CASE REPORT

ADVANTAGES OF INTRAOPERATIVE VIDEOANGIOGRAPHY WITH FLUORESCEIN INTEGRATED TO THE MICROSCOPE IN CEREBROVASCULAR PATHOLOGY. INITIAL EXPERIENCE AT DOS DE MAYO NATIONAL HOSPITAL.

Ventajas de la videoangiografía intraoperatoria con fluoresceína integrada al microscopio en patología cerebrovascular. Experiencia inicial en el Hospital Nacional Dos de Mayo.

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ABSTRACT

Introduction: Fluorescein sodium (FNa) is a fluorescent substance used to evaluate cerebral blood flow. We present our first cases of vascular microsurgery using microscope-integrated intraoperative fluorescein video angiography. We review the practical applications and benefits of this technique in vascular microsurgery.
Clinical cases: A 63-year-old woman, Glasgow: 9 on admission, with subarachnoid hemorrhage (SAH) Fisher IV. A ruptured anterior communicating aneurysm was diagnosed. After stabilization in the ICU, she underwent surgery, undergoing microsurgical clipping guided by intraoperative videoangiography. The postoperative evolution was favorable.
A 33-year-old man with a history of epilepsy on carbamazepine treatment. After suspension and irregular treatment 2 years ago, seizures reappear. An angiography and magnetic resonance imaging were performed, and he was diagnosed with a left posterior temporal arteriovenous malformation (AVM) close to Wernicke's area, for which he underwent surgery using tractography and videoangiography in real-time integrated into Neuronavigation. In both cases, the benefits of using the integrated microscope were observed thanks to the vascular anatomical assessment in real-time with fluorescein.
Conclusion: Videoangiography with FNa allows examining afferent and efferent vessels during surgery for arteriovenous malformations, checking the persistence of flow in a microvascular anastomosis, and evaluating flow during clipping of an aneurysm. It has the advantages of being able to be repeated during surgery, allowing surrounding anatomical visualization, as well as allowing any surgical correction in real-time.

Keywords: *Fluorescein Angiography, Microsurgery, Aneurism, Arteriovenous Malformations (Source: MeSH NLM)*

RESUMEN

Introducción: La fluoresceína sódica (FNa), es una sustancia fluorescente usada para evaluar el flujo sanguíneo cerebral. Presentamos nuestros primeros casos de microcirugía vascular utilizando videoangiografía con fluoresceína intraoperatoria integrada al microscopio. Revisamos las aplicaciones prácticas y beneficios de esta técnica en microcirugía vascular.
Caso clínico: Case 1: Mujer de 63 años, Glasgow: 9 al ingreso, con hemorragia subaracnoidea (HSA) Fisher IV. Se diagnosticó un aneurisma de comunicante anterior roto. Luego de estabilización en UCI fue sometida a cirugía realizándose un clipaje microquirúrgico guiado por videoangiografía intraoperatoria. La evolución postoperatoria fue favorable.
Case 2: Varón de 33 años con historia de epilepsia en tratamiento con carbamazepina. Luego de suspensión y tratamiento irregular hace 2 años reaparecen convulsiones. Se le realizó una angiografía y resonancia magnética siendo diagnosticado de una malformación arteriovenosa (MAV) temporal posterior izquierda próxima al área de Wernicke, por lo que fue operado utilizando tractografía y videoangiografía en tiempo real integrada a la Neuronavegación. En ambos casos se observó los beneficios del uso del microscopio integrado gracias a la valoración anatómica vascular en tiempo real con fluoresceína.
Conclusión: La videoangiografía con FNa permite examinar vasos aferentes y eferentes durante la cirugía de malformaciones arteriovenosas, comprobar la persistencia de flujo en una anastomosis microvascular y evaluar el flujo durante el clipaje de un aneurisma. Tiene las ventajas de poder repetirse durante la cirugía, permitir la visualización anatómica circundante, así como permitir cualquier corrección quirúrgica en tiempo real.

***Palabras clave**: Angiografía con fluoresceína, Microcirugía, Aneurisma, Malformaciones Arteriovenosas (Fuente: DeCS Bireme)*

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Techniques to assess cerebral blood flow are essential for the success of surgery for vascular lesions such as aneurysms, arteriovenous malformations (AVMs), fistulas, and vascular anastomoses. Clinical results can be catastrophic if the flow is compromised or a vessel ruptures during the procedure. Surgery includes blood flow monitoring, to minimize the risk of rupture or to reestablish compromised normal circulation. [1]

There are methods to check intraoperative circulation. These can be classified based on physical principles, drugs, and devices used:

1. The observation and palpation evaluate the patency of the vessel, the pulsation, and the color (bright red is oxygenated, dark red is deoxygenated). [2]
2. Doppler angiography measures the volume and the flow velocity, a point probe measures the artery from one side, or a Charbel probe measures the artery from two sides. [3]
3. Laser spectrum imaging enables the generation of a two-dimensional, color-coded perfusion map in real-time and is used as a non-invasive visualization and measurement of cortical blood flow. [4]
4. Digital subtraction angiography (DSA) is an invasive method and the gold standard for vascular lesions, but intraoperative angiography requires an angiography team in the operating room, a sterile femoral area, and additional personnel. [5]
5. Fluorescent videoangiography with a high-resolution surgical microscope and suitable filters includes the use of indocyanine green (ICG) and sodium fluorescein (FNa), allowing real-time visualization. [6]
6. Confocal laser endomicroscopic angiography can use FNa or ICG and evaluate the cerebral microvasculature. [7]

Fluorescein sodium (FNa) has a long history of use to assess retinal blood flow in ophthalmology and in vascular neurosurgery is gaining popularity. We present our first cases of vascular microsurgery using intraoperative videoangiography with fluorescein (FNa) integrated to the microscope to assess blood flow in real-time.

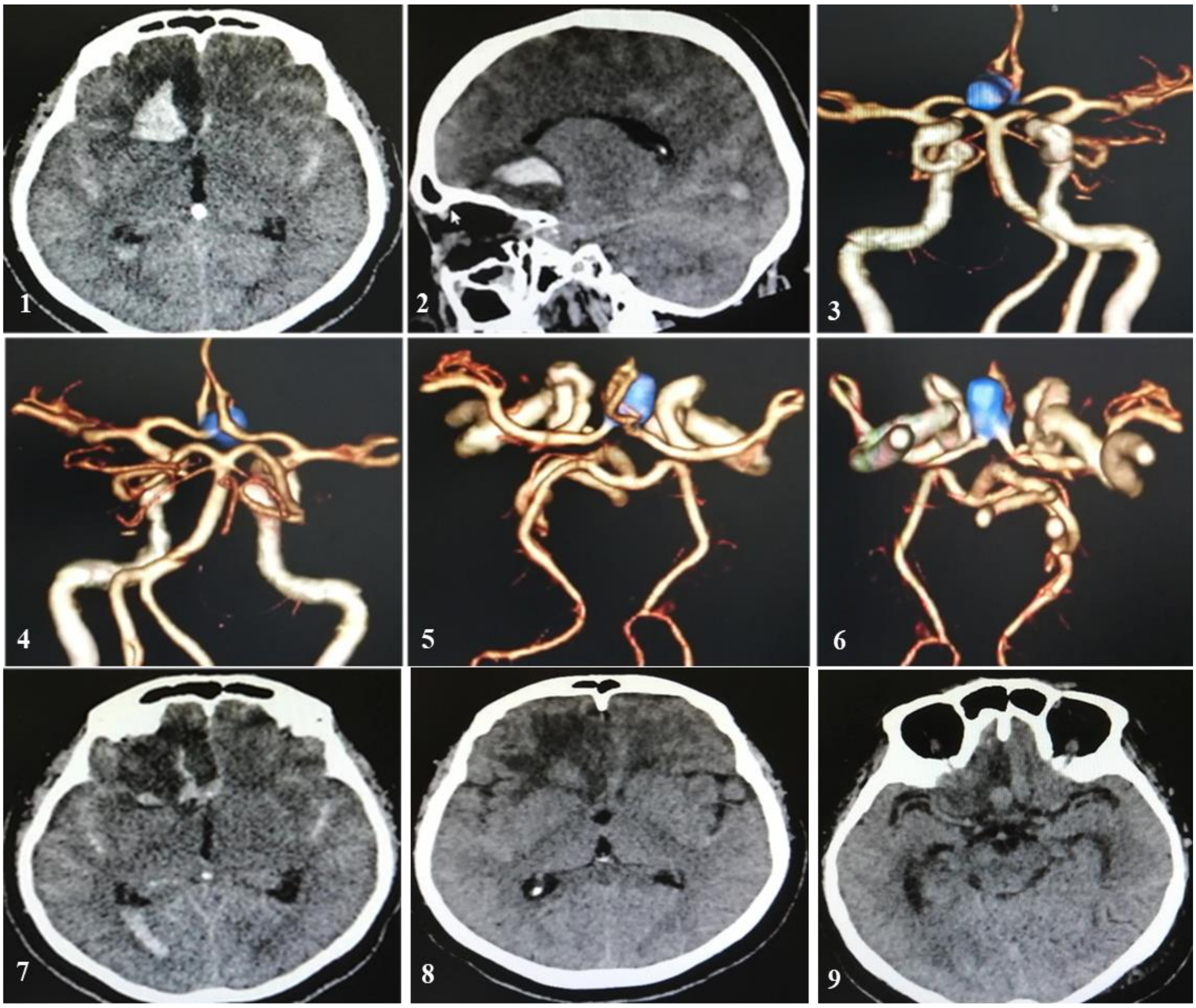

Fig. 1. CASE 1: (1) Brain CT without contrast in axial view showing right frontobasal hematoma, subarachnoid hemorrhage, and ventricular bleeding. **(2)** Brain CT in sagittal view showing right frontobasal hematoma, and perilesional edema. **(3, 4, 5 and 6)** 3D AngioCT showing anterior communicating aneurysmal dilation in an anterior direction (blue color) in anterior, posterior, and superior views. **(7, 8)** Control CT in axial view, 7 days later, showing resolution of the right frontobasal hematoma with subcortical peripheral hypodensity, subarachnoid hemorrhage, and blood in the right lateral ventricle. **(9)** Anterior communicating aneurysmal dilation with anterior direction.

CLINICAL CASES

CASE 1

History and examination: 63-year-old female patient, unconscious who was brought to the emergency room in Glasgow: 9. uncontrolled hypertension. Brain TEM she evidenced Fisher IV SAH with right frontal hematoma and ventricular invasion for which she was transferred to the neurointensive therapy unit (NICU) where she also presented aspiration pneumonia and sepsis. 3D brain angioTEM showed a saccular aneurysm with a wide base in the anterior communicator (7mm neck x 17.5mm long) and sac with a right frontal anterior direction in relation to hematoma *(Fig 1).*

Surgical treatment: A classic left pterional approach was performed, plus clipping of the ruptured anterior communicating aneurysm (AComA). Microsurgery was performed using a Kinevo 900 microscope integrated with a filter for intraoperative videoangiography that allowed to check vascular permeability in real-time using EV fluorescein *(Fig 2)*

Clinical evolution: The evolution was favorable in the postoperative period, being transferred from Neurointensive therapy to hospitalization and later discharged. In the outpatient clinic, the patient presented a good neurological evolution, understood, and obeyed orders, mild expression dysphasia, did not present cranial nerve alteration, wound in good condition, without an evident motor deficit.

CASE 2

History and examination: 33-year-old male patient, with a history of epilepsy for 8 years on treatment with carbamazepine 200 mg every 12 hours. After suspension and irregular treatment in the last 2 years, the seizures reappeared. A brain tomography (TEM) showed a hyperdense lesion suggestive of an AVM in the left temporal region, which was confirmed with a brain MRI. Given the persistence of the seizures and with the diagnosis of AVM, he went to the emergency room of our hospital. A 4-vessel digital subtraction cerebral angiography showed the presence of a temporary SM III AVM *(Fig 3).*

Due to the proximity to the language area (Wernicke), surgery was planned to use the Neuronavigator (Brainlab), integrating the MR images with tractography, appreciating the close relationship of the temporal AVM with the arcuate fascicle and Wernicke's area. *(Fig 4)*

Surgical treatment: A left frontotemporoparietal craniotomy was performed and after the dural opening the AVM nest was evidenced, feeders were identified, subarachnoid and pial dissection was performed. The Neuronavigation integrated into the microscope (Kinevo 900) was used as an aid and the flow in the afferent and efferent branches was evaluated in real-time by means of videoangiography with fluorescein, which gave us a greater margin of surgical safety. Total excision of the temporal AVM was performed *(Fig 5).*

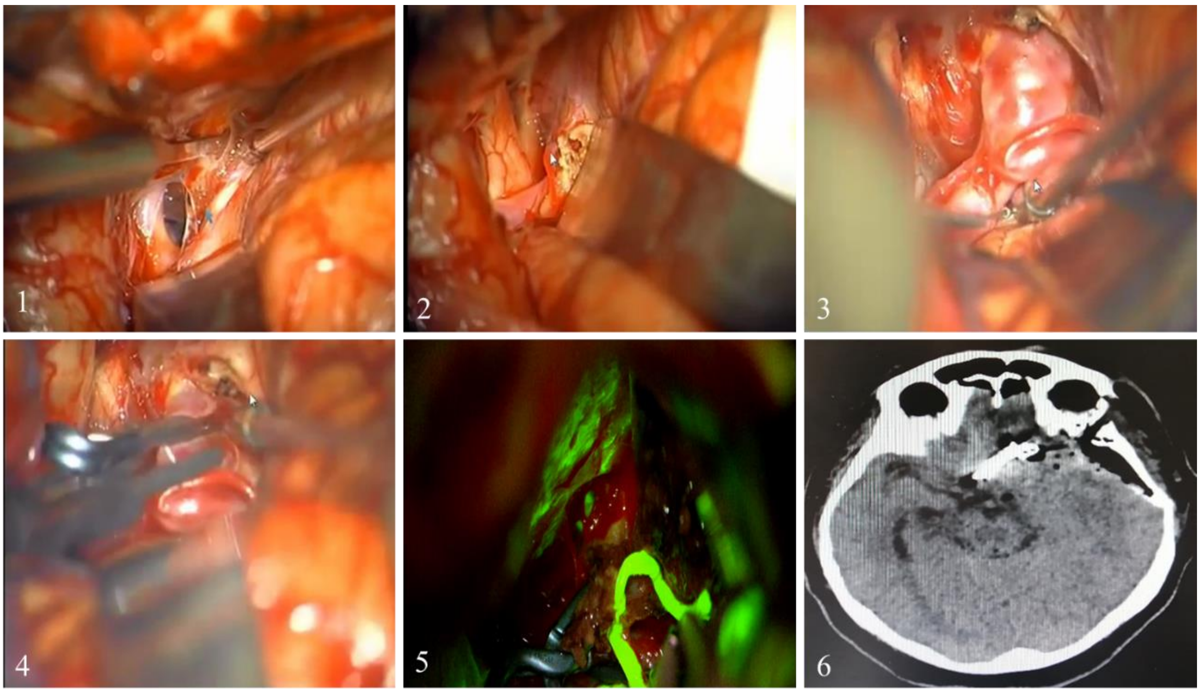

Fig. 2. CASE 1: (1) Microsurgical view, dissection of the left carotid optic space. **(2)** The left A1 and both optic nerves are dissected and exposed. **(3)** Dissection of the anterior communicating complex aneurysm left orbitofrontal artery adhered to the dome. **(4)** Clipping with two straight clips of the aneurysm respecting the left orbitofrontal artery. **(5)** Fluorescein videoangiography, complete arterial exclusion of the aneurysm, and left A2 patency. **(6)** Postsurgical brain CT showing metal clips and a slight temporal pneumocephalus.

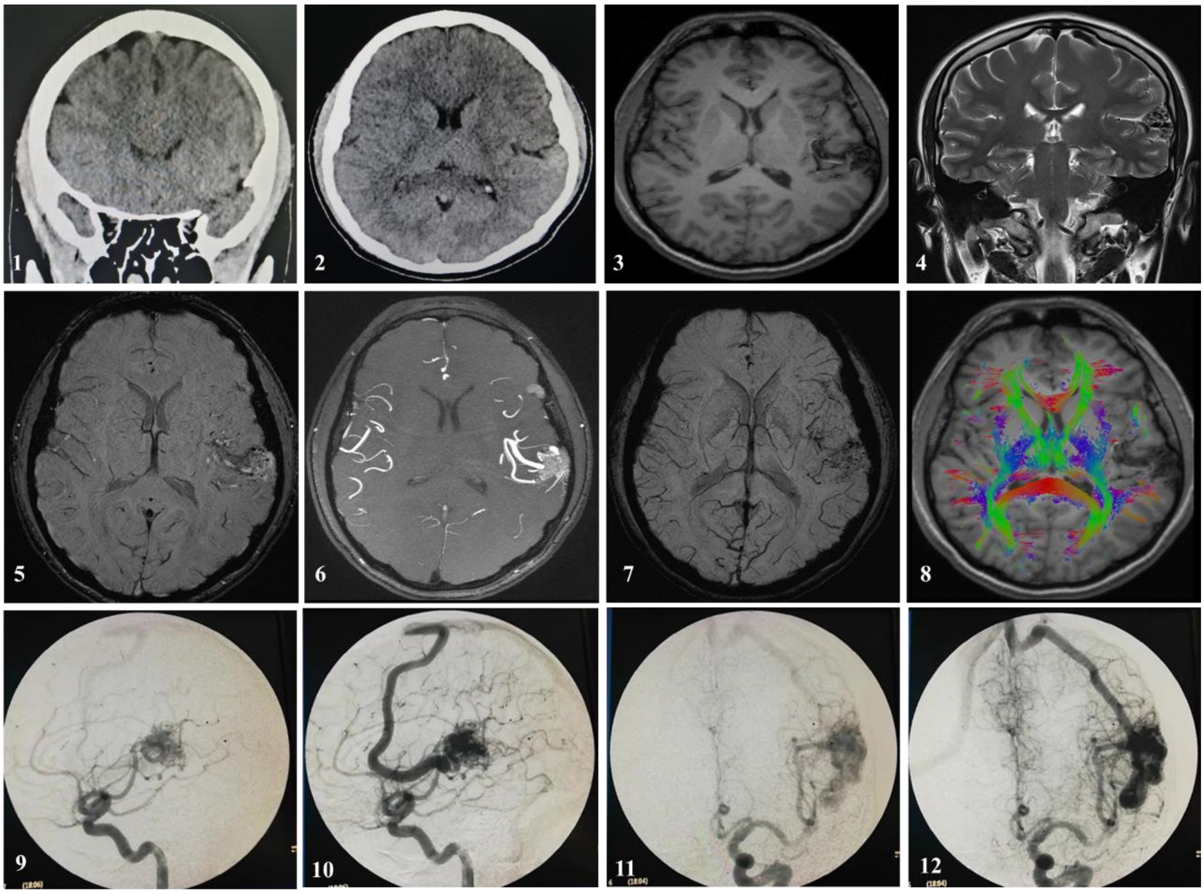

Fig. 3. CASE 2: (1 and 2) Brain CT in coronal and axial view showing a hyperdense image in relation to the AVM nest and left temporal drainage vein with superior direction. **(3)** T1 MRI without contrast in axial section showing left temporal AVM. **(4)** T2 MRI in coronal view showing temporal AVM of the lateral surface and left Valle Silviano. **(5, 6 and 7)** MRI and MRI angiography in axial view showing left temporal AVM with arterial afferents from left M3-M4 branches. **(8)** Brain MRI with tractography showing the corticospinal tract, visual pathway, and part of the bilateral arcuate bundle, showing contact of the AVM with the posterior part of the left arcuate bundle. **(9 and 11)** Angiography in early arterial phase in lateral incidence and AP showing left temporal AVM with left M4 afferents. **(10 and 12)** Late arterial phase angiography in lateral incidence showing a left temporal AVM with a fistulous draining vein to the superior longitudinal sinus.

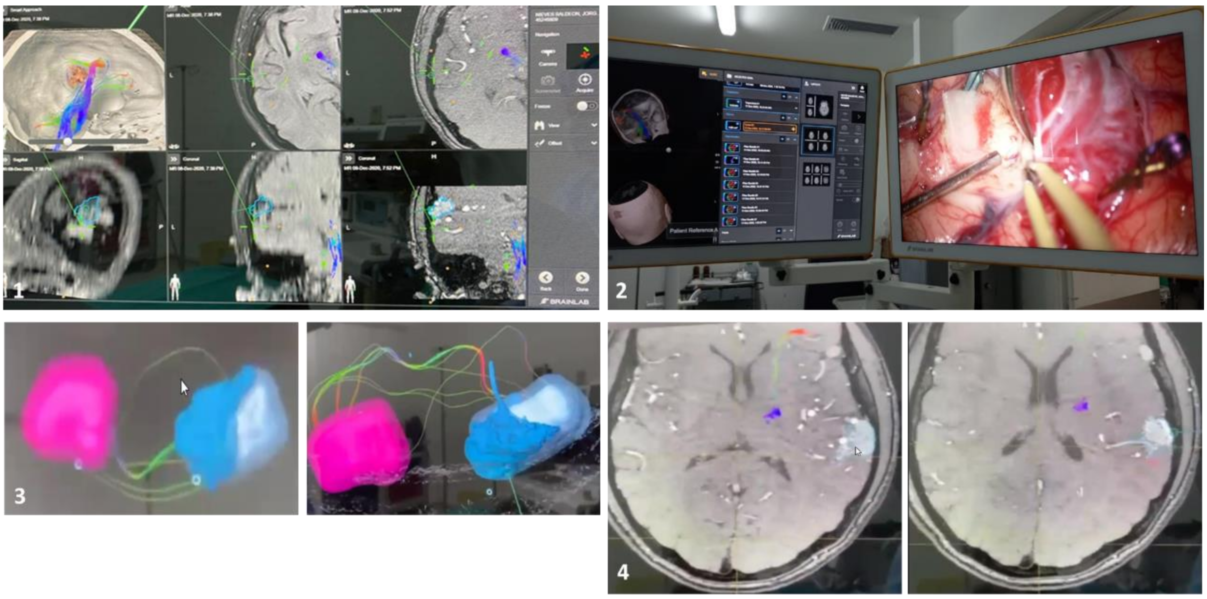

Fig. 4. CASE 2: (1) Image of the Neuronavigation system prior to surgery showing the planned trajectory to address AVM. The edges of the AVM were delimited ("brushing") and finally a 3D view of the AVM and its relationship with the arcuate and left corticospinal tract (fiber tracking) was obtained. **(2)** Neuronavigation system integrated into the microsurgical microscope. **(3)** 3D representation of the Broca area (purple color), Wernicke (light blue color), AVM (blue color), and the arcuate fascicle. **(4)** Brain MRI integrated into Neuronavigation showing part of the left temporal AVM and the pyramidal pathway on the same side.

Clinical evolution: In the immediate postoperative period, the patient presented mild nominative aphasia (he could not find the word "pen"), the rest of the neurological examination did not show any alteration, he had periods of psychomotor agitation for which he was treated in the Neurocritical Care unit. His neurological evolution was favorable, presenting improvement in the language deficit in the following days. He was discharged from the hospital and was subsequently evaluated in an outpatient clinic where no neurological deficit was found *(Fig 6)*

DISCUSSION

Preservation of normal flow and exclusion of vascular lesion flow are key concepts in vascular neurosurgery. Even minimal involvement of the vascular lumen can cause ischemic changes; the residual flow towards a vascular malformation may maintain the risk of rupture and hemorrhage.[8] There are several methods for the intraoperative evaluation of the patency of the vessels as we have mentioned.[9] With intraoperative digital subtraction angiography (DSA), it has been reported that 7–34% of cases required additional manipulation to restore optimal blood flow.[10] Intraoperative Doppler and flowmetry are effective for detecting major vessel stenosis after clipping, however, these techniques are not highly accurate and they only provide an indirect assessment of vascular lumen involvement. [11]

Fluorescence angiography with fluorescein sodium (FNa) and indocyanine green (ICG) was introduced in the 1960s for neurovascular procedures.[12] Initially, for the observation of vessels on the brain surface; Static images were captured and analyzed after surgery.[13] This evolved in modern videoangiography, fluorescence excitation sources and integrated microscope filters allow video images that can be analyzed intraoperatively.[14] Observation of a contrast agent A fluorescent tube introduced into blood vessels allows the evaluation of blood flow dynamics.[15] Multiple clinical trials have demonstrated the efficacy of fluorescence angiography in the management of vascular pathologies of the brain and spinal cord. [16] The use of FNa videoangiography has been reported in vascular surgery for aneurysms, arteriovenous malformations, dural arteriovenous fistulas (DAVF), and bypass revascularization surgeries.[17]

In brain aneurysm surgery, it is important to confirm the obliteration of the neck, as well as the patency of the major and small intraoperative perforating vessels.[18] Lane et al. reported that fluorescein sodium (FNa) is preferable to indocyanine (ICG) in terms of visualization of small perforators and obliteration of the aneurysm. 19 For deep site aneurysms, requiring a narrow corridor (anterior cerebral artery aneurysms using a lateral frontal approach), real-time manipulation of the surrounding anatomy under FNa videoangiography allows maximum exposure and inspection of the vessels of interest. [19]

AVMs are usually attached to the surrounding brain parenchyma and can be considered "intra-axial lesions" since most require subarachnoid and pial dissection. Numerous feeders can supply the nest from the deep side and these feeders can be blocked by brain parenchyma. Such a complex nature means that angiography remains the gold standard for evaluation, [20] but it is not always available, fluorescence with traditional ICG video angiography cannot be visualized through an eyepiece in real-time.

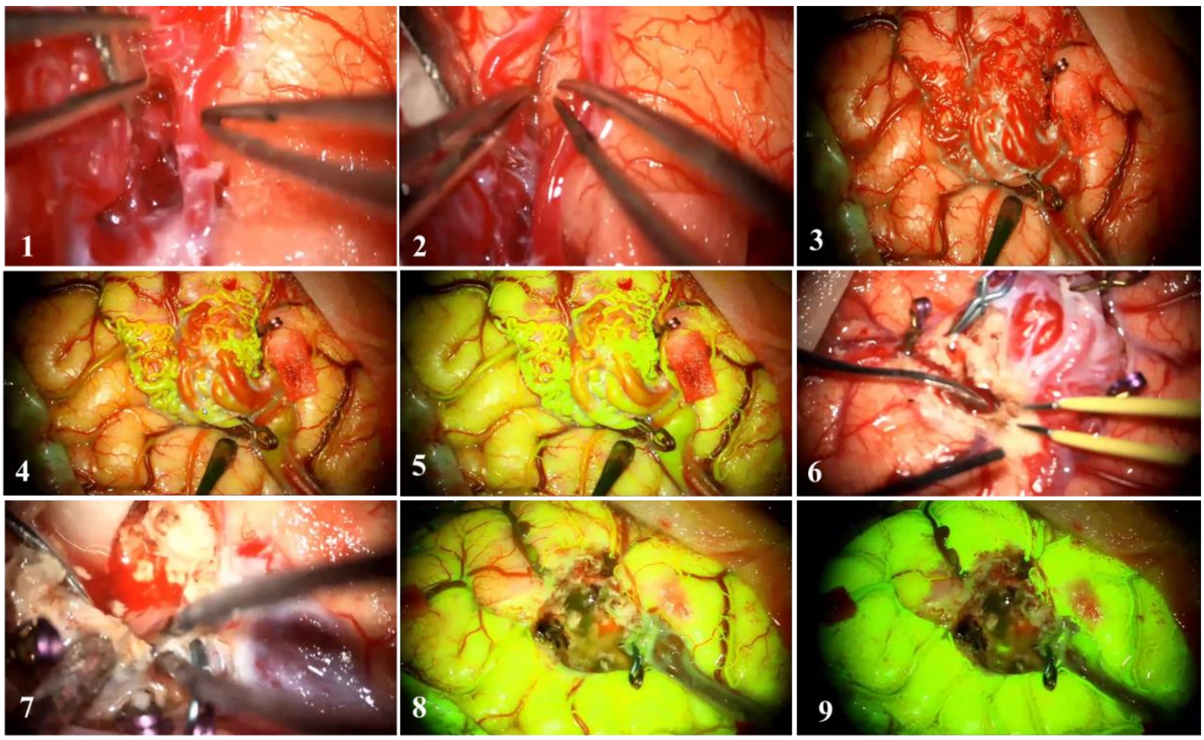

Fig. 5. CASE 2: (1 and 2) Microsurgical stage of subarachnoid dissection of the AVM and its arterial afferents. **(3)** Panoramic view of the left temporal AVM with temporal clips in arterial afferents. **(4 and 5)** Intraoperative videoangiography with 10% fluorescein for the identification of arterial afferents. **(6 and 7)** Stage of pial and parenchymal dissection of the temporal AVM. **(8 and 9)** Intraoperative videoangiography with 10% fluorescein after total resection of the AVM showing the absence of vascular lesion and almost total staining of the surrounding parenchyma.

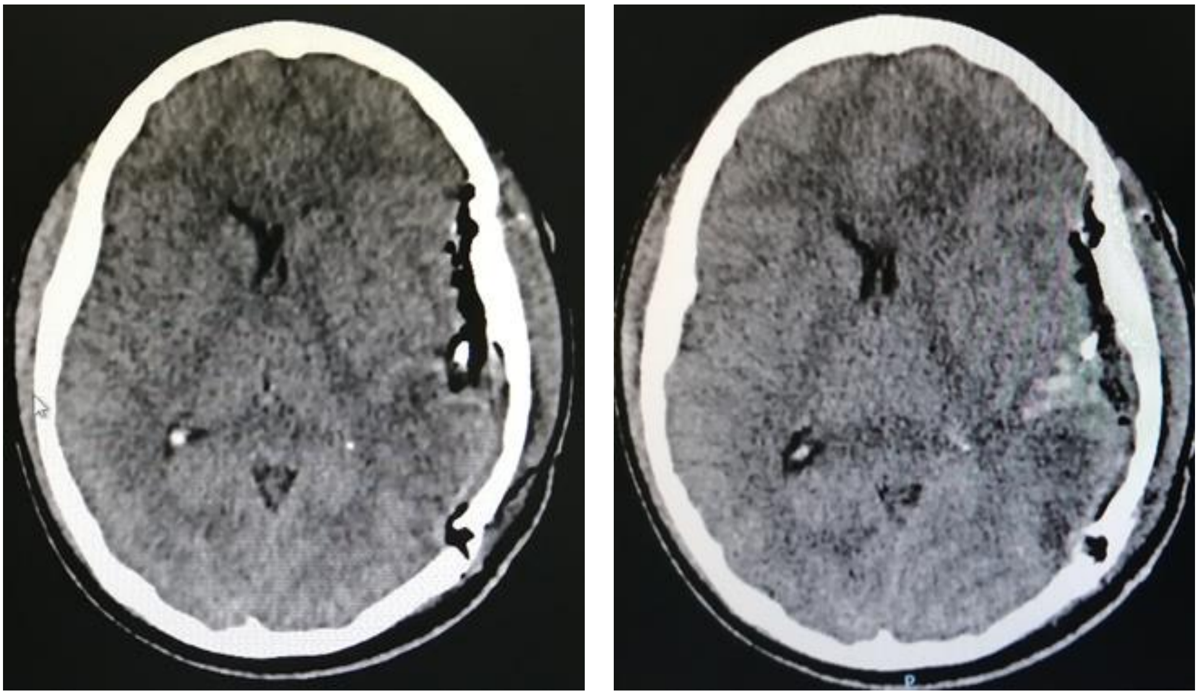

Fig. 6. CASE2: Immediate postsurgical brain CT showing slight hypodensity in the surgical bed in relation to an area of vascular hypoflux.

The deep feeders and the adhesive nature of AVMs make them difficult to operate because comprehensive information generally cannot be obtained from a single angiogram. Especially after circumferential nest dissection or closure of superficial feeders, premature venous filling indicates the presence of remaining deep feeders. Real-time dissection of the nest and full inspection of the nest under video angiography can facilitate the location of the rest of the feeders, as well as provide a thorough examination of the lesion. [21] The real-time feature of FNa video angiography is preferable to ICG in such settings.

CONCLUSION

Intraoperative fluorescein videoangiography can be used for flow monitoring during aneurysm clipping surgery or arteriovenous malformation (AVM) excision, as shown in this initial report on vascular microsurgery in the Neurosurgery Service of Hospital Nacional Dos de Mayo. For this, a Karl Zeiss Kinevo 900 surgical microscope integrated with modules for fluorescein videoangiography and ICG was used.

During surgery, fluorescein videoangiography was performed by intravenous injection, safely without interrupting the surgical procedure. This allowed us to have the videoangiography images in real-time, and thus to evaluate the arterial patency during clipping of a cerebral aneurysm and the microvasculature in real-time during AVM resection, without presenting complications.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: All the authors. *Drafting the article:* Acha. Critically revising the article: Acha. *Reviewed submitted version of manuscript:* Acha. *Approved the final version of the manuscript on behalf of all authors:* Acha.

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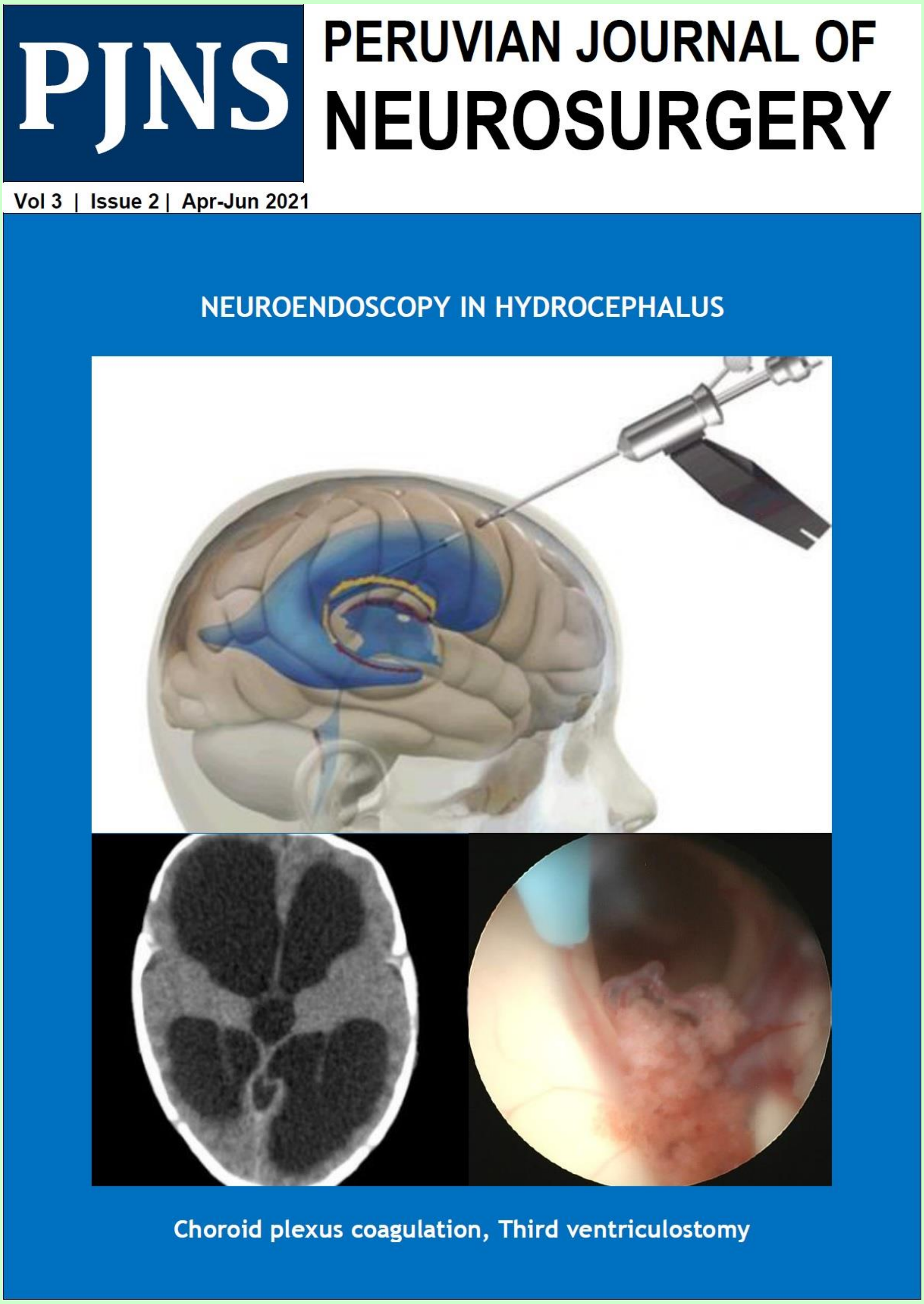
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