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Research article

Microanatomical study of the recurrent artery of Heubner

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SUMMARY

The purpose of this study has been to describe the microanatomy of the recurrent artery of Heubner (RAH) in detail, to deepen anatomical knowledge and aid neurosurgeons in their work.

The material was obtained from cadavers (ages 31–75 years) at routine autopsy. A total of 70 human brains (39 male and 31 female) were examined. People who died due to neurological disorders were not included in the study. Right after dissection, the arteries were perfused with acrylic paint emulsion, through the Circle of Willis or electively through the RAH. Brains were fixed in a 10% solution of formaldehyde, sectioned and placed in methyl salicylate for tissue transparency. To obtain corrosion-casts, the vessels were perfused with polyvinyl chloride or Mercox CL-2R resin and corroded using concentrated potassium chloride. The obtained material was analyzed using a stereoscopic light microscope.

The RAH was present in 138 hemispheres with a mean of 1.99 RAH per hemisphere (275 RAH in total). The mean RAH length was 25.2 mm and the mean RAH diameter, in its place of origin, was 1 mm. Two to 30 branches (mean = 9.4) originated from the stem of the RAH. The number of RAHs showed a negative correlation to the number of arteries from the medial group of lenticulo-striate arteries (LSA) ($R = -0.62$; $p < 0.0001$) which branch off the middle cerebral artery (MCA).

This study further supports the RAH embryologic theory by Abbie. The RAH, in its extra- and intracerebral course, may join with the middle group of the LSA or directly with the MCA.

1. Introduction

The recurrent artery of Heubner (RAH) was first described in 1872 by Heubner (1872). Other authors called this vessel the long centralis artery (Tran-Dinh, 1986), telencephalic artery (Gomes et al., 1984), distal medial striate artery (Kaplan, 1965) or the rostral striate artery (Clara, 1953).

The RAH is normally the largest of the medial lenticulo-striate arteries branching from the proximal A2 or A1 segment of the anterior cerebral artery (ACA) (Loukas et al., 2006). It gives off branches which supply the antero-medial part of the caudate nucleus, the anterior limb of the internal capsule, the anterior third of the putamen, and the globulus pallidus (Zunon-Kipré et al., 2012).

Occlusion or vascular damage to the RAH, secondary to surgical procedures involving the anterior portion of the Circle of Willis, may cause hemiparesis with facial and brachial predominance and aphasia on the dominant hemisphere (Gomes et al., 1984). Thus, this vessel must always be recognized and preserved.

Current knowledge on the origin, number, course and branches of the RAH is based on studies performed on a very limited amount of specimens. By carrying out this large study, we wanted to significantly increase the information available to surgeons operating in the area of the ACA (Fig. 1) and the anterior communicating artery (ACoA).

The purpose of this study has been to describe the microanatomy of the RAH in detail to both deepen anatomical knowledge and help neurosurgeons in their work.

2. Materials and methods

The material for this study was obtained from cadavers (ages 31–75 years) during routine autopsies performed at the Department of Pathology, Jagiellonian University Medical College (JUMC). A total of 70 human brains (39 male and 31 female), yielding 140 hemispheres, were examined. The material was collected not later than 48 h post-mortem. People who had died due to neurological disorders were not included in the study.

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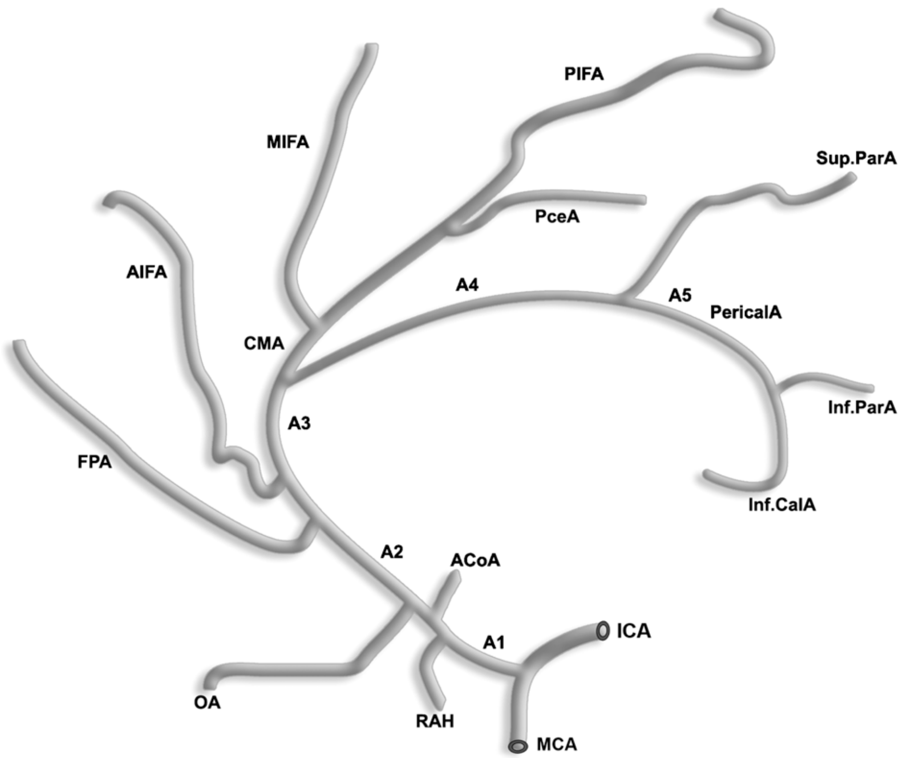

Fig. 1. Branching pattern of anterior cerebral artery (ACA) (Perlmutter and Rhoton, 1978) on the medial surface of the right hemisphere. MCA – middle cerebral artery, ICA – internal carotid artery, A1–A5 – segments of ACA, OA – orbitofrontal artery, FPA – frontopolar artery, AIFA – anterior internal frontal artery, CMA – callosomarginal artery, MIFA – middle internal frontal artery, PIFA – posterior internal frontal artery, PceA – paracentral artery, Sup. ParA – superior parietal artery, PericalA – pericallosal artery, Inf. ParA – inferior parietal artery, and Inf. CalA – inferior callosal artery.

The research protocol was approved by the JUMC Bioethics Committee (registry KBET/270/B/2012).

In this study, the authors chose to strictly adhere to the classic "recurrent" definition of the RAH, as given by Heubner (1872). When identifying RAHs, we traced the course of the vessel and the area supplied by it.

After removal from the cranium, the brains were stored in room temperature saline. Existing clots were removed using saline irrigation. Right after dissection, the arteries were perfused (stable pressure of 120 mmHg) with acrylic paint emulsion (Liqutiex R, Binney and Smith) (Pityński et al., 1998; Walocha et al., 2003), through the Circle of Willis or electively through the RAH (Fig. 2a). In instances in which the ACA and the MCA (Fig. 3) were perfused simultaneously, different acrylic colors were used. Perfusion was continued until cortical vessels were fully filled. Next, the specimens were stored in a 10% formaldehyde solution for 2 weeks. Fixed brains were sectioned (slice 1–4 mm thick) along the coronal plane and dehydrated in increasing concentrations of ethyl alcohol. Finally, the slices were placed in pure methyl salicylate for 2–3 weeks to enable tissue transparency.

To obtain corrosion specimens, the vessels were perfused with either polyvinyl chloride (Fig. 2b) or Mercox CL-2R resin (Vilene Comp. Ltd., Japan) (Bereza et al., 2012). Corrosion was performed in high concentrations of potassium chloride.

To obtain RAH radiological pictures, lead oxide was added to polyvinyl chloride (Gorczyca and Mohr, 1987) (Fig. 2a).

The obtained material was analyzed using a stereoscopic light microscope (Technival 2 Carl Zeiss Jena), magnification (×2–40). Digital photographs were taken and later analyzed using Java ImageJ (version 1.46d) software (Mizia et al., 2012).

Statistical analysis was conducted using computer software Statistica 10.0 PL by Statsoft Poland. Elements of descriptive statistics were used (mean, standard deviation, percentage distribution). To assess whether differences between specific groups existed, the Student *t*-test was used. Pearson's correlation was used to assess the correlation between scale scores. Statistical significance was set at $p < 0.05$.

3. Results

Overall, the RAH was present in 138 hemispheres and absent in two cases, with a mean of 1.99 RAH per hemisphere (275 RAH in total). The RAH was present as a single vessel in 41 hemispheres (29.7%), as a double vessel in 60 hemispheres (43.5%) and as a triplicate vessel in 34 hemispheres (24.6%). The quadruple variant was the rarest and present in only 3 hemispheres (2.2%) (Fig. 2c). The number of the RAH was not related to gender or hemisphere side, however, it showed a negative correlation with the number of arteries from the medial group of the lenticulo-striate arteries (LSA) ($R = -0.62$; $p < 0.0001$), that branch off the middle cerebral artery (MCA).

3.1. RAH origin

The RAH originated from the A1 segment of ACA in 26.2% of cases, from the ACA A2 segment in 33.8% and in 40% from the ACA–ACoA level. In one instance, in which the ACA was absent unilaterally, the RAH originated from the contralateral ACA.

When taking into account the circumference of ACA, 38.2% of RAH originated from the top side of the ACA – 36% (Fig. 2d) from the lateral side, 20.7% from the bottom side and from the medial side – 5.1% (only in the A1 segment). Thirty-four (12.4%) of the multiple RAHs originated as a common branch (Fig. 2e), usually from the ACA–ACoA junction. The mean length of the common trunk was 3.1 mm, with a range of 1–18 mm.