cerebral vessels using an i_Open 0.36 T scanner manufactured in 2005 with a serial number of Toc102633006. Transcranial dopplerography was also used to study cerebral hemodynamics using a Philips HD7 ultrasound diagnostic system manufactured in 2014 with a serial number of 69935. Statistical data processing was performed using the R statistical program package (version 4.0.0) distributed under the GNU General Public License 3, as well as the Microsoft Office Excel 2007 program.

Results. A total of 98 patients were included in the study, with a mean age of **47,8±11** years. The female-to-male ratio was 1.04:1.

The aneurysms were classified into four categories: medium size (6-15 mm), small size (up to 6 mm), large size (15-25 mm) and giant size (more than 25 mm). Of the 98 patients, 44 (44.9%) had aneurysms of medium size, 38 (38.8%) had small size aneurysms, 15 (15.3%) had large size aneurysms and one (1%) had a giant size aneurysm. 75 (76.5%) of the patients had aneurysm neck and 23 (23.5%) did not.

The direction of the dome was classified according to the classification of M.G. Yasargil 1984, which includes the following categories: anterior, posterior, superior, inferior, and mixed projection. The direction of the dome of the aneurysms was as follows: anterior – 20 (20.4%), posterior – 22 (22.4%), superior – 30 (30.6%), inferior – 17 (17.3%), and mixed projection – 9 (9.2%).

Among these aneurysms, 19 (19.4%) were multichambered, while 79 (80.6%) were single-chambered. All aneurysms were saccular in shape.

Additionally, 28 (28.6%) patients had aneurysms of other cerebral arteries in addition to the aneurysm of the anterior connecting artery. Of these, 23 (82.1%) had two aneurysms, 4 (14.3%) had three aneurysms, and 1 (3.6%) patient had four aneurysms.

Based on angiographic examination, the study investigated the possibilities of combining AComA aneurysms with aneurysms located in other areas of the brain vessels. (*Table 1*).

Angiospasm occurred in 59 (60.2%) patients, of which 22 (37.3%) had widespread angiospasm. Hemorrhage occurred in 28 (28.6%) patients, and in 38 (38.8%) patients, aneurysm rupture was accompanied by the formation of an intracerebral hematoma or SAH.

In patients with ruptured AComA arterial aneurysms, the nature of subarachnoid hemorrhage was assessed at admission to the hospital using brain computed tomography, which was performed in 95 patients. The severity of subarachnoid hemorrhage was determined using the Fisher Grading Scale (Fisher Grading Scale, 1980). Based on the CT results, it was established that 9 (9.47%) patients had Grade I subarachnoid hemorrhage according to the Fisher Grading Scale, 33 (34.74%) had Grade II, 18 (18.95%) had Grade III, and 38 (40%) had Grade IV.

The types of intracranial hemorrhages according to Fisher's classification are illustrated in Figures 1–4.

Blood is observed in the prechiasmal cistern, as well as around the brain stem and lateral sulci. The blood clots have a thickness greater than 1 mm.

The presence of blood in the subarachnoid space surrounding the cerebral gyrus and lateral sulcus is detected bilaterally. The blood clots have a thickness less than 1 mm.

An intracerebral hematoma is identified in the right frontal lobe of the brain, causing slight displacement of the midline structures.

Hemorrhage is observed in both the subarachnoid space and the body and lateral horns of the right lateral ventricle.

Intracerebral hematoma was detected in 30 out of 98 patients (30.6%). The most common location was in the frontal lobes, found in 26 cases (87.7%), followed by the corpus callosum in 3 cases (9.1%), and/or transparent membrane in 2 cases (6.7%). The volume of the hematoma ranged from 1 to 77 cm^3 (average 24.0 ± 17.4 cm^3), with most patients (21 out of 30, or 71.0%) having a hematoma volume of less than 10 cm^3.

Of the patients with a ruptured AComA aneurysm, 61% were admitted in a clear state of consciousness, while only 2% were comatose. However, the presence and size of an intracerebral hematoma, severity of intraventricular hemorrhage (if present), and prevalence of angiospasm were factors that affected the level of consciousness. Patients in a coma or sopor often had subarachnoid hemorrhage

Table 1

Options for combining multiple aneurysms

Options for combining aneurysms	Number of patients	Number of aneurysms
AComA + right MCA	10	2
AComA + left MCA	8	2
AComA + right ICA	1	2
AComA + left ICA	3	2
AComA + 2 MCA	2	3
AComA + ICA+ 2 MCA	1	4
ACA + right ICA	1	2
ACA + left ICA	1	2

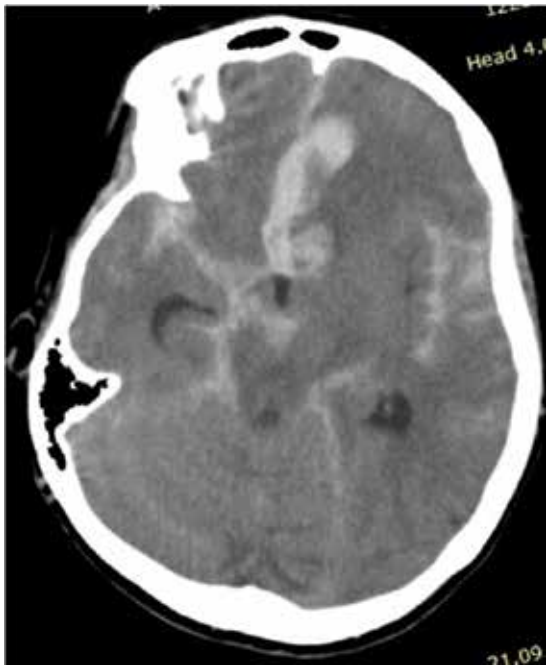

Fig. 1. An axial projection computed tomography of the brain revealing subarachnoid hemorrhage resulting from AComA rupture

Fig. 2. Computed tomography of the brain. Axial projection. Subarachnoid hemorrhage in AComA rupture

Fig. 3. Computed tomography of the brain. Axial projection. Subarachnoid hemorrhage and intracerebral hematoma in AComA rupture

Fig. 4. Computed tomography of the brain. Axial projection. Subarachnoid hemorrhage and intraventricular hemorrhage in AComA rupture

complicated by intracerebral hematoma, intraventricular hemorrhage, and pronounced angiospasm. In conscious patients, angiospasm was only observed in 88% of cases, while 50% of patients with impaired consciousness up to sopor or coma had pronounced angiospasm.

To evaluate the severity of subarachnoid hemorrhage in patients upon admission, the Hunt-Hess scale was used. The evaluation showed that 30 patients (30.6%) were classified as grade 1, 38 patients (38.8%) as grade 2, 20 patients (20.4%) as grade 3, 8 patients (8.2%) as grade 4, and 2 patients (2.0%) as grade 5.

Discussion. The present study contributes valuable insights into the anatomical characteristics of hemorrhage and angiospasm in patients with ruptured anterior

connecting artery (AComA) aneurysms. Our findings highlight the association between certain anatomical features of AComA aneurysms and an increased risk of these complications. These results align with previous studies that have identified similar risk factors for AComA aneurysm rupture and associated complications [1–3].

Our study reveals that medium-sized aneurysms are the most common in patients with AComA aneurysm rupture, while small and large-sized aneurysms are also prevalent in this patient population, consistent with previous research [4, 5]. Clinicians should consider aneurysm size when determining the appropriate treatment approach for these patients.

Furthermore, we observed that the majority of patients with AComA aneurysm rupture have aneurysms with a neck, although a significant proportion of patients have aneurysms without a neck. This factor should be carefully considered when determining the optimal treatment strategy.

The direction of the aneurysm dome was found to vary widely in patients with AComA aneurysm rupture, with superior being the most common direction, followed by posterior and anterior. Evaluating the dome direction is crucial for selecting an appropriate treatment approach.

Additionally, our study revealed that a significant proportion of patients with AComA aneurysm rupture have multiple cerebral artery aneurysms [6]. Therefore, it is important for clinicians to thoroughly evaluate the presence of other cerebral artery aneurysms when planning treatment [7, 8]. This emphasizes the need for a comprehensive assessment of all cerebral arteries in patients with a ruptured AComA aneurysm.

Early diagnosis and prompt treatment of AComA aneurysms are crucial, as treatment delays may increase the risk of hemorrhage and associated complications. Larger aneurysms or those with irregular shapes or multiple lobes may require more aggressive management strategies, such as microsurgical clipping, to mitigate the risk of rupture and minimize the likelihood of hemorrhage and angiospasm [9–12].

Overall, our study sheds light on the pathophysiology and management of subarachnoid hemorrhage (SAH) and associated complications in patients with AComA aneurysms, aligning with prior research [13–15]. The identification of specific anatomical and hemodynamic risk factors for hemorrhage and angiospasm can inform clinical decision-making and improve patient outcomes by enabling personalized treatment strategies based on individual needs and risk profiles [16].

Conclusions:

1. The majority of patients in this study had medium-sized AComA aneurysms, followed by small, large, and giant-sized aneurysms. The direction of the aneurysm dome varied, with anterior, posterior, superior, inferior, and mixed projections observed.

2. Multichambered aneurysms were found in 19.4% of cases, while single-chambered, saccular-shaped aneurysms were more prevalent (80.6%).

3. Approximately one-third of the patients had aneurysms in other cerebral arteries in addition to the AComA aneurysm, most commonly with two additional aneurysms present.

4. Angiospasm was a common occurrence in patients with AComA aneurysms, affecting 60.2% of individuals. Widespread angiospasm was observed in a significant proportion of these cases.

5. Hemorrhage occurred in 28.6% of patients, with aneurysm rupture often accompanied by the formation of an intracerebral hematoma or subarachnoid hemorrhage (SAH).

6. The severity of SAH, as determined by the Fisher Grading Scale, varied among patients, with Grade II and Grade IV being the most common grades.

7. Intracerebral hematomas were present in 30.6% of patients, primarily located in the frontal lobes. Most hematomas had a volume of less than 10 cm^3.

8. The level of consciousness upon admission was influenced by factors such as the presence and size of an intracerebral hematoma, severity of intraventricular hemorrhage (if present), and the prevalence of angiospasm.

Further research and investigation are needed to validate these findings and explore effective strategies for preventing and managing complications associated with AComA aneurysms.

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