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THE ANTERIOR CEREBRAL ARTERY

II. A COMPUTER MODEL OF ITS CORTICAL BRANCHES ESTEREOTAXICALLY OBTAINED FROM ANATOMICAL SPECIMENS.

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The present paper is a continuation of anatomical studies previously published [1,2] on the anterior cerebral artery (A.C.A.), where it was demonstrated that the branches of this artery are responsible for areas of vascularization that imbricate with each other, and correspond to well determined areas of anatomo-functional representation. These areas were evidenced after projection of each arterial branch on a model atlas brain.

We thought it would be feasible to apply these schematic composites of greater and smaller branches in a careful study of their trajectories and thus obtain a mean statistical of each one of those branches.

MATERIAL AND METHODS

The major and minor branches of the A.C.A. obtained radiographically in the forementioned study [1,2] were projected, in their normal size, on millimeter transparent paper in order to determine, millimeter by millimeter, their precise pathways.

This would be a difficult task to perform manually, due to the enormous amount of small calculation required to obtain a final statistical model. It was thus decided to use a computer program to test work hypothesis and an IBM 1130 computer was used for this purpose.

For this test, we chose the middle internal frontal artery (MIFA), corresponding to region 4 of the A.C.A. as determined in the previous study, (left and right sides), projecting each artery of all the 40 hemispheres on separate sheets of millimeter paper (See Fig. 1). A geometric "approximation" of all the arteries corresponding

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to region 4 was then obtained, dividing them in small segments marked on their paths. These segments were chosen, taking into account the mean curvature of the arteries so that this "approximation" by segments would not omit important information, using approximately the same length for the various segments. Pairs of ordinates were then obtained (using the system of X axis for abcissa and Y for ordinate) for artery 4 of each anatomical specimen.

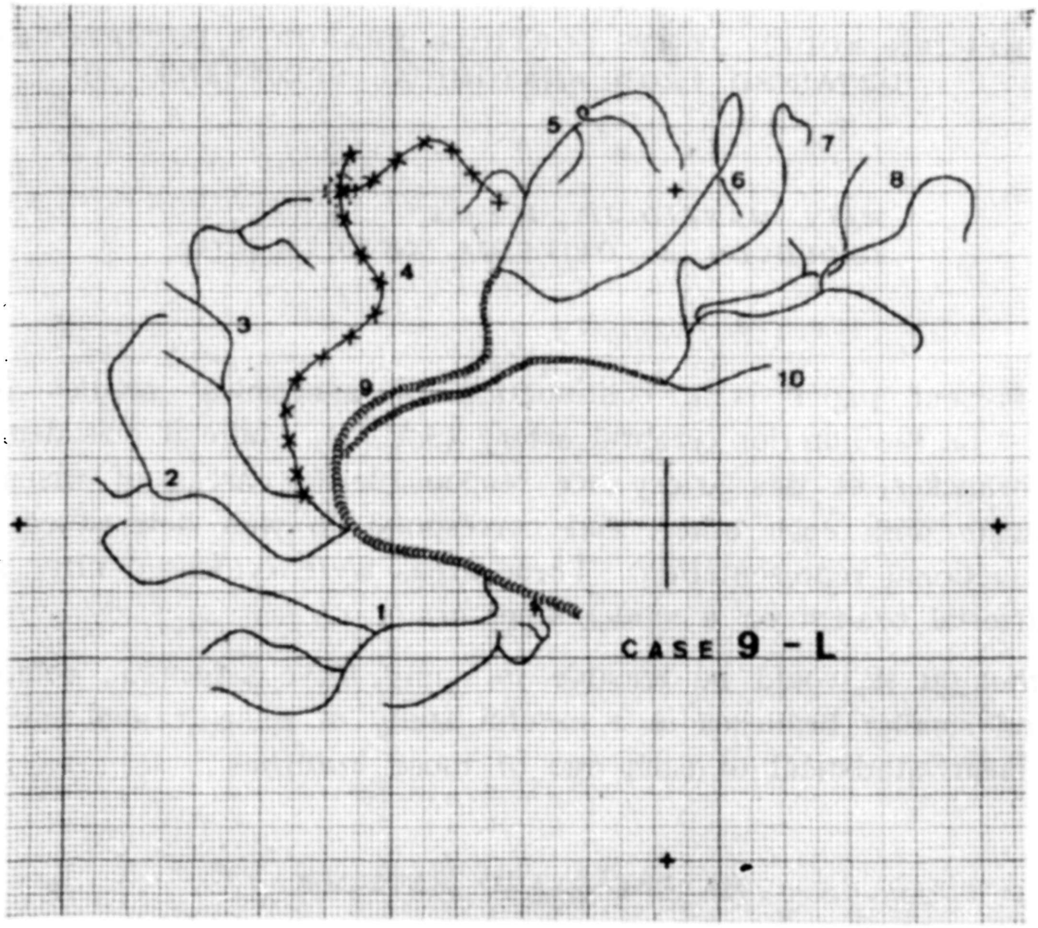

Fig. 1 — One of our specimens diagrams, showing division of artery 4 in segments, por calculation of a "mean" artery.

Each segment of artery 4 was given a number of order, so that each artery 4 could be represented by a set of ordinate pairs, mathematically represented by (X_{4j}, Y_{4j}) were 4 is the index representing that particular artery and J is the order of the segment.

The points of the mean artery were computed according to the following formulas:

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{ij}}{n} \qquad \bar{y}_j = \frac{\sum_{i=1}^{n} y_{ij}}{n}$$

Where: (X_{ij}, Y_{ij}) = pair of orthogonal cartesian coordinates; i = index representing the ith artery (in this example 4); j = index representing the order of the segment; n = total number of points for the jth order.

In the majority of the cases the arteries had ramifications. In order to calculate the mean artery, these ramifications were considered as arteries whose points would have an order equal or greater to that at the origin of the ramification. Thus, in order to facilitate the calculations of the mean artery 4, we gave to the points situated at the begining of the ramification the numbers of order counted from the origin of the ramification and not from the origin of the artery.

The processing of the above data in a digital computer, gave the table of the pairs of coordinates of the points of region 4, the resulting average points and the corresponding graphics (see fig. 2, A and B).

This procedure can be easily extended to each one of the 9 remaining arteries.

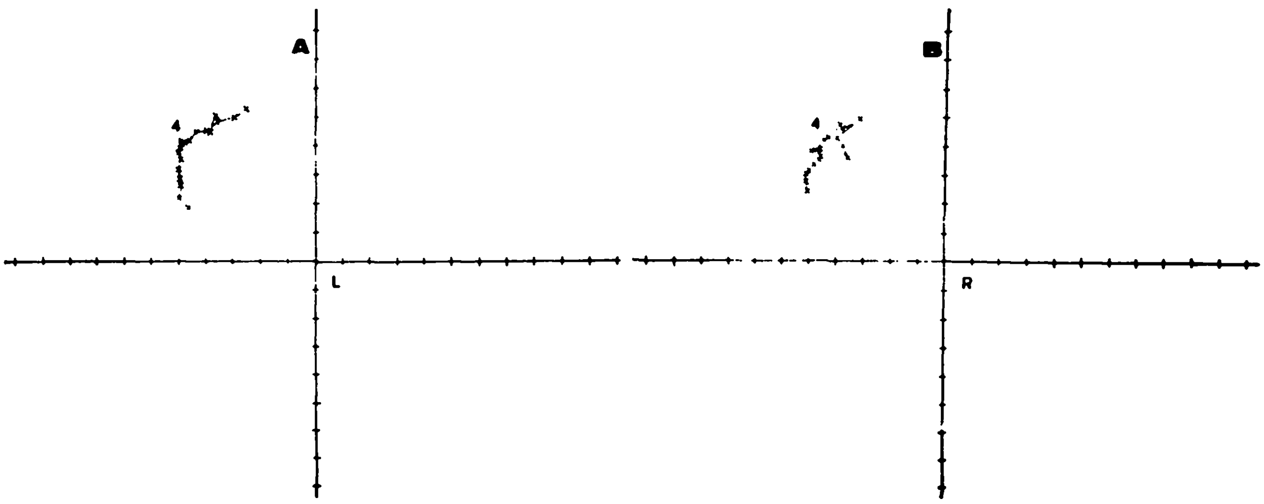

Fig. 2 — Average points of arteries of region 4 projected by the computer for sides left and right respectively.

Obtaining another model — In order to obtain a more schematic computer model, representing all the regions of the A.C.A. (left and right sides) we obtained the mean of the directions, characteristic for each artery and their ramifications.

Arteries 1 to 10 were then graphically approximated through pairs of points, one being the origin and the other the extremity of a segment that defined the *preferential direction* of the artery considered.

The mean length of the segments was chosen based on the graphics obtained by superimposition of 40 anatomical specimens of brain hemispheres, for each region, as it may be seen in our previous publication. The point of origin of the segment was chosen as the same as obtained for model 4.

For each artery in particular, the segment that determines the mean direction was taken from the mean point of the origin and the mean point representing the termination. For the determination of the point representing the termination, the procedure was as follows: (*a*) For each one of the 10 regions we selected a point where there was a greater confluence of arteries, considering the graphics which show the superimposed arteries. This point was looked for in the most distant part of the points originating the arteries. The distance between the mean point of origin of the arteries and this point of greater confluence of arteries was then calculated, for each considered region. (*b*) For each one of the 10 regions and in each one of the 40 graphics an arc of circumference of a radius equal to the distance obtained in (a) was marked from the origin of the artery. (*c*) For representing the termination in each particular artery and each graphic, it was taken the point which, situated on the above mentioned circumference (b), would better represent the direction of the artery. (*d*) For a given region, the point representing its extreme was obtained computing the arithmetic mean of the points obtained in (c).

Thus, the graphics of Fig. 3 A and B were obtained. These, obtained in the same system of stereotaxic coordinates, previously described, 1,2 were then projected on the stereotaxic model brain (Fig. *1 D*, see preceding paper)[1] that produced Figs. *4 A* and *4 B* respectively for right and left sides, representing a model of an ideal A.C.A. and its theoretical relationship with the parasagital cortex.

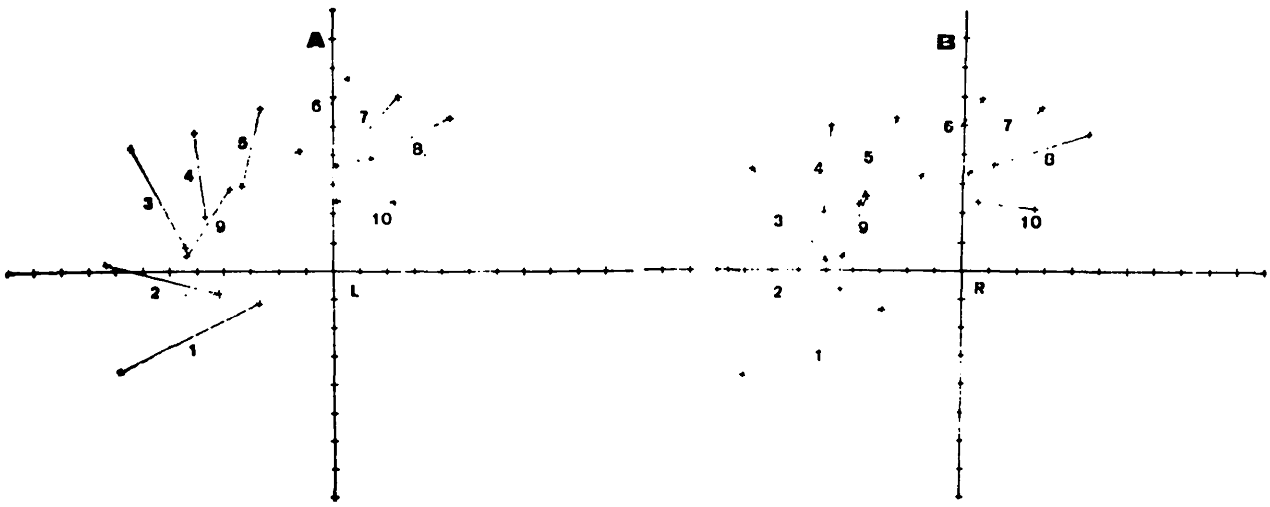

Fig. 3 — Mean of directions of all the ramifications of the A.C.A. obtained by the computer.

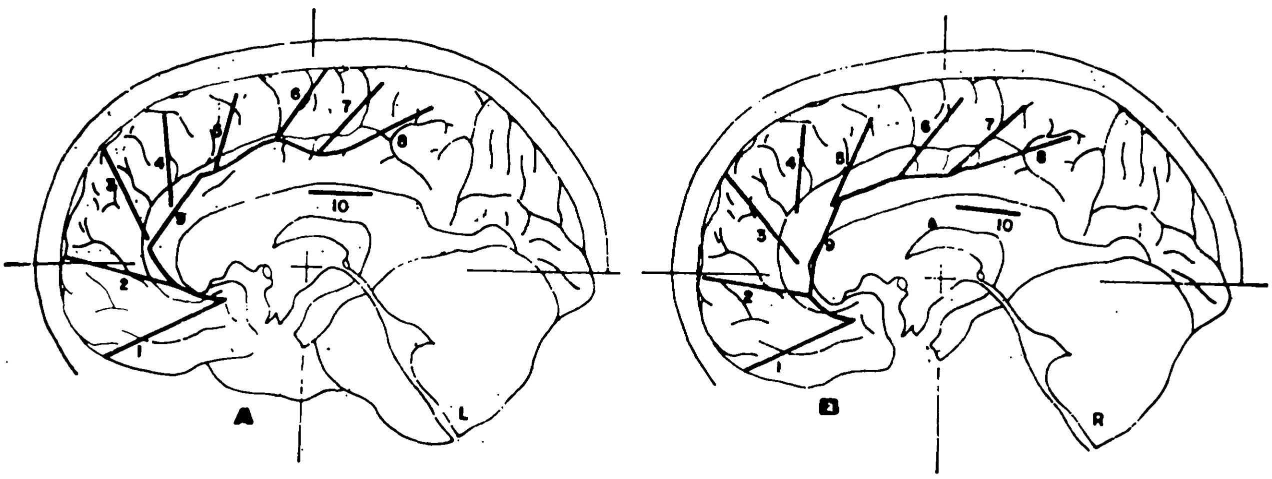

Fig. 4 — Projection of diagrams of Fig. 3 on our atlas brain, representing a model of an ideal A.C.A. and its relationship with the parasagital cortex.

CONCLUSIONS

It is well known that there are marked variations in the vascular system of the brain from individual to individual, and this applies as well to the morphology of the A.C.A., as demonstrated in our previous publication[1]. The aim of the present computer study, was to demonstrate the possibility to obtain the model of any anatomical structure located within a rigid system of coordinates. In this paper this was applied to arterial branches, but the same can be done for other structures like the amygdala, hippocampus, thalamic nuclei, specific gyri etc., of which we want to know its approximate statistical location and morphology in the brain, and also for localization purposes, in stereotaxic studies.

SUMMARY

This article is a corrollary of a previously published anatomical study of the anterior cerebral artery. The authors propose a method to obtain a computer model of the anterior cerebral artery, based on a combined system of stereotaxic coordinates and a specially developed computer program. The graphic analysis, thus obtained, is projected on a model atlas brain and an ideal diagram of this anatomical structure is obtained. Forty anatomical specimens were used for this study.

RESUMO

Artéria cerebral anterior: II. *Um modelo computadorizado de seus ramos obtido estereotaxicamente de espécimes anatômicos.*

Os autores apresentam um estudo computadorizado, aplicado a um trabalho anatômico, previamente publicado, sobre a artéria cerebral anterior, estudada em 40 espécimens. É proposto um método que permite obter um modelo computacional da A.C.A., ou de qualquer estrutura anatômica, situada dentro de um sistema de coordenadas estereotáxicas, a partir de um programa computacional, especialmente desenvolvido para este projeto. A análise gráfica assim obtida, é projetada num modelo de atlas cerebral e um diagrama ideal da estrutura anatômica é, destarte, obtido. O presente estudo tem importância na determinação de assimetrias ou variações de quaisquer estruturas encefálicas, desde que sejam colocadas dentro de um sistema estereotáxico de referência.

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