Clinical Neurology and Neurosurgery 152 (2017) 78–83

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Description of the anterior cerebral artery and its cortical branches: Variation in presence, origin, and size

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ARTICLE INFO

Article history:
Received 2 November 2016
Received in revised form
29 November 2016
Accepted 30 November 2016
Available online 2 December 2016

Keywords:
Absence
Callosomarginal artery
Duplication
Internal frontal artery
Internal parietal artery
Triplication

ABSTRACT

Objective: Certain aspects of the anterior cerebral artery (ACA) cortical branches tend to vary, including absent or additional arteries, variation in origin, and changes to diameter and length. Knowledge of these factors can be crucial in aneurysm and arteriovenous malformation surgery. Few studies report on these aspects and a South African study have not been completed. Therefore, the aim of this study is to report absent or additional arteries, the origin, diameter and length of ACA cortical branches in a Western Cape population.

Methods: A coloured silicone was injected into the ACA of 121 hemispheres (60 right, 61 left), consisting of 83 males and 38 females. Specimens were divided in groups younger than 34 (n = 36), between 35 and 48 (n = 35), older than 49 (n = 40), and unknown (n = 10). There were three population groups; coloured (n = 72), black (n = 37), white (n = 10), and unknown (n = 2). Any absent or additional arteries were noted, as well as the origins. External diameter and lengths were measured using a digital micrometre, string and a ruler.

Results: The diameter and lengths indicated significant differences between right and left, sex, age and population groups. Most commonly absent (callosomarginal artery) and additional (paracentral lobule artery) arteries were noted. Origins were similar to the literature; however, previously unreported origins and common trunks were also observed.

Conclusion: The aspects reported have been neglected in previous work and neurosurgeons should be aware of these variations and anomalies to avoid complications. Studies should continue to assess the cerebral vasculature since undocumented variations are still being reported.

1. Introduction

The anterior cerebral artery (ACA) supplies the medial hemisphere and its cortical branches include the infra-orbital artery (IfO), frontopolar artery (FpA), anterior internal frontal artery (AIFA), middle internal frontal artery (MIFA), posterior internal frontal artery (PIFA), callosomarginal artery (CmA), paracentral lobule artery (PLA), superior internal parietal artery (SIPA) and inferior internal parietal artery (IIPA). Certain aspects of these cortical branches tend to vary. This includes absent or additional arteries, variation in origin, and changes to the diameter and length. Knowledge of these aspects can be crucial in aneurysm and arteriovenous malformation surgery [1].

A detailed review of previous literature on the ACA and its cortical branches was recently published [2]. Unfortunately, there is still certain aspects studies do not report on. Studies generally mention the prevalence of absent and duplicated cortical branches and if cortical arteries arise from the A2, A3, A4 and A5 segments of the ACA. Few studies, however, mention when cortical branches arise with an atypical origin, from another cortical branch, or as common trunks. The diameter and length of the cortical branches varies and have not been adequately reported, particularly, information on differences between the right and left side, sex, age and population groups. None of these aspects of the ACA cortical branches have been studied on a large sample from a South African population. Therefore, the aim of this study is to report absent or additional arteries, the origin, and the diameter and length of the ACA cortical branches in a Western Cape population.

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http://dx.doi.org/10.1016/j.clineuro.2016.11.024
0303-8467/

2. Materials and methods

2.1. Population specifics

During 2014 and 2015, a hundred and twenty-one embalmed hemispheres were selected (60 right, 61 left), consisting of 83 males and 38 females. Age groups were divided into younger than 34 (n = 36), between 35 and 48 (n = 35), older than 49 (n = 40) and unknown (n = 10). Ages ranged between 22 and 75 (average 45). Specimens were distributed over three population groups, namely, coloured (n = 72), black (n = 37), white (n = 10) and unknown (n = 2). The cause of death was unrelated to brain trauma and exclusion criteria included degraded (due to an extended period between death and embalming) or damaged (during removal) hemispheres.

2.2. Methods

Ethical clearance was obtained from the Health Research Ethics Committee (HREC). Isotonic saline was injected into the ACA to remove blood or blood clots, followed by injection of a coloured silicone (MM922 Silicone, ACC Silicone Concepts). Specimens were stored in 10% buffered formaldehyde for at least two weeks before the arteries were dissected. Thereafter, each cortical branch was identified, and any absent, duplicated or triplicated arteries were noted. Origins of the cortical branches were noted and any common trunks or unusual origins were reported. The external diameter was measured at the origin of the branch using a digital micrometre. Lengths were measured from the origin of the branch to the anterior communicating artery (AcoA), using string and a ruler.

2.3. Statistics

The diameter and lengths of the cortical arteries were compared using Mixed-effects REML regression. Statistical analysis was performed using Statistica® Version 12.0 (StatSoft Inc. 2014, USA).

3. Results

Cortical branches could exhibit variation in the form of complete absence, duplication or triplication, variation in the origin, and changes in diameter and length. Each aspect is described separately. The presence, duplication, triplication and origins of the ACA cortical arteries are tabulated in Table 1.

3.1. Absence duplication and triplication

The cortical branches could either be completely absent, or present as one, two or three branches. The CmA (87.6%) and IFA (70.2%), were most commonly absent, the paracentral lobule artery (31.4%) most commonly duplicated, and the paracentral lobule artery (0.8%), and IIPA (0.8%) were the only triplicated arteries.

3.2. Origins

3.2.1. Most common origins

The most common origins are illustrated in Fig. 1. However, this particular configuration was not observed in the present study. Cortical branches that usually arose from the A2 segment included the IfO and frontopolar artery, and the CmA and frontal arteries typically originated from the A3 segment. The PLA mostly originated from the A4 segment, and the SIPA from the A5 segment. The IIPA originated almost equally from the posterior cerebral artery (PCA) and A5 segment.

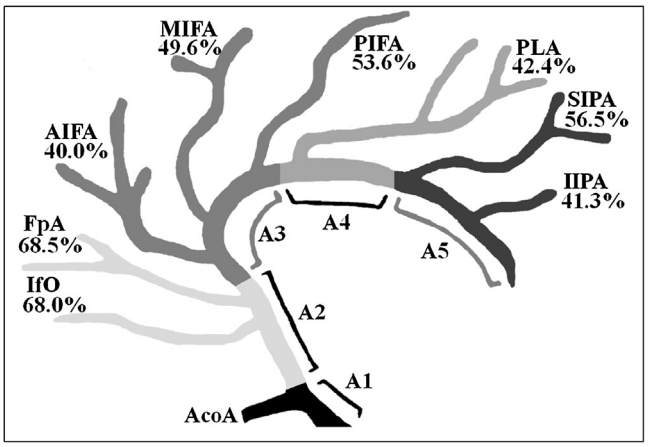

Fig. 1. The most common origins of the anterior cerebral cortical branches. (AIFA) Anterior internal frontal artery; (FpA) Frontopolar artery; (IfO) Infra-orbital artery; (IIPA) Inferior internal parietal artery; (MIFA) Middle internal frontal artery; (PIFA) Posterior internal frontal artery; (PLA) Paracentral lobule artery; and (SIPA) Superior internal parietal artery.

3.2.2. Origin from another cortical branch

Cortical branches can originate from another cortical branch. This type of origins was most commonly seen in the IfO and FpA. The infra-orbital artery originated from the FpA (12.0%) and from the AIFA (12.0%), and the frontopolar artery arose from the AIFA (11.0%) and from the MIFA (9.6%). Other cortical branches could also arise from a preceding or succeeding cortical branch (Table 1).

3.2.3. Common trunks

Two cortical branches can originate with a common trunk that divides into two equal sized arteries. The infra-orbital artery and FpA arose with a common trunk in 11 cases. These trunks originated from the A2 segment (seven cases), AIFA (two cases), A3 segment (one case) and the callosomarginal artery (one case). The frontopolar artery and AIFA arose with a common trunk in ten cases. These trunks originated from the A2 segment (eight cases), A3 segment (one case) and callosomarginal artery (one case).

A common trunk between two or all three frontal arteries is common and this trunk is referred to as the internal frontal artery (observed in 36 cases). The IFA can give rise to the anterior and middle internal frontal arteries (41.7%), the middle and posterior internal frontal arteries (44.4%), or all three frontal arteries (13.9%). The IfO and FpA could also originate from the internal frontal artery in 2.0% and 4.1%, respectively.

3.2.4. Unusual origins

A few unusual origins that have not been previously reported were observed. In one case the SIPA arose from the A2 segment, while the IIPA was absent, and the callosomarginal artery gave rise to the other cortical branches. The infra-orbital artery and AIFA arose with a common trunk from the A1 segment in one case. Lastly, the CmA originated from the junction of the A1 and A2 segments. These unusual origins are illustrated in Fig. 2.

3.2.5. Callosomarginal artery configuration

The CmA is only present in some hemispheres and can be typical or atypical. This artery usually runs in the cingulate sulcus, and gives rise to two or more cortical branches. An atypical CmA is defined as one or more short arteries running in the cingulate sulcus, and a typical CmA is one longer artery running in the cingulate sulcus [3–6]. The CmA was only present in 15 cases (12.4%) and had a typical configuration in all 15 cases. Several arteries (frontal arteries, PLA, IfO and frontopolar artery) can originate from the CmA and consequently five different subgroups were identified (Fig. 3). The