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ORIGINAL ARTICLE

Cerebral CT angiography findings: A single-center observational study.

Carlos Jacinto Valle Ochoa [1] ID *, Yoel Enrique Pinto Mejía [1] ID, Paola González Pazmiño [1] ID, Carmen Matilde Navas Palma [1] ID, Jean Carlos Galló Valverde [1] ID, Stalin Santiago Celi Simbaña [1] ID

1. Imaging Service, Alcívar Hospital, Guayaquil, Ecuador.

Abstract

Introduction: This study aims to review the indications for CT angiography and the findings obtained at Alcívar Hospital, encouraging the study and understanding of complex cerebral vascularization.

Methodology: This is a descriptive study, and the findings are presented in tables and graphs. An atlas was created with images obtained through volumetric reconstructions.

Results: A total of 190 CT angiography records were analyzed. The most common CT findings were anatomical variants (28.9%), aneurysms (4.7%), and arteriovenous malformations (3.2%). Vertebral artery hypoplasia (14.2%), a posterior cerebral artery of fetal origin (10.5%), vertebral agenesis (3.2%), and agenesis of the A1 segment of the anterior cerebral artery (3.2%) were the most frequently found anatomical variants.

Conclusions: The results obtained are consistent with those of similar studies. Although cerebral circulation is complex, it is possible to understand it and perform an efficient evaluation to safeguard patient integrity.

Keywords:

Cerebral CT angiography, Anatomical variants, Aneurysms, Arteriovenous malformations.

Abbreviations

ACA: anterior cerebral artery.

Additional information

No supplementary materials are declared.

Acknowledgments

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Authors' contributions

Carlos Jacinto Valle Ochoa: Conceptualization, research, writing—original draft, resources, software, supervision.

Yoel Enrique Pinto Mejía: Conceptualization, research, writing—original draft, resources, software, supervision.

Paola González Pazmiño: Conceptualization, research, writing – original draft, resources, software, supervision.

Carmen Matilde Navas Palma: Methodology, Data curation, Formal analysis, Funding acquisition, Project administration.

Jean Carlos Galló Valverde: Validation, Visualization, Writing – review and editing.

Stalin Santiago Celi Simbaña: Research, Writing – original draft, Resources, Software, Supervision.
All the authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets used and analyzed during the present study are available from the corresponding author upon reasonable request.

Introduction

Computed tomography angiography is predominantly utilized in most medical institutions to assess cerebral circulation initially in cases of cerebral infarction, subarachnoid hemorrhage, and during both pre- and postsurgical evaluations. Understanding the variants of normality and different subtypes of arteriovenous malformations and identifying the presence of aneurysms are crucial for selecting the appropriate therapy. High spatial resolution three-dimensional (3D) sequences, maximum intensity projection (MIP), and axial sequences of the skull base in a bone window enhance the identification of the greatest number of variants and anomalies [1].

Variants of normal size include fenestrations, duplications, and patent fetal arteries. The prevalence and clinical relevance of aneurysms are critical, especially if aneurysm formation is risky. The connection between fenestration and aneurysm formation is well established. Digital subtraction angiography is the gold standard for excluding intracranial vascular abnormalities. However, computed tomography angiography boasts high sensitivity and specificity of up to 90% and 93%, respectively [1].

Vascular lesions are primarily of congenital origin. They can be categorized into arteriovenous malformations, pial or dural malformations, cavernous hemangiomas, capillary telangiectasias, and developmental venous anomalies. CT angiography assists in differentiating between these entities. Depending on the risk-benefit assessment, treatment for arteriovenous malformations may involve surgery. However, developmental venous anomalies do not require treatment. Consequently, an accurate imaging diagnosis is essential for the patient's clinical and surgical outcomes [2].

Computed tomography angiography is a well-known tool for diagnosing intracranial aneurysms and planning surgical therapy. This is the first examination for a patient with a sudden onset of severe headache when a vascular etiology is suspected. If a subarachnoid hemorrhage is evident, the bleeding site must be identified. Although it is the most sensitive diagnostic method for detecting aneurysms, subtraction angiography is invasive. The sensitivity of computed tomography angiography ranges from 80% to 97%, depending on the size and location of the aneurysm. 3D reconstruction is the most widely used postprocessing tool [3].

Technological advances in image acquisition techniques and postprocessing analysis during the performance of CT angiography have positioned this imaging method as one of the primary and essential methods in the initial evaluation of patients with cerebrovascular accidents. Although it has not surpassed cerebral subtraction angiography as the gold standard for diagnosing many pathologies, it is a rapid, noninvasive examination that enables therapeutic decisions to be made in minutes [4]. This study aims to present the main cerebral angiographic variants and their most frequent indications.

Materials and methods

Study design

This study is observational. The source is retrospective.

Scenery

The study was conducted at the Imaging Service of Alcívar Hospital in Guayaquil, Guayas Province, from August 1, 2023, to August 31, 2024.

Participants

Records of adult patients with indications for cerebral CT angiography were included. No patients were excluded.

Variables

The variables were the type of indication for the study and the tomographic findings. Representative images are shown.

Data sources/measurements

The source was indirect; an electronic form was completed using data from the institutional medical records. The findings from the CT angiograms were analyzed and categorized into the following groups.

- Tomographic findings:

1. Dural fistula.
2. Absence of flow.
3. Postsurgical control.
4. Normal
5. Aneurysm.
6. Anatomical variant.
7. Thrombosis.
8. Arteriovenous malformations
9. Others.
10. Decreased flow.
11. Brain death.
12. Arteriovenous fistula.

In cases where a relevant finding was identified, volumetric reconstructions were performed, and an atlas was created with the obtained images. The group of patients who had an anatomical variant was subclassified based on the type of variant identified:

1. Duplication of the anterior communicating artery.
2. Agenesis of the anterior communicating artery.
3. Agenesis of one of the vertebral arteries.
4. Posterior cerebral artery of fetal origin.

5. Hypoplasia of one of the vertebral arteries.
6. The posterior communicating artery originates from the middle cerebral artery.
7. Vertebral artery fenestration.
8. Hypoplasia of segment A1 of the Anterior Cerebral Artery.
9. Azygos anterior cerebral artery.
10. The anterior cerebral artery originates from the middle cerebral artery.
11. Bilateral P1 segment hypoplasia. (Bilateral posterior cerebral artery of fetal origin).
12. Agenesis of the A1 segment of the anterior cerebral artery.
13. Asymmetry of the internal carotid arteries.
14. Vertebral artery originating from the external carotid artery.
15. Extracranial posterior inferior cerebellar artery.
16. Hypoplasia of one of the anterior cerebral arteries.

Biases

The application of the participant selection criteria avoided observation and selection bias. To mitigate potential interviewer, informational, and recall biases, the principal investigator maintained the data consistently via a guide and records approved in the research protocol. Two researchers independently analyzed each record in duplicate, and the variables were entered into the database after verifying their concordance.

Study size

The sample was nonprobabilistic and census-type, and all incident cases from the study period were included.

Quantitative variables

Descriptive statistics were used. The results are expressed as frequencies and percentages. Scale variables were not converted to categorical variables.

Statistical analysis

Qualitative variables are presented as frequencies and percentages.

Results

Participants

A total of 190 cases were reviewed.

Main characteristics of the study group

Normality was found in 54.7% of the sample (n = 104). Anatomical variants were the most frequent finding at 28.9% (n = 55). Aneurysms were detected in 9 patients, representing 4.7% of the sample. Arteriovenous malformations were found in 6 patients, accounting for 3.2% of the sample. Six patients underwent postoperative control, constituting 3.2% of the sample. Two patients (1.1% of the sample) presented without flow. Dural fistulas, decreased flow, arteriovenous fistulas, and brain death were each found in 0.5% of the samples (n = 1) for the respective pathologies (Table 1), (Figure 1).

The most common anatomical variant was hypoplasia of one vertebral artery, observed in 27 patients and represented 14.2% of the sample. Regarding frequency, 20 patients (10.5% of the sample) had one of the posterior cerebral arteries of fetal origin. Six patients (3.2% of the sample) exhibited agenesis of one of the vertebral arteries. In comparison, another six patients (3.2% of the sample) had agenesis of the A1 segment of one of the anterior cerebral arteries. Three patients (1.6% of the sample) presented hypoplasia of the A1 segment of one of the anterior cerebral arteries, and three patients (1.6% of the sample) presented asymmetry of the internal carotid artery. Two patients (1.1% of the sample) had anterior communicating artery duplication, whereas another two patients (1.1%) exhibited a fenestrated vertebral artery. Additionally, two patients (1.1%) had an azygos anterior cerebral artery. One patient (0.5%) with each anomaly presented with agenesis of the anterior communicating artery, a posterior communicating artery originating from the middle cerebral artery, an anterior cerebral artery originating from the middle cerebral artery, bilateral P1 segment hypoplasia, a vertebral artery originating from the external carotid artery, an extracranial PICA, and hypoplasia of one of the anterior cerebral arteries (Table 2) (Figure 2).

Table 1. Findings found in the angiotomography.

Find	Frequency n=190	%
Normal	104	54.7%
Anatomical variant	55	28.9%
Aneurysm	9	4.7%
Postsurgical control	6	3.2%
Arteriovenous malformation	6	3.2%
Others	4	2.1%
Absence of flow	2	1.1%
Arteriovenous fistula	1	0.5%
Dural fistula	1	0.5%
Decreased flow	1	0.5%
Brain death	1	0.5%

Table 2. Anatomical variants found in CT angiography.

	Frequency n=190	%
Not reported	112	58.9%
Hypoplasia of the vertebral column	27	14.2%
Posterior Cerebral Artery of Fetal Origin	20	10.5%
Agenesis of Vertebral Agenesis	6	3.2%
A1 agenesis of ACA	6	3.2%
ACA Hypoplasia A1	3	1.6%
ACI asymmetry	3	1.6%
Duplication A. Previous Com	2	1.1%
Fenestrated vertebral art.	2	1.1%
Anterior Cerebral Art. Azygos	2	1.1%
Agenesis A. Com Previous	1	0.5%
Art. Com post by ACM	1	0.5%
ACA of ACM	1	0.5%
Bilateral P1 hypoplasia	1	0.5%
Vertebral Art. of ACE	1	0.5%
Extracranial PICA	1	0.5%
ACA Hypoplasia	1	0.5%

A short-necked, saccular aneurysm was found in the posterior communicating segment of the left internal carotid artery. A wide-based aneurysm was identified in the anterior communicating artery. A fusiform aneurysm was detected in the M1 segment of the right middle cerebral artery and the distal segment of the right internal carotid artery. A frontopolar aneurysm was present in the right pericallosal branch. An aneurysm was observed in the superficial temporal artery. An additional aneurysm was noted in the M2 segment of the right middle cerebral artery. There was an aneurysm of the internal carotid artery above the left posterior communicating artery. A fusiform aneurysm was present in the right vertebral artery. An aneurysm was located at the top of the basilar artery, and aneurysms of the posterior communicating segments of the right and left internal carotid arteries were observed in a single patient. Arteriovenous malformations were discovered in the right frontal region, the right and left parietal regions, the right occipital subgaleal level, and the right occipital region. The atlas containing images of the most relevant findings and variants of normality can be found in Annex 1.

Figure 1. Findings found in the angiotomography.

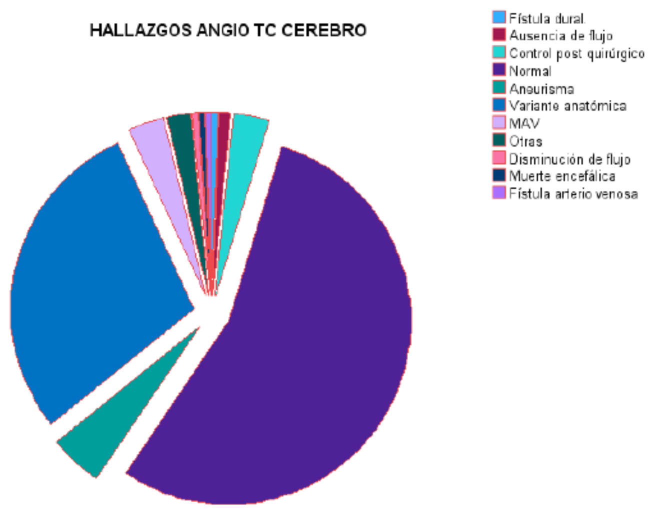
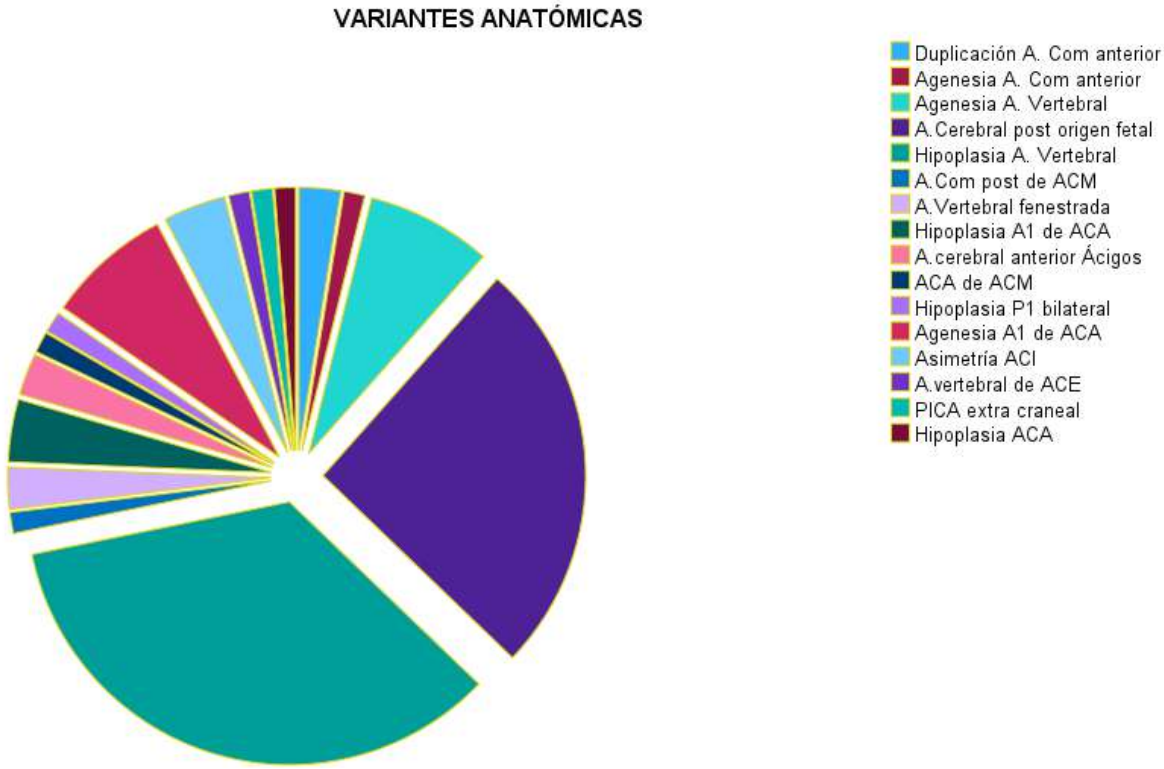


Figure 2. Anatomical variants found in cerebral CT angiography.



ACA: anterior cerebral artery

Discussion

The classic circle of Willis, which we define as normal, is found in only 20–25% of patients [4]. This fact explains why this study's most common angiotomographic finding was the finding of at least one normality variant. They are usually incidental findings when a patient is studied for aneurysms, stenosis, vascular occlusions, etc. [5].

The clinical impact depends on the variant found, although in most cases, patients are asymptomatic. Some variants are significant in cerebral infarctions, such as the fetal origin of the posterior cerebral artery. Since it flows from the anterior cerebral circulation, it is affected in instances of interruption or reduction in flow from the internal carotid or middle cerebral artery. A total of 10.5% of the samples presented this variant in one of the cerebral hemispheres, whereas 0.5% presented it in both cerebral hemispheres. Similar studies reported that 10% of the cases were unilateral and 8% were bilateral [6].

When there is a single anterior cerebral artery or azygos artery, the bilateral anterior cerebral territory experiences hypoperfusion in the event of occlusion. In this study, 1.1% of the population had this variant of normality, compared with 0.2- 4% reported in similar studies [7].

Hypoplasia of one vertebral artery was found in 14.2% of the samples. Patients with this variant are more likely to experience lateral medullary or inferior cerebellar artery infarction [8]. Healthy individuals with vertebral hypoplasia may also experience abnormal evoked myogenic vestibular potentials [9]. Similar studies found this variant in 2.6% of cases [10- 11].

The prevalence of anterior communicating artery duplication is 18% [12]. Its fenestration is found in 12–21% of autopsies and 5.3% of angiograms [13]. In this study, the anterior communicating artery was duplicated in 1.1% of the samples. No fenestration was observed.

Fenestration of the A1 segment of the anterior cerebral artery occurs in 0–4% of fetuses according to anatomical studies and 0.58% according to angiography [14]. Fenestration of the A2 segment was found in 2% of fetuses [15]. The reported prevalence of middle cerebral artery duplication is 0.2–2.9% [6]. Its fenestration has been reported in 1% of autopsies and 0.17% of angiographies, mainly in the M1 segment [7]. None of these variants were found in this study; however, the emergence of the anterior communicating artery from the middle cerebral artery, hypoplasia and agenesis of the A1 segment of the anterior cerebral artery, the anterior cerebral artery originating from the middle cerebral artery, and hypoplasia of the anterior cerebral artery were observed. Basilar artery fenestration has been found in 0.6% of angiographies and 5% of autopsies. It is commonly located near the vertebrobasilar junction 9]. Vertebral artery fenestration has been reported in 0.3–2% of cases [10– 11]. This study revealed vertebral artery fenestration in 1.1% of the samples.

The prevalence of intracranial aneurysms in the general population is between 1.5% and 8%. Multiple aneurysms may occur in up to 20% of patients [12]. The sensitivity of CT angiography for detecting aneurysms can reach 90% [13]. In this study, aneurysms were found in 4.5% of the sample, and 10% of these patients had multiple aneurysms.

Arteriovenous malformations affect 0.01 to 0.5% of the population [14]. This finding was observed in 3.2% of the samples. They occur in more than 50% of patients with intracranial hemorrhage, with an annual risk of bleeding of 1.5-3%. After the first bleeding event, the mortality rate can reach 10%, which increases with each subsequent episode [15]. In this study, no bleeding was observed in any of the patients. Future studies should evaluate the impact of Angiotac contrast agents on renal function [16 - 17].

Conclusions

The CT angiography findings of the cerebral circulation found in this study are similar to those published elsewhere. Anatomical variants are the most common. Within this group, the most common abnormalities were vertebral hypoplasia, a posterior cerebral artery of fetal origin, vertebral agenesis, and agenesis of the A1 segment of the anterior cerebral artery.

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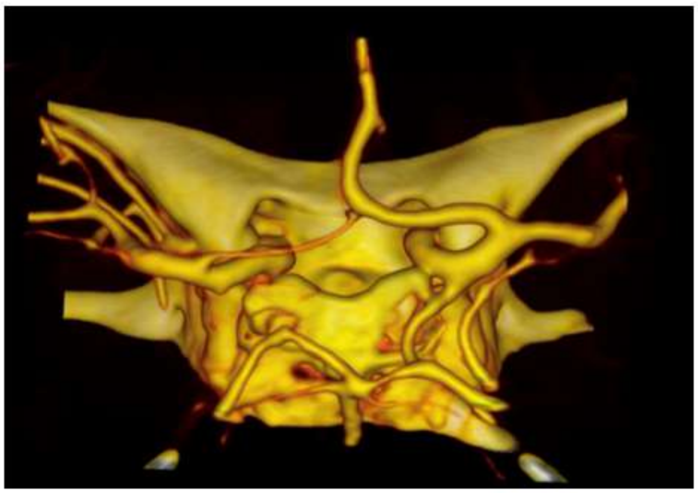
Figura 3. Arteria cerebral anterior ácigos.



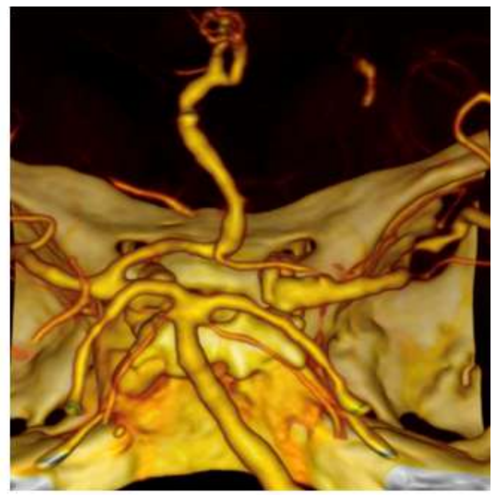


Figura 4. Agenesia del segmento A1 de la arteria cerebral anterior.

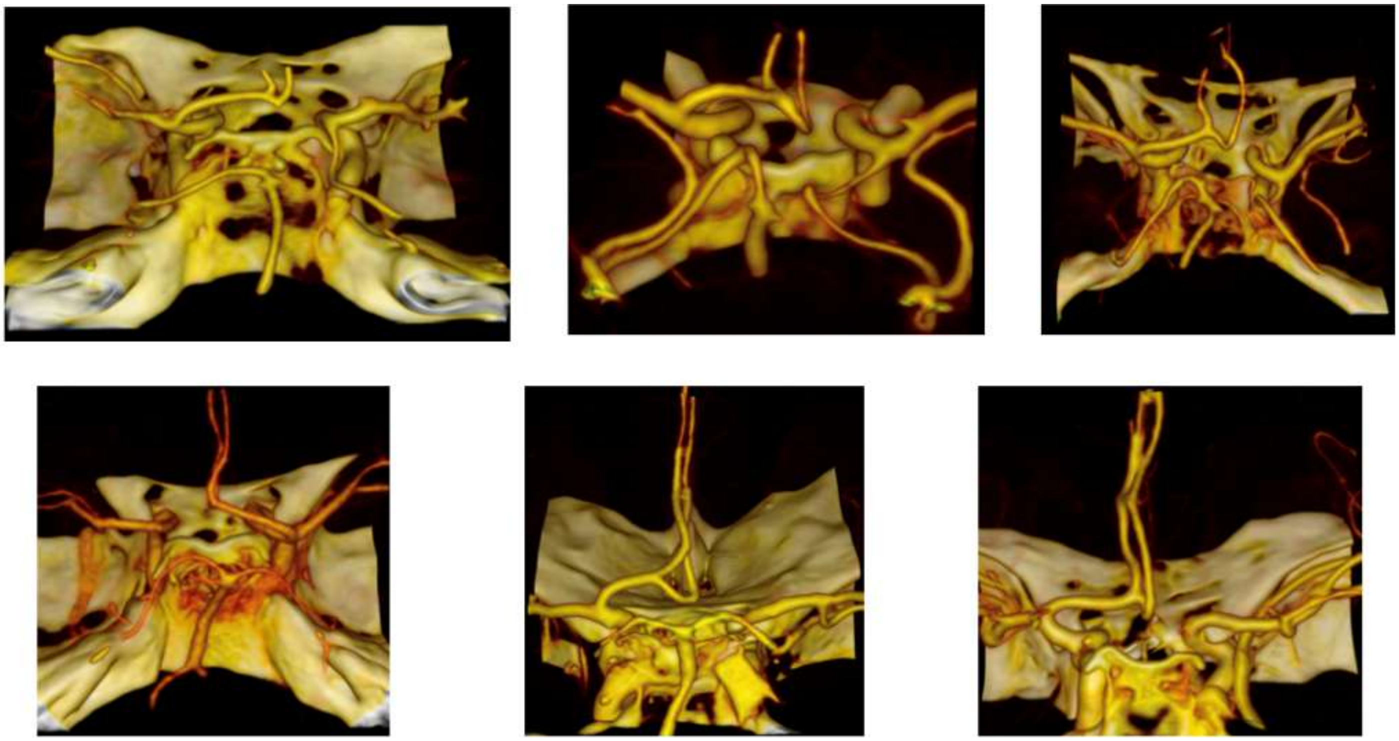


Figura 5. Hipoplasia del segmento A1 de la arteria cerebral anterior.

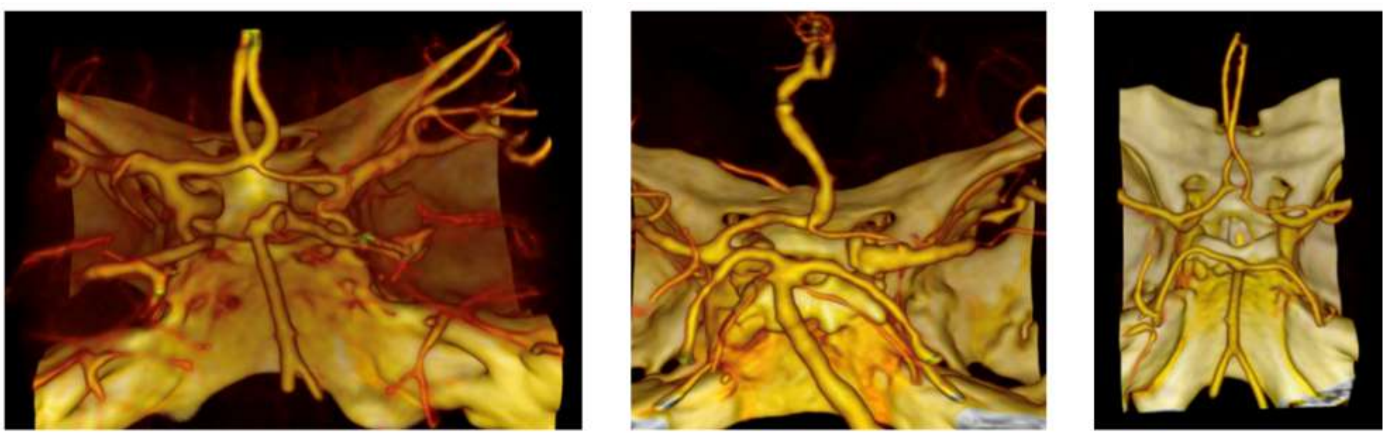


Figura 6. Hipoplasia de la arteria cerebral anterior.

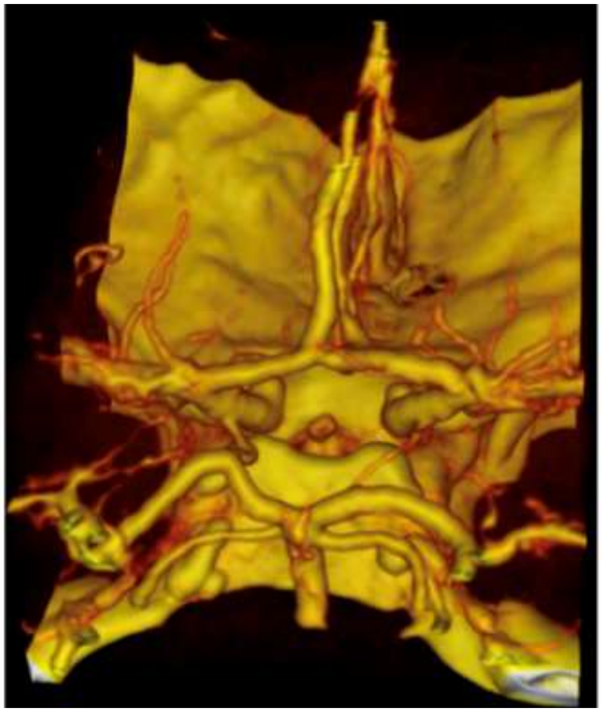


Figura 7. Nacimiento de la arteria cerebral anterior de la arteria cerebral.

Figura 8. Duplicación de la arteria comunicante anterior.

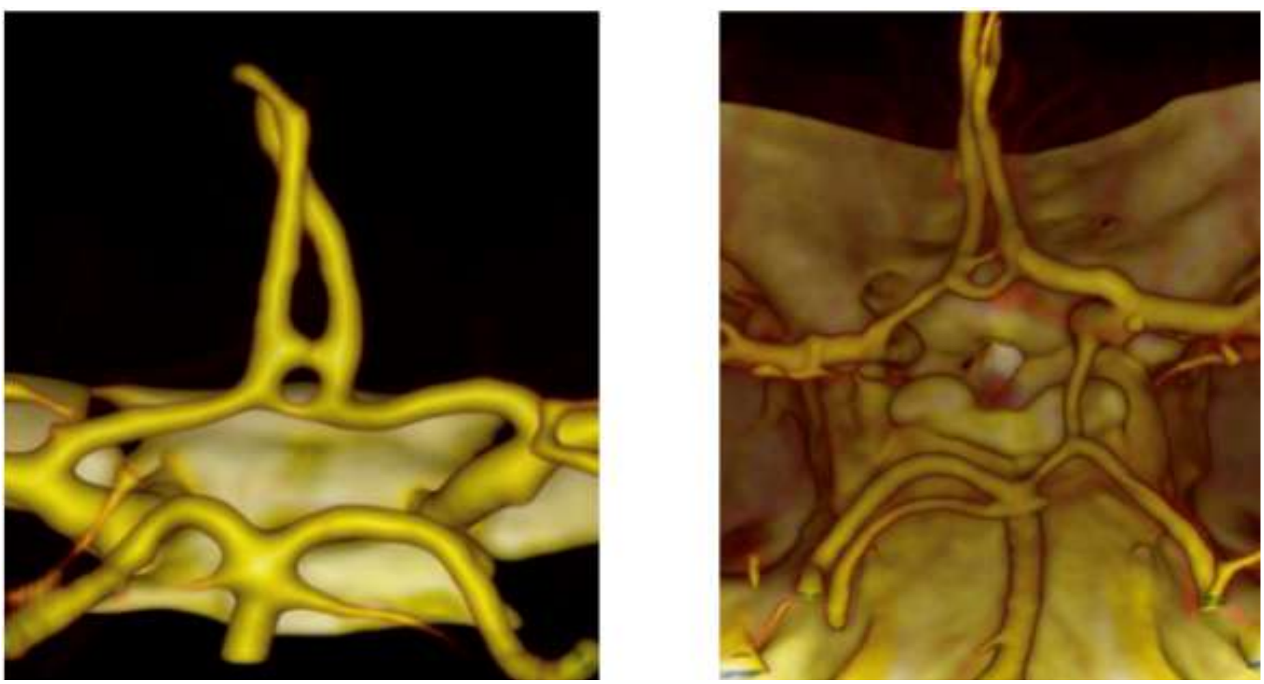


Figura 9. Agenesia de la arteria comunicante anterior.

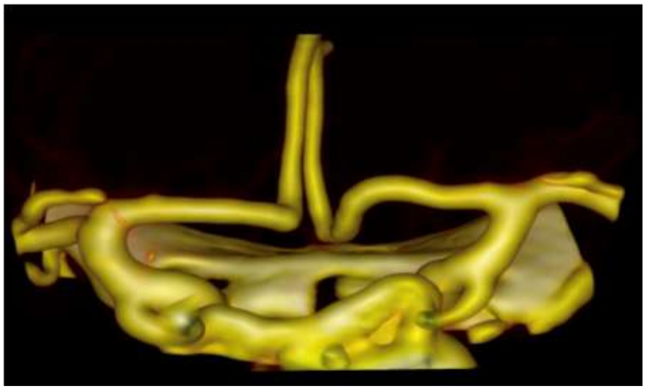


Figura 10. Arteria cerebral posterior de origen fetal (Agenesia del segmento P1).

Figura 11. Hipoplasia de la arteria vertebral.

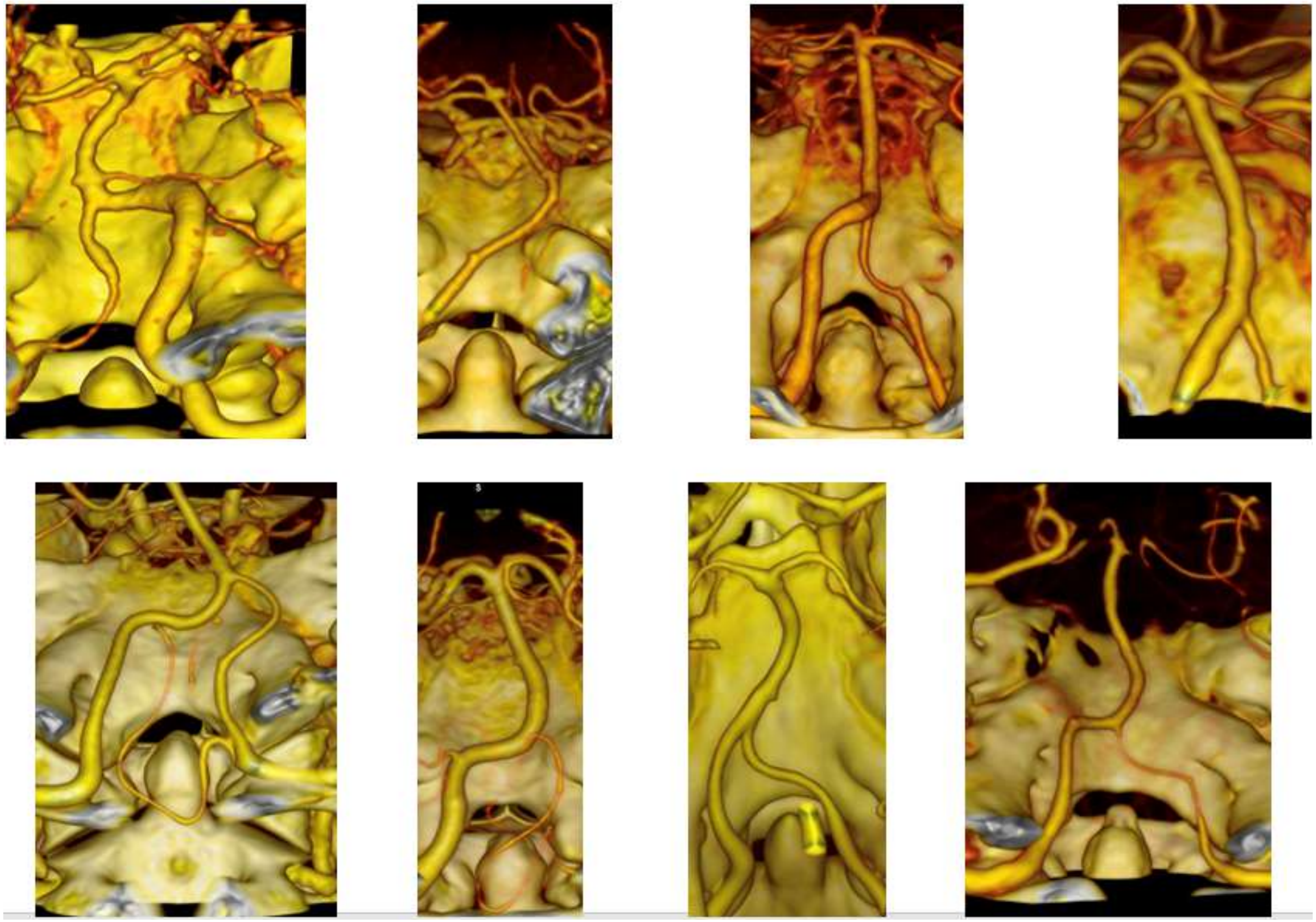


Figura 12. Agenesia de la arteria vertebral.

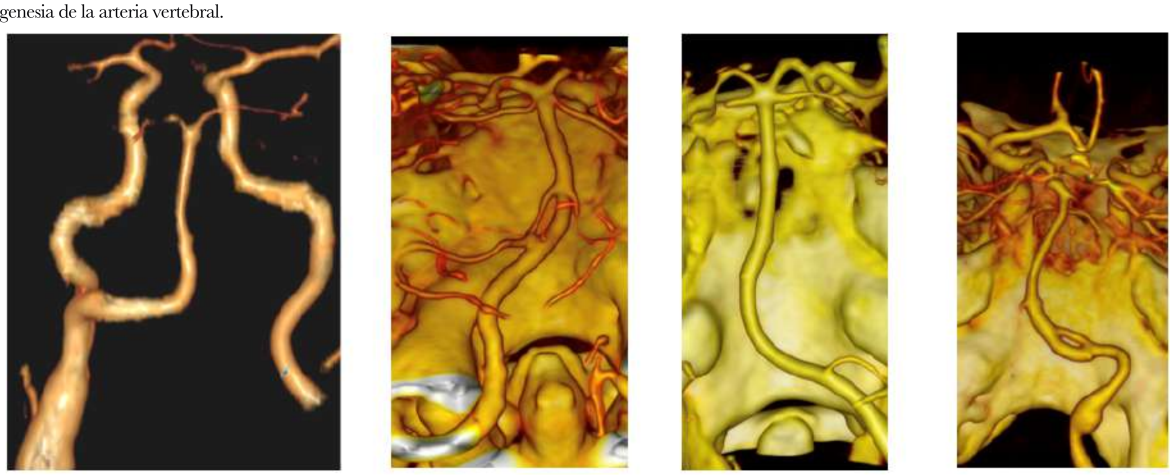


Figura 13. Aneurismas

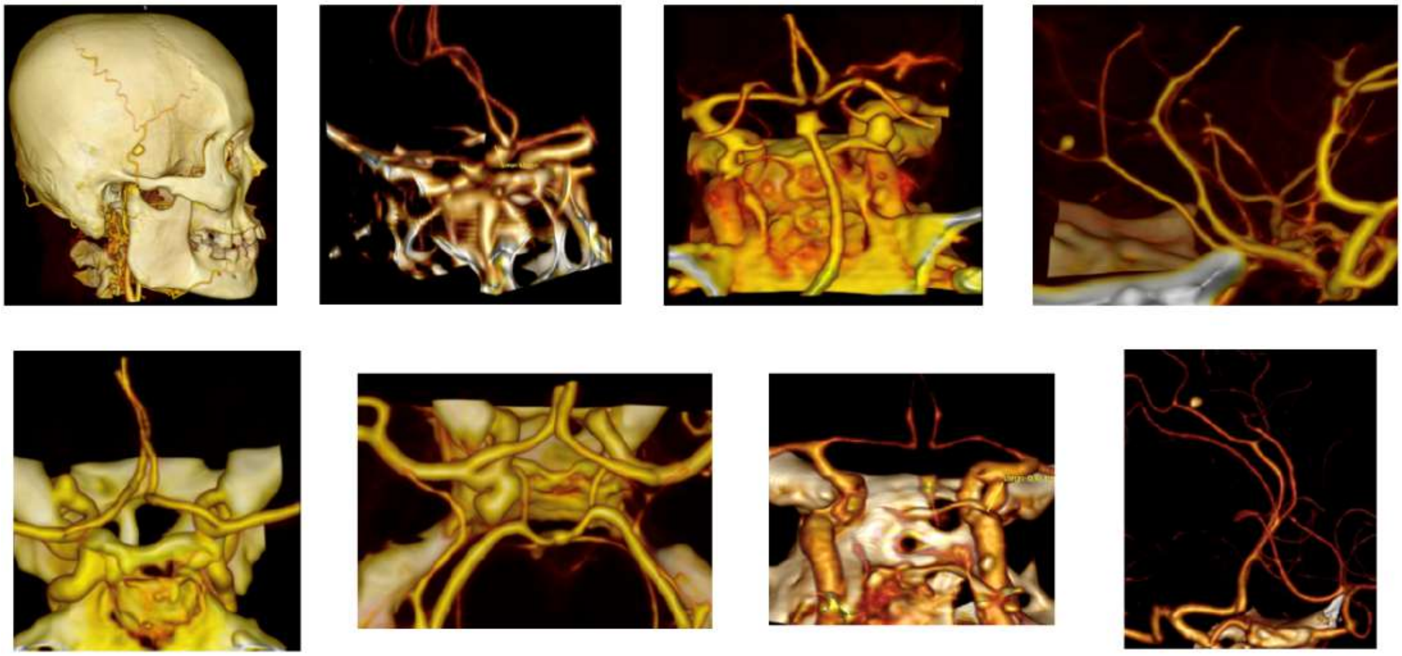


Figura 14. Arteria vertebral fenestrada.

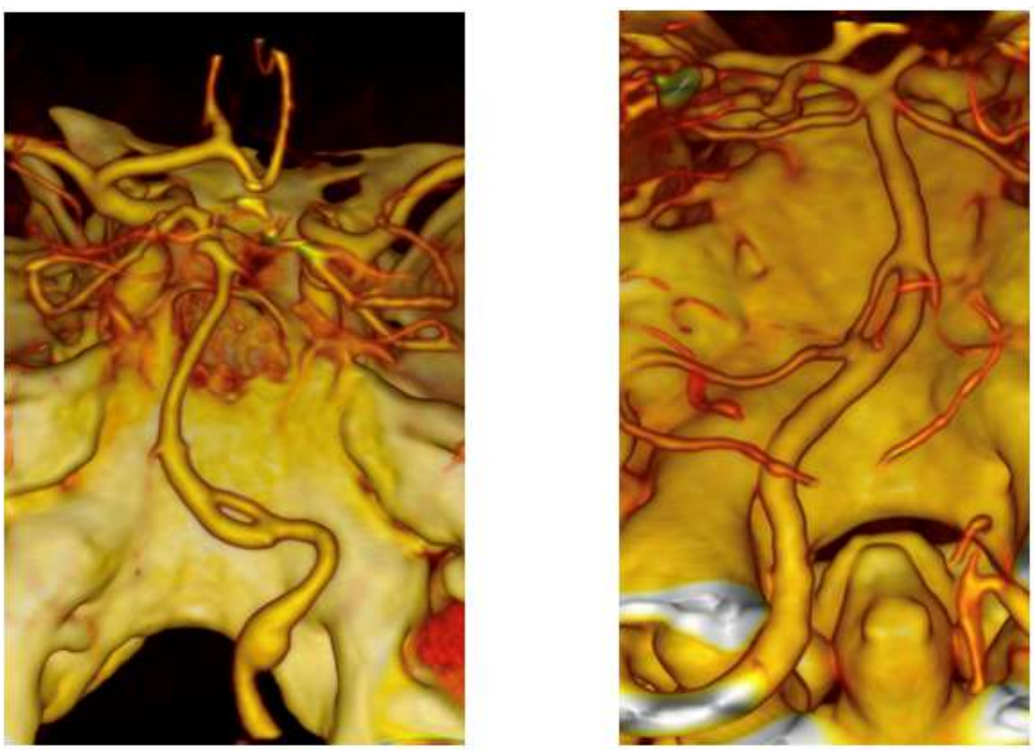


Figura 15. Malformación arterio venosa.

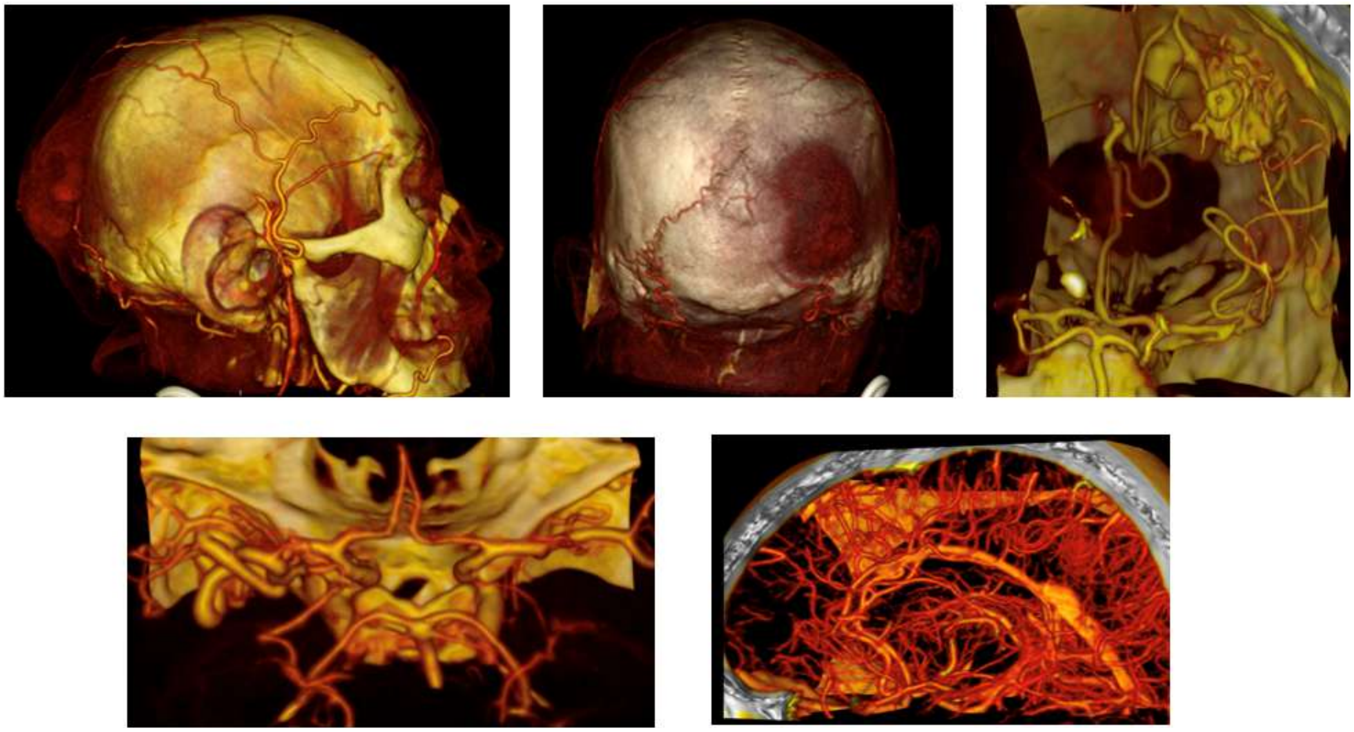


Figura 16. Arteria vertebral fenestrada.

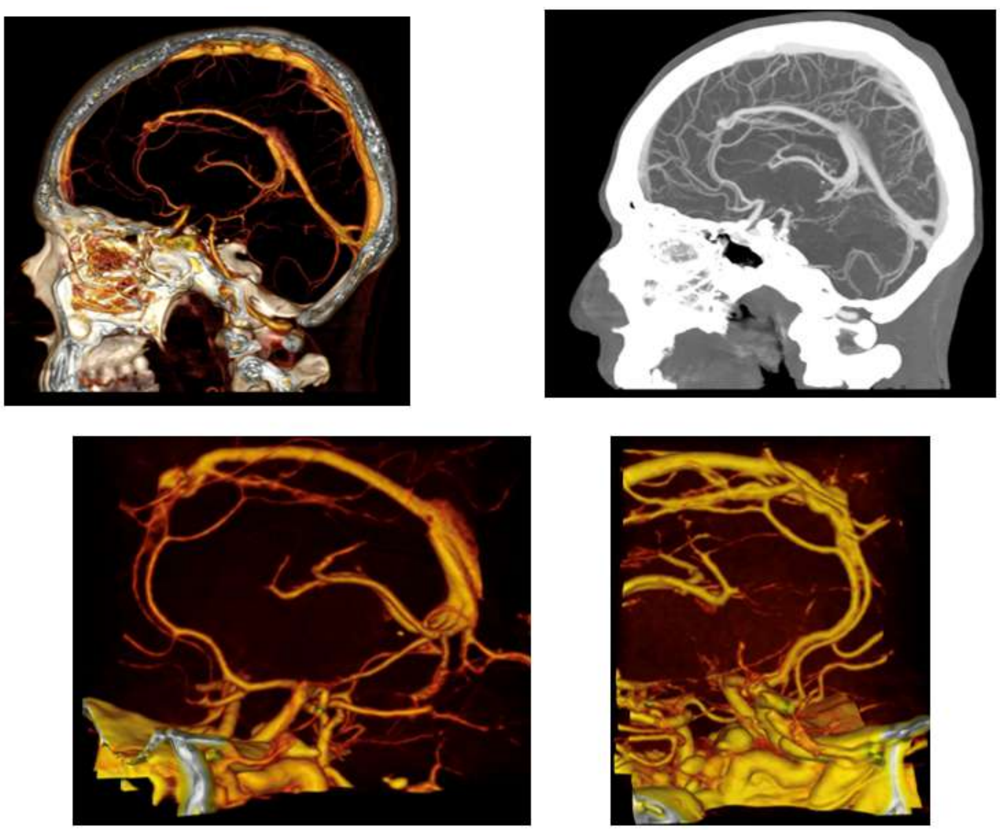
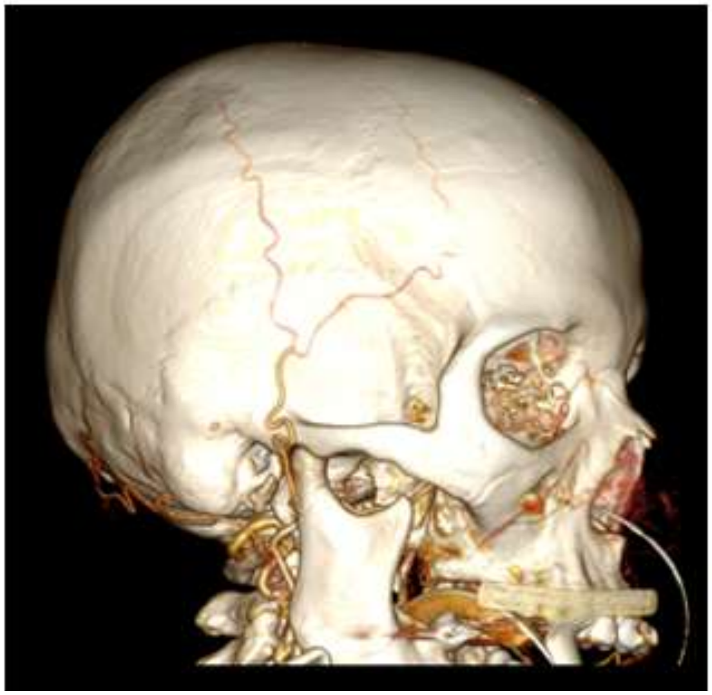


Figura 17. Muerte cerebral.



Statements

Ethics committee approval and consent to participate

The Bioethics Committee of the Faculty of Medical Sciences, University of Guayaquil, Guayaquil, Ecuador, approved the study.

Consent to publication

The authors have permission to publish written images from the patients.

Conflicts of interest

The researchers report that they have no conflicts of interest.

Authors' information

Carlos Jacinto Valle Ochoa, Doctor of Medicine and Surgery from the University of Guayaquil (Guayaquil, 2002), and Specialist in Imaging from the University of Guayaquil (2007). Member of the team and technical director of the Imaging Service at Alcívar Hospital, Guayaquil, Ecuador.
Email: drcvalleo@hotmail.com
ORCID https://orcid.org/0009-0009-2509-2136

Yoel Enrique Pinto Mejía, MD, PhD, University of Guayaquil (Ecuador, 2017). He holds a degree in Pediatrics from the University of Guayaquil (Ecuador, 2011) and a degree in neonatology from the University of Guayaquil (Ecuador, 2021). He is the Head of the Department of Pediatrics at Alcívar Hospital.
Email: yoelpintomejia@hotmail.com
ORCID https://orcid.org/0000-0001-6301-976X

Paola González Pazmiño, Medical graduate in Imaging from the International University of Ecuador, Guayaquil, Ecuador. Paola González Pazmiño, Medical Graduate in Imaging from the International University of Ecuador, Guayaquil, Ecuador.
Email: pao217@hotmail.com
ORCID https://orcid.org/0009-0009-9806-278X

Carmen Matilde Navas Palma, MD, PhD, University of Guayaquil (Ecuador, 2015). Master's degree in Occupational Health and Safety from the University of the Pacific, Business School (Ecuador, 2022). Postgraduate degree in Imaging from the International University of Ecuador, Guayaquil, Ecuador.
Email: carmennavas.p@gmail.com
ORCID https://orcid.org/0000-0002-7749-1392

Jean Carlos Galló Valverde, MD, M.D., from the University of Guayaquil (Ecuador, 2018). He holds a postgraduate degree in Imaging from the International University of Ecuador, Guayaquil, Ecuador.
Email: medjeangallo@gmail.com
ORCID https://orcid.org/0000-0002-3709-3947

Stalin Santiago Celi Simbaña, MD from the Central University of Ecuador (Ecuador, 2017). He holds a postgraduate degree in Imaging from the International University of Ecuador, Guayaquil, Ecuador.
Email: ssantiago.celi19@gmail.com
ORCID https://orcid.org/0000-0003-2091-9295

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Correspondence: Carlos Jacinto Valle Ochoa. Email: drcvalleo@hotmail.com
Address: Idelfonso Coronel y Mendez 2301, Guayaquil 090101, Guayas, Ecuador. Imaging Service, Alcívar Hospital.
Telephone: [593] (04) 3720100.