JMS 2018;1(1):5-9
UDC:611.133

MORPHOLOGICAL CHARACTERISTICS OF THE RECURRENT ARTERY OF HEUBNER

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Abstract

Cerebral circulation, especially arterial, in recent decades has attracted the interest of anatomists and clinicians.

The aim of this study was to present the morphological and topographic characteristics of the Heubner artery.

Anatomical characteristics of the recurrent artery of Heubner of 133 human brains without cerebrovascular pathology from both sexes at the age from 23 to 68 years were examined. Brain specimens were fixed in a 10% solution of formaldehyde, and the obtained material was analyzed using a stereoscopic light microscope.

In 94% brain specimens had a recurrent artery of Heubner while in 6% of the brains we could not identify the artery. The artery was present as a single vessel in 76% of cases, and as a double vessel in 24% of cases. It originated from the junction of the anterior cerebral artery and the anterior communicating artery in 60% of the specimens, from the A_2 segment of the anterior cerebral artery in 21% of the specimens, and from the A_1 segment of the anterior cerebral artery in 19%. The length of the recurrent artery of Heubner ranged from 14 to 46 mm, with a mean value of 24 mm. The diameter of the artery ranged from 0.9 to 2.8 mm, with a mean value of 1.3 mm.

Detailed anatomical knowledge of the recurrent artery of Heubner is important when considering vascular surgery in the area of the anterior portion of the circle of Willis.

Keywords: recurrent artery of Heubner, brain; anatomy, origin, diameter

Introduction

The term Heubnerĝs artery was first used in 1909 by Aitken, after Heubnerĝs classical description of the vessel in 1872. Other authors called this vessel the long central artery, telencephalic artery, distal medial striate artery or the rostral striate artery [1].

The recurrent artery of Heubner (RAH) supplies blood to the medial portion of the orbitofrontal cortex, the anterior portion of the caudate nucleus, the anterior third of the putamen, the external segment of the globus pallidus, and the anterior crus of the internal capsule. The artery also supplies the olfactory region, the anterior hypothalamus, the nucleus accumbens, parts of the uncinate fasciculus, the diagonal band of Broca, and the basal nucleus of Meynert [1, 2, 3].

Currently the RAH attracts the attention of neurosurgeons, radiologists and anatomists because of its variations.

The aim of this study was to present morphological features of the RAH and to emphasize their clinical significance during routine clinical work.

Materials and methods

The study included 133 human brain specimens without cerebrovascular pathology, from both sexes, at the age from 23 to 68 years. The specimens were randomly selected from the collection of the Institute of Anatomy at the Medical Faculty in Skopje, R. Macedonia. Macroscopical analysis of the morphological and topographic characteristics of the RAH was performed by inspection, dissection and perfusion-injection methods.

The brains were taken out from the cranial cavity and the arachnoidea was carefully removed from the base and lateral sides of the brain. Precautions were taken to avoid disruption of the normal topographical relationships. To remove the clots, the blood vessels were irrigated with isotonic saline, using catheters placed in the internal carotid and basilar arteries. Then, the blood vessels were filled with mixture of gelatin and India ink, and placed in a 10% solution of formaldehyde for 10 days. The obtained material was analyzed using a stereoscopic light microscope.

The following parameters of the RAH were analyzed: presence, origin, variation in the number, outer diameter at the place of origin, length, course and site of penetration in the brain parenchyma. The origin of the RAH was defined in regard to the junction of the anterior cerebral artery (ACA) with the anterior communicating artery (AComA). According to the relationship with the A1 segment of the ACA, three different courses of the RAH were found: type I or anterior, type II or posterior and type III or superior course. Each of the specimens was analyzed by 2 independent examiners.

Results

The RAH was present in 94% of the analyzed brain specimens. In 60% of the specimens the RAH originated from the junction of ACA and AComA. In 21% of the examined brains the RAH originated from the A1 segment of the ACA, and in 19% of cases from the A2 segment of the ACA. The RAH was present as a single vessel in 76% of the examined brains, and in the other 24% duplication was observed. The outer diameter of RAH at its origin was in the range between 0.9-2.8 mm, with a mean value of 1.3 mm. The length of the RAH was in the range between 14- 46 mm, with a mean value of 24 mm.

Variations in the course and termination of the RAH:

Type I, or superior course, was seen in 63% of the arteries, type II, or anterior course, was seen in 34% of the arteries and type III, or posterior course, was seen in 3% of the arteries.

In all 133 specimens the artery terminated in the lateral part of the anterior perforated substance.

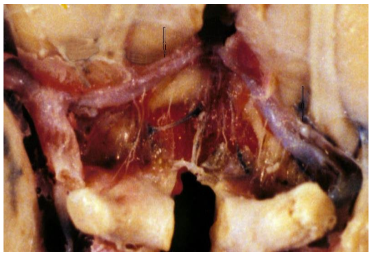

Figure 1. Origin of the RAH from the A_1 segment of the ACA.

Figure 2. Origin of the RAH from the A_2 segment of the ACA.

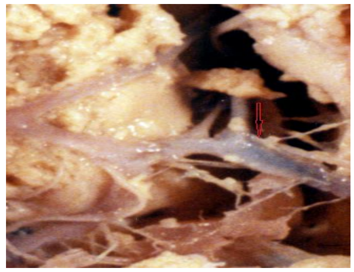

Figure 3. Origin of the RAH from the junction of ACA and AComA.

Discussion

Anatomical knowledge of the exact topography of the RAH and the surrounding structures is of great importance when performing surgical interventions in the vicinity of the anterior circulation of circle of Willis. Classically, the RAH doubles back on its parent ACA and passes above the carotid bifurcation and middle cerebral artery into the medial part of the sylvian fissure before entering the anterior perforated substance. However, anatomical studies have reported numerous variations in origin, course, length and diameter of the RAH.

A number of previous studies in the field of anatomy have focused on the presence and variations in the number of the RAH in which the artery could be detected as a single vessel, duplication, triplication or multiple vessels. In the literature, occurrence of RAH was found to be between 94% and 100%. In our study, the RAH was found in 94% the specimens, similar to the results published by Vasovic (97.3%), Faloygy (94.78%) and Dimitriu (94.6%) [2, 3, 4]. The RAH was absent in 6% of the specimens in our study, which is similar to the results reported by Loukas (6%), Dimitriu (5.3%) and Faloygy (5.19%) [4, 5, 2]. The RAH was found as a single vessel in 95%, 88.5%, 74.2%, 71.6% by Zunon-Kipre [6], Faloygy [4], Avci [7] and Vasovic, respectively [3]. In our study the presence of the RAH as a single vessel was noticed in 76% of the specimens, similar to the results published by Avci and Vasovic et al. Duplication of the RAH was seen in 25.1%, 22.6%, 17%, 14.3%, 6.28%, 5% by Vasovic [3], Avci [7], Loukas [5], Dimitriu [2], Faloygy [4] and Zunon-Kipre, respectively [6]. The triplication of the RAH was seen in 3.3%, 1.6% by Vasovic and Avci, respectively [3, 7]. In our study we did not find triplication of the RAH, which is in agreement with the results of the studies conducted by Dimitriu, Faloygy, Loukas, Zunon-Kipre [2, 4, 5, 6]. Only Rosner [8] and Maga [1] obtained significantly different results. They found single RAH in 28% and 29.7% of their cases; double RAH in 48% and 43.5% of their cases, triple RAH in 23% and 24.6% of their cases and quadruple variant in 1% and 2.2% of their cases [1, 8].

In attempting to classify RAH origin data, we discovered large discrepancies in the literature and heterogenous data. The A1 segment of the ACA is reported as the site of origin of the RAH in 3.55ï 14.3% of the cases [4, 9, 10]. Vasovic et al. reported origin of the RAH from A1 segment of the ACA in 20% of the cases [3], Maga in 26.2% of the cases [1]. According to our knowledge the highest reported incidence of origin from the A1 segment is 30% observed in the study conducted by Zunon-Kipre et al [6]. In our study RAH originated from the A1 segment of the ACA in 21% of the cases, similar to the results published by Vasovic et al. (20%). Vasovic [3], Faloygy [4], Zunon-Kipre [6], Avci [7], Gomes [10], Perlmutter [11] reported A2 segment of the ACA as the most frequent site of origin of the RAH, found in 23-78% of the cases. On the other hand, several studies reported the junction between the ACA and AComA as the most frequent site of origin, observed between 8-62.3% of the cases. In our study the junction between the ACA and AComA was observed as the most frequent site of origin of the RAH, noticed in 60% of the cases. In the study conducted by Aydin [9] and Loukas [5] this origin was observed in 58% and 62.3%, which coincides with our results.

Three basic courses of the RAH in relation with A1 segment of the ACA have been described: superior, anterior and posterior course. In the available literature type I or superior course of the RAH was predominating, in 31% of cases, in the study of Zunon-Kipre [6], in 38% in the study of Avci [7], in 60% of the study of Kedia [12], in 63% in the study of Gomes [10] and up to 71% of cases in the study of Aydin [9]. The results of our study correspond with the previous published data by Maga, Gomes and Kedia [1, 10, 12]. Type II or anterior course was found in 25% of cases presented by Aydin [9], in 30% of cases by Kedia [12], in 52% of cases by Avci [7], in 63.4% of cases by Boongird [13] and up to 80% of cases presented by Narayanan [14]. The results obtained in our study correspond with the previous published data by Maga, Gomes, and Kedia. Type III or posterior course occurred in 3% of cases in the Gomes study [10], 4% in the Aydin study [9], in 6.7% in the Boongird study [13], in 7.2% in the Narayanan study [14] and up to 10% in the Kedia and Avci study [7, 12]. The results from our study correspond with the previous published data by Maga, Aydin and Gomes [1, 9, 10].

Most studies have confirmed that the RAH terminates by penetrating brain parenchyma in medial or lateral part of anterior perforated substance [1, 3, 4]. In our study the RAH penetrated in the lateral part of the anterior perforated substance, which is in accordance with the previous published data by Narayanan, Gomes, Perlmutter [10, 11, 14].

Based on measurements of outer diameter in its place of origin the mean diameter of RAH was 1 mm (range 0.2-2.5 mm) and the mean RAH length was 25.2 (range 10ï45) mm in the study conducted by Maga [1]. According to Gomes et al. the RAH had a mean outer diameter of 0.8 mm (range 0.3 to 1.5 mm) and a mean length of 23.4 mm (range 12 to 38 mm) [10]. Zunon-Kipre et al found that the main outer diameter was 0.7 mm (from 0.3 to 1.2 mm) and the length had an average of 24 mm [6]. In the study conducted by Loukas et al the diameters of the artery ranged from 0.2 to 1.3 mm with a mean of 0.8 mm, while the length ranged from 9 to 38 mm with a mean of 24 mm [5]. In our series the measured length and diameter were similar to those reported in the literature. The multiplicity of RAH did not impact its length or diameter. The AComA is the most frequent site (30-37%) for intracranial aneurysms formation and the most common site for ruptured aneurysms [15, 16]. These are the most complex and difficult to manage in their anterior circulation because of the angio architecture, dynamic circulation flow in the region of the ACoA and frequent anatomic variants that are occasionally not well known and are not visible on preoperative imaging [15]. Aneurysms that occur in the A1 segment of the ACA or in the AComA often require surgical exposure of the area. In such cases, the close association of the RAH with the ACA would make the RAH particularly susceptible to damage during the surgical procedures [1, 6, 15]. Microsurgical clipping has historically been the standard treatment. Heubnerộs artery should be identified on both sides, carefully dissected, and preserved [17]. Surgical interventions in the anterior circle of Willis can be complicated by obstruction of or vascular damage to the RAH, usually caused by irregular clip placement, the structureộs location in the immediate vicinity of the ACA trunk, or insufficient knowledge about its anatomical variations [3]. Classically, occlusion of the RAH results in hemiparesis with faciobrachial predominance, paralysis of the face, palate and tongue, rarely severe weakness in upper limbs [1, 4]. Iatrogenic lesions may occasionally result in significant neurological defects, including memory loss, disturbed cognitive function, and personality changes [18]. It is stressed that a thorough knowledge of the anatomical variations of the RAH and ACoA are mandatory for microvascular procedures in this area [18]. The recognition of the anatomical variations of the RAH will allow the neurosurgeon to construct a better and safer microdissection plan, to save time and avoid postoperative neurological deficits [1, 18].

Conclusion

Although anatomically interesting, an awareness of the anatomy and variations of the RAH is clinically important. Detailed anatomical knowledge of the RAH is important when considering vascular surgery in the area of the anterior portion of the circle of Willis since improper clip placement can result in occlusion producing neurological deficits. Also this knowledge may find clinical application in diagnostic procedures of pathology of the RAH such as CT, MRI, angiographic and ultrasound investigations and treatment of RAH pathology during endovascular procedures.

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