FOLIA MEDICA CRACOVIENSIA
Vol. LIV, 1, 2014: 13–20
PL ISSN 0015-5616

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VARIATIONS OF THE ANTERIOR COMMUNICATING ARTERY COMPLEX AND OCCURRENCE OF ANTERIOR COMMUNICATING ARTERY ANEURYSM: A2 SEGMENT CONSIDERATION

Abstract: Introduction: The anterior communicating artery (ACoA) is the most frequent site of intracranial aneurysm location. Despite many studies the frequency of aneurysm occurrence with anatomical anomalies is still poorly described. Moreover the significance of the A2 segment of anterior cerebral artery anomalies has been neglected. The aim of this study was to determine the frequency and types of variations of the anterior cerebral circulation in patients with ACoA aneurysms and to analyze their relation to aneurysm occurrence in the Polish population.
Materials and Methods: We studied 50 patients with an established radiological diagnosis of ACoA aneurysm and 100 healthy age- and sex-matched controls using Computed Tomgraphy Angiography. Maximum Intensity and Volume Rendering Projections were used to examine the cerebral arterial circulation. Univariate logistic regression was used to determine the statistical association between ACoA complex anomalies and aneurysm occurrence.
Results: Patients in the study group had a significantly higher incidence of hypoplastic A1 segment of the anterior cerebral artery (24% vs. 7%; $p < 0.01$) and aplastic A1 segment of the anterior cerebral artery (12% vs. 3%; $p = 0.03$). The frequency of A1 segment hypoplasia or aplasia in the study group was 36%. There was a statistical trend regarding A2 segment aplasia/hypoplasia as a potential predictor of ACoA aneurysm (6% vs. 1%; $p = 0.07$).
Conclusion: Occurrence of an ACoA aneurysm is associated with hypoplasia or aplasia of the A1 segment of the anterior cerebral artery. A2 segment anomalies may potentially be associated with aneurysm formation.

Key words: anterior communicating artery complex, anterior communicating artery aneurysm, cerebrovascular anatom.

INTRODUCTION

Many risk factors for aneurysm formation including cigarette smoking, heavy alcohol and drug consumption, as well as hypertension have been described [1, 2]. It is believed that initiation and growth of an aneurysm is related to hemodynamic force, vascular wall sheer stress and arterial wall biology resulting in a focal damage of the wall [3].

The anterior communicating artery (ACoA) is established as the most frequent site of intracranial aneurysm location. In major studies ACoA aneurysm contribute 20–22.8% of all intracranial aneurysms [4, 5]. Significant anatomical diversity in anterior cerebral circulation [6–10] may promote stronger hemodynamic changes therefore facilitate the formation of an aneurysm. Anomalies include aplasia or hypoplasia of the A1 or the A2 segment of the anterior cerebral artery (ACA) fenestration or duplications of the aforementioned segments. Recent studies using computational fluid dynamics modeling showed significant flow-dependant alterations in formation of ACoA aneurysm [11]. Moreover Castro *et al.* [12] found an association between an asymmetric A1 artery blood inflow, ACoA aneurysm formation and rupture. The significance of asymmetric flow as a mechanism of aneurysm formation was well described in animal models. Hashimoto *et al.* [13] developed an experimental model of ACoA aneurysm formation by unilateral or bilateral carotid ligation in hypertensive rats, causing hemodynamic stress. Arterial wall sheer stress can lead to activation of numerous molecular mechanism including nitric oxide synthase [14] and apoptosis of smooth muscle cells in the arterial wall [15] — leading to aneurysm formation. In addition similar alterations can be provided by anatomical variations in humans.

Many studies described A1 ACA segment anomalies as a variant most commonly accompanying ACoA aneurysm. Its frequency ranges from 41.33% up to 50% [16–19]. All of the mentioned studies were performed on non-caucasian populations. The study by Bazowski *et al.* [20] established anomaly frequency of anterior communicating artery complexes bearing aneurysm at 37.7%. Charbal *et al.* [21] found a statistically significant association between a dominant A1 segment of the ACA and ACoA aneurysm using angiography. Data describing frequency and characteristics of the ACoA complex in relation to the A2 segment of the ACA seems to be incomplete.

The aim of our study was to determine the frequency of anatomical variations of the ACoA complex in ACoA aneurysm patients and establish whether a correlation existed between specific variations and aneurysm occurrence.

MATERIALS AND METHODS

The study group consisted of 50 patients undergoing head Computed Tomography Angiography (CTA) in the Department of Radiology (Jagiellonian University Medical College) with an established radiological diagnosis of ACoA aneurysm. Patients with co-existing intracranial pathologies (neoplasm, hematoma, arterio-venous malformation or other congenital malformations) or the presence of cerebral vasospasm were excluded from the study. Low quality images or images with imaging artifacts were also excluded.

The control group consisted of 100 sex and age (± 3 years) matched patients with no radiological signs of intracranial pathology. Medical indications for CTA

of patients recruited to control group were mild head trauma or viscerocranial pathology.

The protocol of the study has been approved by the Jagiellonian University Bioethics Committee (registry number: KBET/299/B2012).

IMAGING AND ANALYSIS

Images were acquired using a multi-row Computed Tomograph (Somatom Sensation 16; Siemens AG, Germany) using the following study parameters — exposure: 120 kV, 74 mA, 120 mAs; rotation time: 0.75; slice thickness: 3mm; pitch: 1.5. Patients were injected intravenously with an iodine contrast medium (Ultravist, Bayer, Germany) to achieve angiographic images. The collected date were transferred to a workstation equipped with eFilm 3.4 Software (Merge Healthcare, USA). Maximum intensity (MIP) and Volume Rendering (VR) reconstructions were examined in three planes — coronal, sagittal and transverse. We carefully examined each part of the ACoA complex and measured the internal diameter of each artery.

Arterial segments that were less than 1 mm in diameter were classified as hypoplastic. All images were carefully studied by two independent examiners. If a difference in opinion on particular patients occurred, the patient was examined jointly by both researchers until consensus was achieved.

ANTERIOR COMMUNICATING ARTERY COMPLEX CLASSIFICATION

We categorized the observed ACoA complex variations into 9 following types: A — typical configuration, B — hypoplastic ACoA, C — AcoA aplasia, D — unilateral hypoplasia of the A1 segment of the anterior cerebral artery (ACA), E — unilateral aplasia of the A1 segment of the ACA, F — hypoplasia of the A1 segment and contralateral A2 segment of ACA, G — hypoplasia of the unilateral A1 and A2 segments, H — unilateral hypoplasia of the A2 segment, I — unilateral aplasia of the A2 segment of ACA.

STATISTICAL ANALYSIS

Elements of descriptive statistics were used (mean, standard deviation, percentage distribution). We used the χ^2 Pearson's test to compare proportions and the Students t-test to compare continuous variables. We obtained adjusted odds ratios (OR) using univariate logistic regression. P-values of less than 0.05 were considered to indicate statistical significance. The analysis was performed using STATISTICA 10.0 (Statsoft).

RESULTS

The study group consisted of 25 males and 25 females (mean age ± SD 53.66 ± 14.01). The control group included 100 age- (mean age ± SD 53.47 ± 14.48) ($p = 0.94$) and gender-matched patients.

The study group had a lower incidence of a typical ACoA complex anatomy and a higher frequency of hypoplastic or aplastic arteries (36% vs. 9%; $p < 0.01$) (Fig. 1). We found a strong statistical association between unilateral A1 ACA segment hypoplasia and the presence of an ACoA aneurysm (24% vs 7%; $p < 0.01$). There was no association between A2 ACA segment hypoplasia or aplasia and the presence of an aneurysm. When A2 segment hypoplasia and aplasia groups were merged a statistical trend ($p < 0.1$) was observed (Table 1) towards ACoA aneurysm formation.

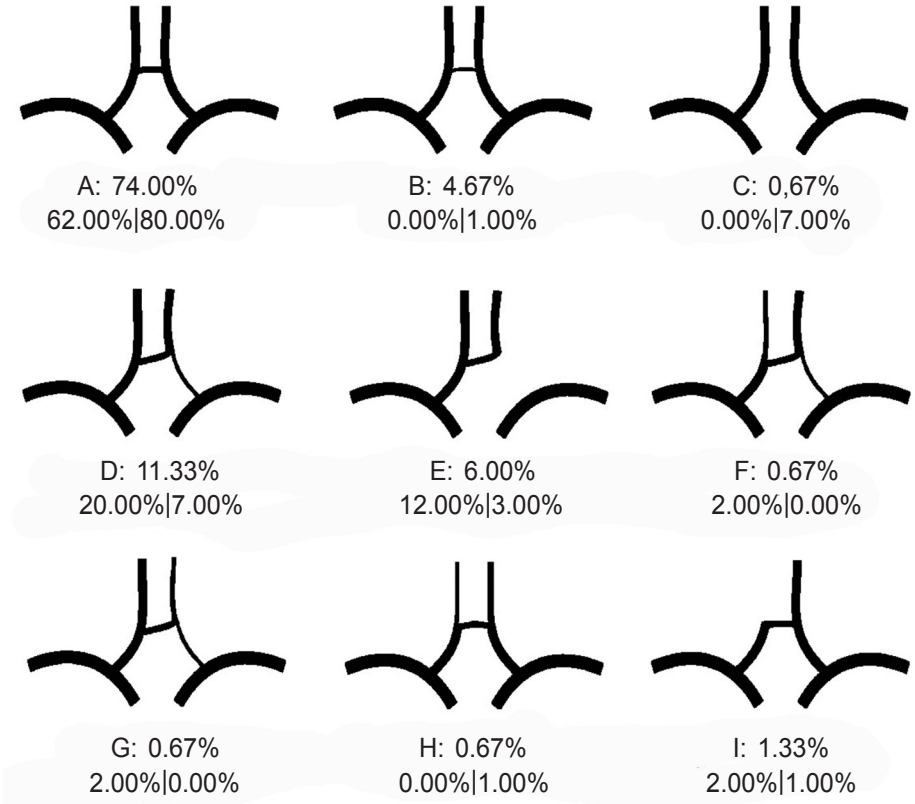

Fig. 1. Distribution of anterior communicating artery complex variants in the study population (upper index) and the studied groups (lower index).
Study group | Control group.

Table 1

Basic demographic data and odds rations indicating the risk of ACoA aneurysm formation connected with specific anatomical ACA variants.

	Study group	Control group			
	n = 50	n = 100	OR	95% CI	p-value
Age Age, mean (SD)	53.66 (14.01)	53.47 (14.48)	0.99	0.98–1.02	0.94
Female, n (%)	25 (50)	50 (50)	1.00	0.50–1.98	1.00
Hipoplastic A1 segment, n (%)	12 (24)	7 (7)	0.24	0.09–0.66	<0.01
Hipoplastic A2 segment, n (%)	2 (4)	1 (1)	0.24	0.05–0.96	0.22
Aplastic A1 segment, n (%)	6 (12)	3 (3)	0.23	0.05–0.96	0.03
Aplastic A2 segment, n (%)	1 (2)	1 (1)	0.49	0.03–8.27	0.62
Aplastic or Hipoplastic A1, n (%)	18 (36)	9 (9)	0.19	0.08–0.48	<0.01
Aplastic or Hipoplastic A2, n (%)	3 (6)	1 (1)	0.15	0.02–1.59	0.07

p — value of comparison between groups, OR — Odds Ratio, CI — Confidence Interval, SD — Standard Deviation.

DISCUSSION

The aim of the present study was to determine the frequency of anatomical variations of the ACoA complex in ACoA aneurysm patients and establish whether a correlation existed between specific variations and aneurysm occurrence.

In this case-control study we observed an association between ACoA complex anatomical variations and the occurrence of an ACoA aneurysm. Most significant relations were seen in the case of an anomalous A1 ACA segment. Moreover, an association between A2 ACA segment variations and aneurysm formation was also seen. Only 62% of aneurysm bearing arteries were accompanied by a typical variant of the ACoA complex.

The frequency of A1 segment anomalies in our study was 36%. In a similar study on the Polish population, the established frequency of A1 segment anomalies in aneurysm patients was 37.7% [7]. Other studies (Table 2) show a similar distribution of variations in the anterior cerebral circulation in patients with ACoA aneurysm. Although a higher incidence of aplastic arteries is observed. This may result from various definitions, methods and confounding factors. It is worth noting that Eftekhar *et al.* [22] found no significant differences in the distribution of cerebral arterial anomalies in different populations.

Our study also indicates that A2 segment anomalies might be associated with aneurysm formation. Only one mentioned study [19] included the A2 segment

Table 2

Comparison of obtained results with selected literature data.

	This study		Agayev *et al.*		Charbal *et al.*		Kauya *et al.*	
Patients group	Study	Control	Study	Control	Study	Control	Study	Control
Number of subjects	50	100	75	107	51	50	42	21
Study method	CTA		DSA		DSA		CTA	
Hypoplastic A1, %	24.00	7.00	21.33	8.41	24.00	6.00	11.90	4.76
Aplastic A1, %	12.00	3.00	20.00	1.86	30.00	8.00	33.33	4.76
Hypo- or aplastic A1, %	32.00	9.00	41.33	10.28	54.00	14.00	45.23	9.52
Hypoplastic A2, %	4.00	1.00	–	–	–	–	–	–
Aplastic A2, %	2.00	1.00	–	–	–	–	–	–
Hypo- or aplastic A2, %	6.00	2.00	–	–	–	–	–	–

into analysis and found that a decreased angel between the A1 and A2 segments is associated with the presence of an aneurysm. De Gast *et al.* [23] described associations between ACoA fenestration and occurrence of an aneurysm. Intracranial artery fenestration is a rare finding and in the present study we have not observed any arterial fenestrations. Intracranial arterial fenestrations may by more prevalent in the posterior part of the cerebral circulation [24, 25].

Concluding, in this study we confirmed the relation between A1 segment hypoplasia/aplasia and the occurrence of ACoA aneurysm. There was a considerable difference in the frequency of variations between our study and other populations. We also point towards the probable relevance between A2 segment hypoplasia/aplasia and ACoA aneurysm occurrence. It is possible that the statistical significance of this finding was not confirmed in this study due to a relatively small study population.

AUTHOR CONTRIBUTION

Michał Kłosiński was involved in study design, material acquisition, specimen preparation, analysis and interpretation of data and revision of the manuscript.

Krzysztof A. Tomaszewski was involved in study design, analysis and interpretation of data, drafting and revision of the manuscript.

Andrzej Wróbel was involved in specimen preparation and analysis and interpretation of data.

Krzysztof Piech was involved in searching bibliographic databases, analysis and interpretation of data and revision of the manuscript.

Janusz Skrzat was involved in study design, analysis and interpretation of data and obtaining funding.

Piotr Kłosiński was involved in material acquisition and specimen preparation.

Jerzy A. Walocha was involved in study design, analysis and interpretation of data and critical revision of the manuscript.

All authors approved the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest or financial relationship to disclose.

STUDY FUNDING

This study was not funded.

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