A CADAVER STUDY ON THE ANATOMICAL VARIATION AND BRANCHING OF THE ANTERIOR CEREBRAL ARTERY

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Introduction

The cortical branches of the distal anterior cerebral artery (ACA) are primarily responsible for the blood supply of the corpus callosum[1-3]. Anatomical variation in these arteries leads to difficulty in defining a standard vascularisation pattern for the distal ACA, which in turn complicates the task of neurovascular surgeons operating on these structures[4].

Literature review

The corpus callosum is the largest and most important commissure. It appears by the tenth week of development and consists of a dense mass of fibres found in the depth of the longitudinal fissure. It is attached rostrally to the lamina terminalis and extends caudally, superior to the lateral ventricles and diencephalon, to end approximately 7cm from the occipital pole[5]. The corpus callosum is anatomically divided into five parts the rostrum, genu, body, splenium and tapetum. The rostrum and genu form a connection between the frontal lobes, predominantly at their anterior portion, and comprise the floor and anterior wall of the frontal horn in each lateral ventricle. The fibres radiate laterally into both hemispheres to form the forceps minor. The body of the corpus callosum connects the posterior portion of the frontal lobes, as well as the parietal lobes, and constitutes the roof of the body of the lateral ventricles. The splenium, the most posterior portion of the corpus callosum, connects the regions of the temporal and occipital lobes. The radiating fibres of the splenium form the forceps major. A subgroup of fibres that connect in the splenial region sweep laterally and inferiorly to form the roof and lateral wall of the antrum of the lateral ventricles; they also sweep around the temporal and occipital horns. This subgroup of fibres, called the tapetum, separates the fibres of the optic radiation from the temporal horn[6]. The corpus callosum is responsible for uniting the frontal, parietal, occipital and, to a lesser extent, temporal lobes, leading to the integration of functions between both hemispheres[5].

The distal ACA and its respective branches forms one of the three primary arterial systems that supply the corpus callosum. This artery therefore possess an essential role in the blood supply of this significant structure[1]. The ACA supplies the medial surface of the frontal and parietal lobes, but not the surfaces of the occipital lobe. It extends over the edge of the medial surface of these lobes to supply an area of about a finger's width on the superolateral surface of the frontal and parietal lobes and on the inferior surface of the frontal lobe[5].

Many classifications have been proposed for the segments of the ACA. The part between the bifurcation of the internal carotid artery and the anterior communicating artery (ACoA) has been called the A1 segment or the proximal ACA. The section after the ACoA has been referred to as the distal segment, which also has been subdivided[1,3].

Currently there is no consensus regarding the segments of the distal ACA and this causes confusion regarding the branching pattern and number of branches per segment. This study is an attempt to use clear landmarks to improve current descriptions, since this will aid pre-operative planning and help to avoid complications during neurosurgical procedures[6].

Aims

The aims of the study were to evaluate anatomical variation and branching patterns of the anterior cerebral artery by determining the number of arterial branches per segment and the branching pattern in order to study the vascularisation of the corpus callosum.

Materials and Methods

The sample consisted of 34 embalmed brains from the Department of Anatomy, for which ethical clearance was obtained from the Main Ethics Committee, Faculty of Health Sciences (26/2009). The brains were carefully cut in half in order to preserve the arteries. The diameter of the distal ACA (segment after the ACoA) was measured with a digital Vernier caliper with an accuracy of 0.01mm, at the following intervals (see Figure 1): Genu of the copus callosum, anterior commissure and stalk of the pineal gland. These landmarks represent the start of each A4 segment (extending from the genu to the splenium of the corpus callosum) respectively. The number of supplying branches in each segment was also noted.

Statistical analysis, including percentage and frequency determinations, was used to describe the occurrence of the arteries supplying the corpus callosum. The chi-square test was used to determine the significance of variation in these supplying arteries, in order to effectively distinguish between the specific arteries and the respective areas vascularised.

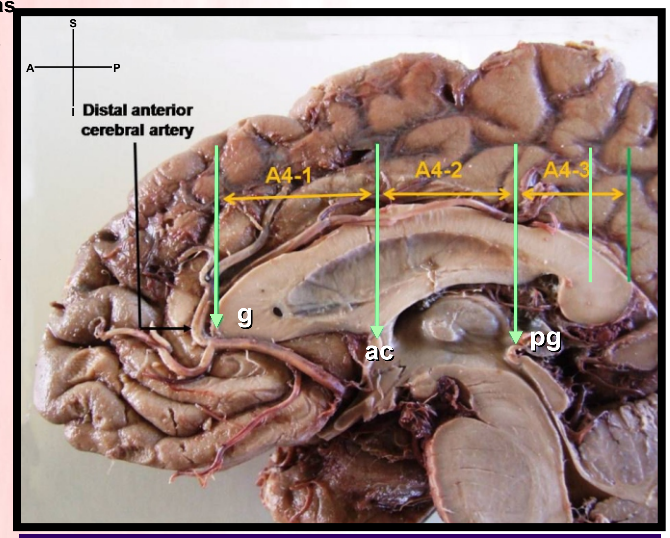

Figure 1: A midsagittal section through the brain to illustrate the intervals and landmarks representing the start of the three A4 segments respectively. The number of supplying branches was noted per interval, as indicated above (g: genu of corpus callosum; ac: anterior commissure; pg: pineal gland).

Results

Table 1. Results for measurements of the distal ACA diameter at the start of each segment

Segment	Distal anterior cerebral artery diameter		
	n	Mean (mm)	SEM (mm)
A4-1	22	^{a}2.46	0.10
A4-2	23	^{a,b}1.61	0.09
A4-3	22	^{b}1.31	0.10

^{a,b} Significant differences ($p \leq 0.05$)

Results of measurements of the diameter of the distal ACA at the start of each segment are presented in Table 1 below.

The study revealed that the diameter of the distal ACA was the largest (2.46 ± 0.1mm) at the start of the A4-1 segment. At the start of the A4-2 segment, the ACA was significantly smaller (1.61 ± 0.09mm), and the smallest (1.31 ± 0.1mm) at the start of the A4-3 segment. A significant difference was found between the start of the A4-1 and A4-2 segments, as well as between the A4-2 and A4-3 segments respectively (T-test, $p < 0.05$).

From Figure 2 it can be seen that in 29.4% of subjects, 4 branches of the A4-2 segment were found to supply the body of the corpus callosum. The A4-1 segment had 3 branches in 29.4% of subjects, supplying the genu of the corpus callosum. In 38.2% of subjects, 1 supplying branch of the A4-3 segment was found. The difference between the number of branches supplying the first 2 segments and the last segment (A4-3) were significant (chi^2, $p < 0.05$).

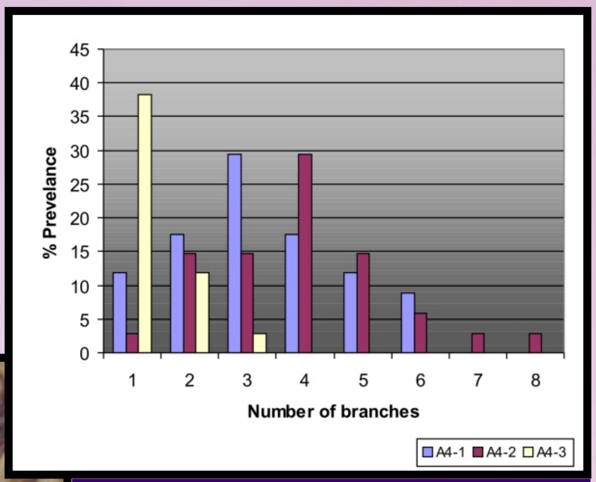

Figure 2: Number of supplying branches from segments A4-1, A4-2 and A4-3 of the distal ACA to the corpus callosum.

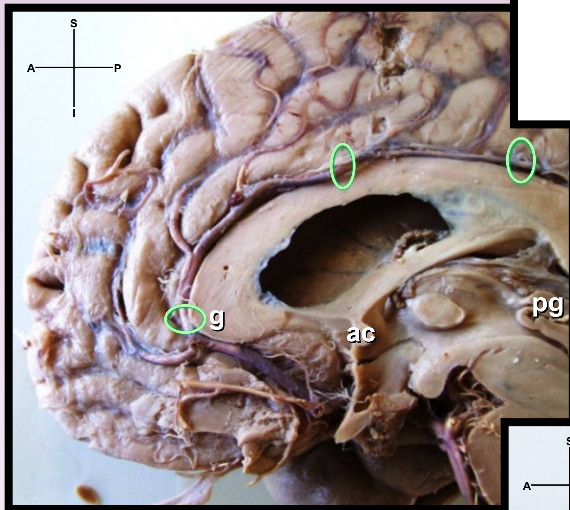

Figure 3: A midsagittal section through the brain to illustrate the diameter of the distal ACA at the start of the three A4 segments respectively. A decrease in diameter can be observed as the artery continues posteriorly (g: genu of corpus callosum; ac: anterior commissure; pg: pineal gland).

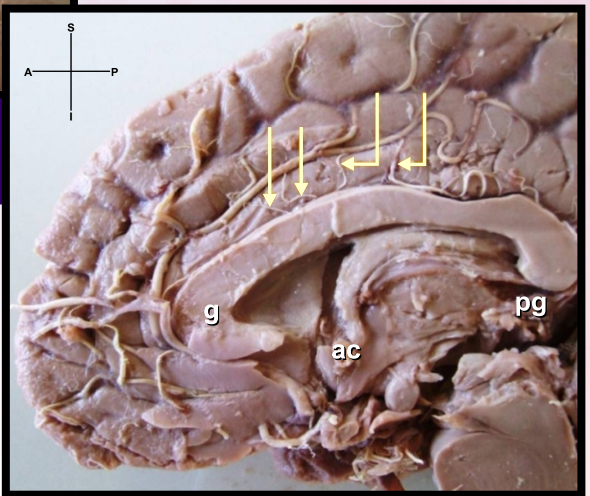

Figure 4: A midsagittal section through the brain to illustrate the branches of the A4-1 and A4-2 segments of the distal ACA. These branches supply the genu and body of the corpus callosum respectively (g: genu of corpus callosum; ac: anterior commissure; pg: pineal gland).

Discussion

A study by Ture et al (1996)[1], determined that there are three main arterial systems that supply the corpus callosum. These include the anterior communicating artery, the pericallosal artery and the posterior pericallosal artery. In their study, they distinguished and named various supplying branches from the distal ACA that contribute to the blood supply of the corpus callosum. Over the last ten years, several studies supported this nomenclature[1-4]. The following supplying branches have been described: Short and long callosal arteries, cingulocallosal and recurrent cingulocallosal arteries, median callosal artery (described by some as a third pericallosal artery), and subcallosal artery. The "long callosal arteries" and "cingulocallosal arteries" were found to be the major contributing arteries to the blood supply of the corpus callosum by Ture et al (1996)[1].

However, the lack of consensus regarding the segments of the distal ACA as well as the inconsistent branching pattern, gives rise to confusion when using the nomenclature as proposed by Ture et al (1996)[1] and subsequent studies[2-4]. This study attempted to provide a better description without confusing names by using empirical values and clear landmarks to describe the segments of the distal ACA.

In our study, we found that the pericallosal artery, otherwise known as the distal ACA, and its respective branches are the primary source of the blood supply to the corpus callosum. In this regard, we found that the distal ACA becomes thinner as it proceeds posteriorly over the corpus callosum and that, in contrast to our prediction and despite great variation in diameter, there was no significant difference between the diameter at the start of the A4-1 and A4-3 segments (T-test, $p > 0.05$).

In terms of the supplying branches, it was expected that the A4-1 segment of the distal ACA would give rise to a higher number of branches. However, we found that the A4-2 segment of the distal ACA gave origin to the most arterial branches supplying the body of the corpus callosum, causing it to be the most vascular portion. The A4-1 segment had the largest diameter, but it was shorter in length compared to the A4-2 segment. This may possibly be the reason for the fewer number of supplying branches that originate from this segment. Very few branches from the A4-3 segment were found to supply the splenium.

Conclusion

Exploration of the corpus callosum is an integral part of several neurosurgical procedures. Knowledge of the detailed anatomy of the corpus callosum, especially its blood supply, is essential for performing successful neurosurgical procedures in this area. We have described the distal ACA in terms of clear landmarks and were able to note the branching pattern of each segment. We found that the blood supply of the corpus callosum differs in the various segments of the distal ACA, with the highest number of branches originating from the A4-2 segment that supplies the body of the corpus callosum. It is thus worthwhile to consider the variations occurring in the small cortical branches of the distal ACA, which primarily supply the corpus callosum.

References

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