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Original Article

Microsurgical insights: A comprehensive anatomical study of Heubner's recurrent artery

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ABSTRACT

Background: The recurrent artery of Heubner (RAH) was first described by Johann Heubner in 1872 and later named by H.F. Aitken in 1909. It is the largest medial lenticulostriate artery from the anterior cerebral artery (ACA). Originating from the A1, A2, or ACA-anterior communicating artery junction, it supplies key brain structures like the caudate nucleus and anterior hypothalamus, with variations in origin and course among individuals.

Methods: We studied 15 human brains (5 females and 10 males), ensuring no neurological disease or damage to the anterior communicating complexes. Brains were fixed in 10% formalin for a month and then injected with red-colored latex for vascular visualization. Dissections were performed using a Zeiss OPMI surgical microscope, and detailed notes and images were captured for analysis.

Results: RAH was identified in 28 of 30 hemispheres, with 11 exhibiting double arteries. RAH origin is located approximately 1–4 mm from the anterior communicating artery (ACOM). The most common origins were the juxtacommunicating, A2, and A1 segments. Trajectories observed included "L," inverted "L," oblique, and sinuous, with oblique being the most common. Variations included the absence of RAH replaced by an accessory middle cerebral artery in some cases.

Conclusion: The RAH shows significant anatomical variability, originating from different ACA segments or the frontopolar artery, with four main trajectory types. Understanding these variations is critical for neurosurgical planning, as preserving the RAH can prevent neurological deficits. Gender differences in origin and trajectory were noted, influencing surgical approaches and outcomes.

Keywords: Anatomy, Heubner's recurrent artery, Microsurgery, Neuroanatomy, Neurosurgery

INTRODUCTION

The recurrent artery of Heubner (RAH) was first described by German pediatrician Johann Otto Leonhard Heubner in 1872. H.F. Aitken, an artist at Massachusetts General Hospital, later named it "Heubner's artery" in 1909. The anatomist Joseph Shellshear at St. Bartholomew's Hospital in

London introduced the current term "recurrent artery of Heubner," in 1920, referring to its distinctive course along the A1 segment of the anterior cerebral artery (ACA).[1,2]

Typically, the RAH is the largest of the perforating medial lenticulostriate arteries arising from the ACA. It can originate from the A1, A2, or at the ACA-anterior communicating artery (ACoA) junction, then characteristically turns posteriorly and runs close to the gyrus rectus to reach the anterior perforating substance.[3,4] A study showed that the RAH has a mean diameter of 0.8 ± 0.04 mm and a mean length of 23.4 ± 1.1 mm.[4,5] The artery primarily supplies blood to the head of the caudate nucleus, the medial portion of the globus pallidus, the anterior crus of the internal capsule, the anterior hypothalamus, the nucleus accumbens, parts of the uncinate fasciculus, the diagonal band of Broca, and the basal nucleus of Meynert.[4-6]

The most common origin of the RAH is from the A2 segment, followed by the ACA-ACoA junction (43.4%).[4] However, other studies found that the RAH most commonly originates from the junction of the A1 and A2 segments of the ACA in 76.2% of cases, followed by the A2 segment in 16.3% of cases.[4,5] The RAH was either absent or duplicated in about 6% of cases and tripled in 0.14% of cases.[3,4] The RAH follows three types of recurrent courses relative to the A1 segment: superior (63%), anterior (34%), and posterior (3%).[4,5] Its intracerebral course is unidirectional, heading toward the head of the caudate nucleus. During its course, it may join with the middle group of lenticulostriate arteries or directly with the middle cerebral artery (MCA) to form a rete.[6-8]

The development of the telencephalic vesicles leads to the formation of a vascular system from the rostral division of the internal cerebral artery, which gives rise to all lenticulostriate vessels, including the RAH, and forms the adult MCA. This embryological origin explains the rete communication among branches of the RAH and lenticulostriate branches from the ACA and MCA.[7,8]

In the context of clipping ACOM aneurysms, it is crucial to ensure the preservation and patency of the RAH and other perforators. Surgeons can confirm this intraoperatively by visualizing the flow of indocyanine green (ICG) dye within the RAH after aneurysm clipping. Modern techniques, such as intraoperative angiography, endoscopy, and Doppler vascular flow assessment, help visualize blind areas and minimize the risk of inadvertent clipping or kinking of the RAH. Vascular mapping allows both visual and quantitative assessment of flow within perforators and parent vessels, reducing the risk of postoperative vasospasm. This technique also helps identify high-risk patients who may benefit from early anti-spasmodic therapy.[7,9,10]

During initial retraction of the frontal lobe in surgery, the RAH is typically the first artery visible, anterior to the A1 segment, in 60% of cases.[7] Differentiating the RAH from the orbitofrontal artery (OFA) can be challenging. The RAH usually follows the path of the A1 segment, whereas the OFA crosses perpendicularly over the gyrus rectus and the olfactory tract.[9-11]

The study aims to enhance the understanding of the RAH's origin, trajectory, and variations, which are crucial for improving surgical planning and outcomes, particularly in neurosurgical procedures involving the ACA and ACoA complex. By offering precise anatomical data and observations, the study seeks to contribute to the body of knowledge required for minimizing intraoperative complications and optimizing patient care in cerebrovascular surgeries.

MATERIALS AND METHODS

Study design

This study involved an anatomical and descriptive examination of 15 human brains, comprising 5 females and 10 males. The inclusion criteria were stringent, ensuring that the causes of death were not secondary to any neurological conditions and that the anterior communicating complexes were undamaged during the extraction and preservation processes. This careful selection was crucial to maintain the integrity of the anatomical structures for accurate and reliable analysis.

Sample preparation

Fixation process

Each brain was subjected to a fixation process using a 10% formalin solution. The brains were immersed in this solution for a minimum period of 1 month. This duration was selected to ensure complete penetration and adequate preservation of brain tissues, preventing decomposition and maintaining structural integrity. Formalin is a well-established fixative in anatomical studies due to its effectiveness in preserving biological tissues by cross-linking proteins, thus providing a stable and manipulable structure for detailed examination.

Latex injection

To facilitate the detailed examination of the vascular structures, each brain was infused with red-colored latex through the internal carotid artery. The latex injection process was carefully monitored to ensure consistent and uniform filling of the vascular network. This step was essential for enhancing the visibility of the anterior communicating complex and associated blood vessels, thereby aiding in the accurate identification and analysis of these structures during dissection.

Dissection procedure

The dissections were performed using a Zeiss OPMI surgical microscope (Carl Zeiss Inc., New York). This high-precision microscope instrument provided the necessary magnification and clarity required for the meticulous dissection of brain tissues.

Methodological steps

Selection and collection of specimens

A total of 15 human brains were carefully selected from cadavers in a forensic pathology department. The criteria for selection included the absence of neurological diseases and undamaged anterior communicating complexes. These criteria were crucial to ensure that the anatomical structures studied were representative and free from pathological alterations.

Fixation

Each brain was immersed in a 10% formalin solution for at least 1 month. This prolonged fixation ensured thorough preservation, allowing for a detailed examination of the brain structures. The formalin fixation process prevents tissue autolysis and microbial degradation, thereby maintaining the morphological characteristics necessary for accurate anatomical studies.

Latex injection

After fixation, each brain was injected with red-colored latex through the internal carotid artery. This injection process was meticulously controlled to ensure that the latex adequately filled the vascular system, highlighting the blood vessels and making them more visible during dissection. The use of colored latex is a standard technique in anatomical studies to enhance the contrast and visibility of vascular structures.

Dissection using microscope

Dissections were performed using the Zeiss OPMI surgical microscope. This advanced microscope provided high magnification and clear illumination, essential for the intricate work involved in neuroanatomical dissection. The high-resolution optics allowed for the precise identification of small and complex structures within the brain, facilitating detailed study and documentation.

Documentation and analysis

Throughout the dissection process, detailed notes and high-resolution images were captured. These records included precise measurements of the vascular structures and observations of the anatomical variations of the anterior communicating complex. The data collected were meticulously analyzed to identify any significant anatomical patterns and variations. The use of digital imaging and detailed documentation ensured that the findings could be accurately recorded and analyzed.

Ethical considerations

All procedures were conducted following stringent ethical guidelines for the use of human tissues in research. Informed consent was obtained from the next of kin for the use of the deceased individuals' brains for research purposes. The study protocol was reviewed and approved by the relevant ethical review board, ensuring compliance with ethical standards and respect for the dignity of the deceased individuals.

Data analysis

The data collected from the dissections were subjected to rigorous statistical analysis to identify significant patterns and variations in the anatomical structures. Descriptive statistics were employed to summarize the findings, providing a comprehensive overview of the anatomical features of the anterior communicating complex in the studied population. Comparative analyses were also conducted to explore potential differences between male and female specimens.

RESULTS

In our study, the RAH was identified in 28 of the 30 hemispheres examined. Among these, 11 hemispheres exhibited a double artery configuration, while 17 hemispheres had a single artery.

The most common origin of the RAH was the juxta-communicating segment, followed by the A2 segment and the A1 segment [Figures 1 and 2]. In two hemispheres, the RAH originated from the frontopolar artery [Figure 3]. The trajectories observed for the RAH were consistent with those described in the literature: the "L" trajectory (initially backward then outward), inverted "L" (outward then backward), oblique (diagonal and posterolateral), and sinuous (anteroposterior curvatures along the extracerebral segment), with the oblique trajectory being the most common [Table 1].

The relationship of the RAH varied based on its trajectory: the "L" and oblique trajectories were associated with the A1 segment and the rectus gyrus of the frontal lobe; the inverted "L" trajectory was related to the olfactory tract and olfactory sulcus; and the sinuous trajectory was mostly related to the rectus gyrus of the frontal lobe.

In two cases where the RAH was absent, an accessory MCA (AMCA) was observed, which emitted some branches to the

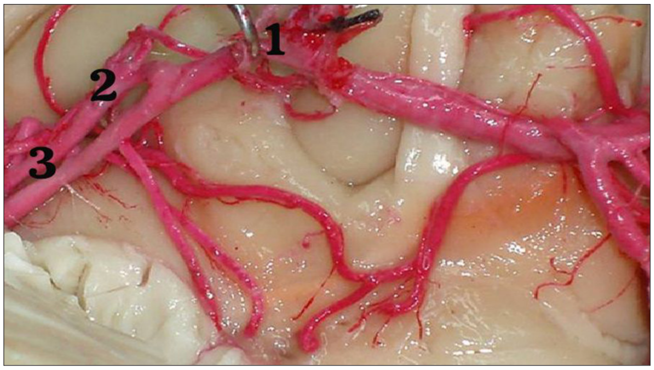

Figure 1: (1) ACoA, (2) Heubner's recurrent artery "L" inverted, (3) Sinus trajectory of RA

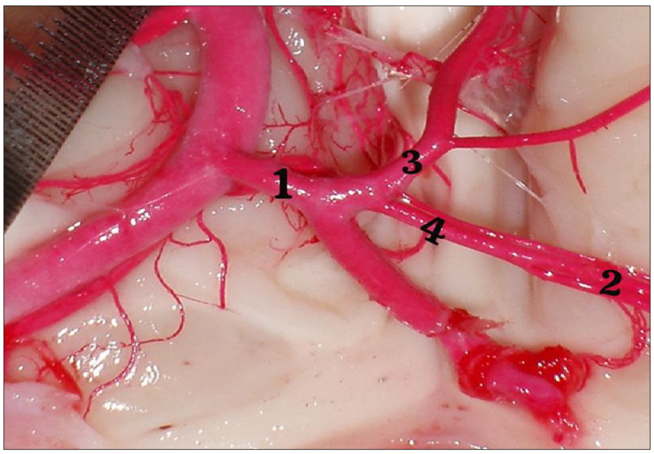

Figure 2: (1) ACoA, (2) Sinus trajectory of Heubner's artery, (3) Frontobasal trunk, (4) Double Heubner's artery.

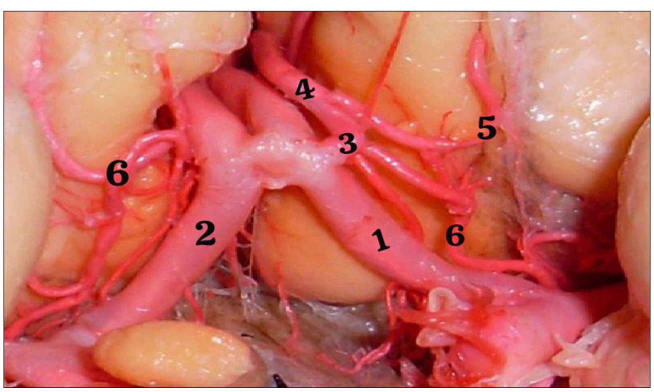

Figure 3: (1) Left hypoplastic A1, (2) Right A1, (3) Frontobasal trunk, (4) Frontopolar artery, (5) Fronto-orbital artery, (6) Heubner's recurrent artery.

anterior perforated substance before traveling parallel to the MCA [Figure 4]. One case showed the RAH originating from a common trunk with the frontopolar artery, and another case from a common trunk with the frontal-orbital artery, corresponding to a double RAH.

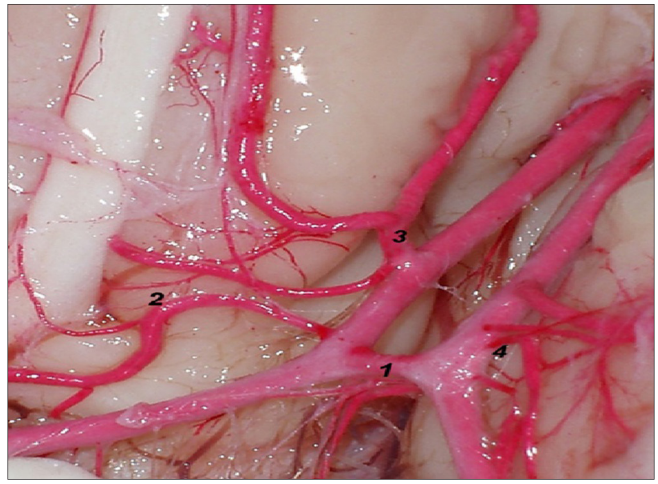

Figure 4: (1) Right A1 segment, (2) Branches to anterior perforated substance, (3) accessory middle cerebral artery, (4) Double Heubner's artery.

DISCUSSION

The RAH plays a critical role in cerebral vascular anatomy, and understanding its microsurgical anatomy is paramount for both clinical and surgical applications. This cadaveric study offers significant insights into the anatomical variations and trajectory patterns of the RAH, which can profoundly impact neurosurgical procedures, especially those involving the ACA and ACoA complex. The importance of such studies cannot be overstated, as they provide a foundational understanding necessary for improving surgical outcomes and developing more effective treatment strategies for cerebrovascular diseases.[3-6]

In our study, the RAH was identified in 28 out of the 30 hemispheres examined. Among these, 11 hemispheres exhibited a double artery configuration, while 17 hemispheres had a single artery. The most common origin of the RAH was the juxta-communicating segment, followed by the A2 segment and the A1 segment. In two hemispheres, the RAH originated from the frontopolar artery.

Cadaveric studies are essential in the field of neuroanatomy and neurosurgery for several reasons. First, they offer an unparalleled opportunity to study the intricate details of human anatomy in a controlled environment. Unlike imaging studies, cadaveric dissections allow for direct visualization and manipulation of anatomical structures, providing a level of detail and accuracy that is critical for understanding complex vascular networks like the RAH. This direct observation is invaluable for identifying variations in anatomy that can significantly affect surgical planning and outcomes.[17-19]

Moreover, cadaveric studies help bridge the gap between theoretical knowledge and practical application. For neurosurgeons, familiarity with the variations and course of the RAH can be the difference between a successful surgery and one with significant complications. By providing a detailed map of possible anatomical variations, cadaveric studies equip surgeons with the knowledge to anticipate and manage potential challenges during surgery.[18]

Microsurgical anatomy of the RAH

The RAH, also known as Heubner's artery, is a significant vessel that arises from the ACA. It is typically the largest of the perforating medial lenticulostriate arteries and has a crucial role in supplying blood to various deep brain structures, including the head of the caudate nucleus, the medial portion of the globus pallidus, and the anterior crus of the internal capsule.[5,19] Understanding its microsurgical anatomy is vital for several reasons:

Surgical planning and execution

Knowledge of the RAH's typical and variant courses aids in surgical planning. For example, in procedures involving aneurysms of the ACoA, preserving the RAH is crucial to prevent postoperative neurological deficits. Our study found that the RAH most commonly originates from the juxta-communicating segment, followed by the A2 and A1 segments. This knowledge helps surgeons anticipate its location and trajectory during surgery.[20]

Avoidance of intraoperative complications

The detailed trajectory patterns observed, such as the "L" trajectory, inverted "L," oblique, and sinuous trajectories, provide a roadmap for surgeons. Understanding these patterns helps in avoiding inadvertent damage to the RAH during frontal lobe retraction or aneurysm clipping. Our findings, showing the prevalence of the oblique trajectory, guide surgeons in anticipating the artery's path relative to critical structures such as the olfactory tract and gyrus rectus.[20,21,25]

Clinical implications of variations

Anatomical variations, such as the presence of a double RAH or its absence in some cases, can have significant clinical implications. For instance, the absence of the RAH was associated with an AMCA supplying the anterior perforated substance. Such variations must be recognized preoperatively to avoid misinterpretation during angiography and unexpected complications during surgery.[22,23]

Comparison with previous studies

Our study identified the RAH in 28 out of 30 hemispheres (96.7%), which is consistent with the high presence rates reported in other studies. Boongird *et al.*[3] (98.03%) and Rhoton *et al.*[37] (93%) reported similarly high detection rates, underscoring the consistency in identifying this artery across various populations and methodologies.[12,14] The origins of the RAH in our study (juxta-communicating segment 44%, A2 segment 21%, and A1 segment 5%) show some divergence from previous findings. For instance, Kedia *et al.*[18] reported higher frequencies of A2 origins (80%), while Maga *et al.*[21] found a more balanced distribution among origins. This variability emphasizes the importance of population-specific anatomical data and methodological differences in identifying arterial origins [Table 2].[15]

Our detailed documentation of RAH trajectory patterns (L, inverted L, oblique, and sinuous) supports previous observations. For example, Pai *et al.*[31] described similar trajectory patterns in an Indian population, indicating commonality in the anatomical course of RAH across different ethnic groups. The predominance of the oblique trajectory in our study adds to the body of knowledge, providing surgeons with critical insights into the typical and variant pathways of RAH.[18]

Anatomical variations

The presence of double RAHs in 11 hemispheres (36.7%) aligns with previous reports of multiple RAH configurations. Yasargil and Rhoton[47] documented multiple RAHs in their studies, indicating that this variation is relatively common and must be anticipated during surgical planning. Moreover, our observation of RAH originating from the frontopolar artery in two cases (6.7%) highlights a rare but significant variation, which underscores the need for vigilance in identifying atypical origins during neurovascular interventions.[13,14]

Gender differences

Our study also highlights subtle gender differences in RAH anatomy. Men exhibited a higher frequency of RAH originating from the juxta-communicating segment (46.4%), while women showed a higher incidence of A2 origins (54.5%). In addition, trajectory patterns varied, with oblique trajectories more common in men and L trajectories more prevalent in women. These findings suggest that gender-specific anatomical data could enhance surgical planning and reduce the risk of complications.

Comparative anatomical data

When compared to previous large-scale studies, such as those by Zhu *et al.*[49] and Pai *et al.*,[31] our findings on the average length of RAH (24.2 mm) and branch range (1–9) are consistent, reinforcing the reliability of our data and its applicability in clinical settings. These comparisons validate our methodology and results, emphasizing the critical role of comprehensive anatomical studies in refining surgical techniques and improving patient outcomes.[16,18]

Table 1: Gender comparison.

Category	Men	Women
Presence	100 percent	80 percent
Origin: A1	3.6 percent	9.19 percent
Origin: Juxta-communicating	46.4 percent	36.4 percent
Origin: A2	35.7 percent	54.5 percent
Origin: Fronto-polar artery	14.3 percent	0 percent
Trajectory: 'L'	28.6 percent	36.4 percent
Trajectory: Inverted 'L'	10.7 percent	18.2 percent
Trajectory: Oblique	46.4 percent	18.2 percent
Trajectory: Sinuous	14.3 percent	27.2 percent
Length: Average (mm)	24.5 mm	25.8 mm
Length: Range (mm)	13.6-36.7 mm	18.7-32.0 mm
Branches: Average	4.2	5.2
Branches: Range	1-8	2-9
Double recurrent artery	40 percent	30 percent

Pathologies involving the RAH

Several pathologies can affect the RAH, each with significant clinical consequences:

Aneurysms

Aneurysms involving the ACoA complex can have a direct impact on the RAH. Intraoperatively, it is critical to preserve the RAH while clipping the aneurysm to prevent ischemia in its vascular territory. Our study highlights the importance of identifying the RAH's origin and trajectory to safeguard it during such procedures.[24,26] Advanced techniques such as intraoperative ICG angiography and Doppler vascular flow assessment are invaluable in ensuring the artery's patency postclipping.[27]

Ischemic stroke

The RAH's supply to key structures such as the caudate nucleus and internal capsule means that occlusion or damage to this artery can result in significant neurological deficits, including motor and cognitive impairments.[28] Detailed anatomical knowledge from cadaveric studies helps in diagnosing and managing such strokes. For example, targeted interventions can be planned to restore blood flow in case of ischemic events affecting the RAH.[29]

Vascular malformations

Arteriovenous malformations (AVMs) involving the RAH can pose significant surgical challenges. Understanding the artery's course and its anastomoses with other lenticulostriate arteries is crucial for successful surgical resection of AVMs.[30] Our findings on the RAH's course and its connections with other vessels provide critical information for planning such complex surgeries.

Clinical and surgical applications

The findings from this study have several direct applications in clinical and surgical settings:

Aneurysm clipping and bypass surgery

Detailed knowledge of the RAH's anatomy helps in safely performing aneurysm clipping and cerebrovascular bypass surgeries. Preservation of the RAH during these procedures is essential to prevent postoperative deficits. Our study's detailed anatomical maps assist surgeons in planning and executing these complex interventions.[31-34]

Endovascular procedures

For interventional radiologists, understanding the precise anatomical variations of the RAH aids in the accurate deployment of endovascular devices such as stents and coils. This knowledge is crucial in minimizing procedural complications and improving the success rates of interventions involving the ACA and ACoA complex.[35-37]

Neuroimaging and diagnostics

Enhanced anatomical knowledge from cadaveric studies improves the interpretation of neuroimaging studies. Radiologists can better identify and differentiate between normal anatomical variations and pathological changes, leading to more accurate diagnoses.[38]

Educational value

For medical students and neurosurgical trainees, cadaveric studies provide an invaluable educational tool. They offer hands-on experience and a deep understanding of neuroanatomy that is essential for developing surgical skills. Our study's comprehensive documentation of the RAH's anatomy serves as a detailed reference for educational purposes.[25,39]

Comparative anatomy and population differences

Our findings show some differences compared to other studies, such as those by Yasargil and Rhoton. These differences highlight the importance of considering population-specific anatomical data in surgical planning and research. For example, our observation that the RAH originated from the frontopolar artery in a subset of cases emphasizes the need for surgeons to be aware of such

Table 2: Comparative series.

Study	Presence (percent)	Origin (A1, Juxta-communicating, A2)	Average length (mm)	Trajectory	Average branches	Multiple recurrent artery (percent)
Boongird *et al.*[3]	98.03	7.7 percent, 31.9 percent, 60.4 percent	2 mm	Anterior: 2 percent, Lateral: 91.1 percent, Posterior: 6.9 percent	-	10 (Double), 5 (Triple)
Yasargil *et al.*[47]	95	1.5 percent, 38 percent, 25 percent	-	Superior: 71 percent, Anterior: 25 percent, Posterior: 4 percent	-	17 (Double)
Rhoton *et al.*[37]	93	14 percent, 8 percent, 78 percent	-	-	-	35 (Double)
Kedia, Shweta *et al.*[18]	-	6.66 percent, 13.33 percent, 80 percent	0.2 mm	Superior: 60 percent, Anterior: 30 percent, Posterior: 10 percent	-	26.6 (Double)
Zhu, H., *et al.*[49]	-	8.9 percent, 41.6 percent, 49.5 percent	4 mm	Superior: 32.7 percent, Anterior: 59.4 percent, Posterior: 7.9 percent	-	33.3 (Double), 5.6 (Triple)
P. Maga *et al.*[21]	98.55	26.2 percent, 40 percent, 33.8 percent	25.2 mm	Superior: 61 percent, Anterior: 32 percent, Inferior: 24.6 percent, Posterior: 3 percent	-	43.5 (Double), 24.6 (Triple), 2.2 (Quadruple)
Pai *et al.*[31]	-	10 percent, 60 percent, 15 percent	-	"L": 31 percent, Inverted "L": 13 percent, Sinuous: 18 percent, Oblique: 38 percent	-	-
Gervith *et al.* (Present study)	96.7	5 percent, 44 percent, 21 percent	24.2 mm (13.6-36.7)	Trajectory: 'L' 28.6 percent, Trajectory: Inverted 'L' 10.7 percent, Trajectory: Oblique 46.4 percent, Trajectory: Sinuous 14.3 percent	3.9 (1-9)	20 (Double)

variations when operating on patients from different ethnic backgrounds.[4,8]

Future directions

The insights gained from this study open several avenues for future research. Longitudinal studies on the development and variations of the RAH in different populations can provide deeper insights into the evolutionary and developmental aspects of cerebral vasculature. In addition, integrating cadaveric study findings with advanced imaging techniques such as high-resolution magnetic resonance imaging (MRI) and computed tomography (CT) angiography can enhance our understanding of the dynamic aspects of cerebrovascular anatomy.[40-43]

Further research into the functional implications of RAH variations can also lead to improved clinical outcomes. For instance, studying the correlation between specific RAH trajectories and the incidence of ischemic strokes or aneurysms can help in developing predictive models for cerebrovascular risk assessment. Such models can be crucial in the early diagnosis and prevention of cerebrovascular diseases.[43,44]

Integrating 3D models in cadaveric studies

The use of 3D models in anatomical studies, especially those involving complex vascular structures like Heubner's recurrent artery, presents a significant advancement in both the visualization and analysis of anatomical variations. Integrating 3D modeling techniques with traditional cadaveric dissection offers a comprehensive approach to studying intricate anatomical features, providing enhanced visualization, improved analysis, and enriched educational opportunities.[45,46]

Enhanced visualization and analysis

3D models provide an unparalleled level of detail and accuracy in visualizing anatomical structures. In the context of Heubner's recurrent artery, creating 3D models from cadaveric dissections can significantly enhance the understanding of its origin, trajectory, and variations. These models can be generated using high-resolution imaging techniques such as MRI and CT scans, followed by reconstruction using specialized software.[47-49]

Limitations of the study

Sample size and demographic limitation

The study involved only 15 human brains, which may not represent the broader population. Variations in the anatomy of the RAH across different ethnicities and larger sample sizes were not explored, limiting the generalizability of the findings.

Fixed cadaveric specimens

The use of fixed cadaveric specimens may not perfectly replicate the *in vivo* conditions. The fixation process can alter the natural anatomical relationships and the physical properties of the tissues, potentially affecting the accuracy of measurements and observations.

Absence of functional analysis

The study focused solely on anatomical descriptions without assessing the functional implications of the observed variations. Understanding the clinical impact of these variations on blood flow and neurological function was not within the scope of this research.

Lack of longitudinal data

The study provides a snapshot of anatomical variations but does not account for potential changes over time or with aging. Longitudinal studies would be necessary to understand how these anatomical features might evolve.

Limited technological integration

Although the study utilized advanced dissection techniques and microscopy, it did not incorporate modern imaging modalities such as high-resolution MRI or CT angiography, which could have provided additional insights and validation of the anatomical findings.

Potential observer bias

The dissection and analysis were conducted by a limited number of researchers, which could introduce observer bias. Independent validation by other researchers or the use of automated measurement techniques could enhance the reliability of the findings.

Exclusion criteria impact

Strict inclusion criteria excluded brains with any neurological conditions or damage to the anterior communicating complexes. While this ensured the integrity of the samples, it also means that the study does not address how pathological conditions might affect the anatomy of the RAH.

Gender disparities

The sample included more males (10) than females (5), which may affect the comparative analysis and conclusions regarding gender differences in the anatomy of the RAH.

Absence of clinical correlation

The study did not correlate anatomical findings with clinical outcomes or surgical data, which would have provided practical relevance to the anatomical variations observed.

CONCLUSION

The HRA is a constant artery. The HRA artery may present as a single or double. The ACA is not the only possible origin of the HRA, but also it can originate from the frontopolar artery. The HRA may have four types of trajectories, and the most common is oblique trajectory. The HRA has an average length of 24.2 mm and emits from 1 to 9 branches in the extracerebral segment. There are slight differences between the anatomies of the HRA in men than in women. The most common origin in males of HRA was the YC segment, while in the women, are A2 segment. In men, the most common trajectory is oblique and in women are "L" trajectory. The presence of HRA is linked up to half of the cases with variants of the anterior communicating complex.

Ethical approval: This study was approved by the Ethics Committee of the National Cancer Institute on January 30, 2024.

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