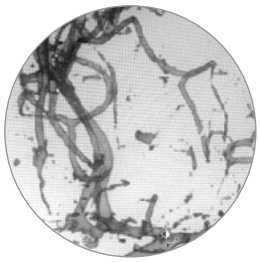

Usefulness of 3D Digital Subtraction Angiography in the Endovascular Approach of Cerebral Aneurysms

Utilidad de la angiografía por sustracción digital 3D en el abordaje endovascular de aneurismas cerebrales

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Summary

Introduction: The trend in management of intracranial aneurysms has shifted during the last decades to minimally invasive endovascular procedures. The usefulness of new imaging tools such as digital subtraction angiography in 3D (3D DSA), added to the experience of neurointerventional radiologists, have led to greater definition and accuracy in the study of intracranial aneurysms. ***Objective:*** To describe the usefulness of three-dimensional digital subtraction angiography for pre and post embolization approach of intracranial aneurysms. ***Methodology:*** A cross-sectional study between January 2016 and April 2017 in patients diagnosed with arterial cerebral aneurysms at the Hospital Infantil Universitario San José in Bogota, Colombia. Results: 32 patients were included, 71.8% (n = 23) were women. Among the risk factors for aneurysm rupture, the most frequent was age above 40 years (81.8%). The most frequent location was in the Right Middle Cerebral Artery (MCA) (30.3%). All cases corresponded to saccular aneurysms. In the immediate post-embolization angiographic control it was evidence that 16 cases (48.5%) presented residual sac. ***Conclusions:*** The realization of multiplanar projections with 3D angiographic reconstruction allows for a better characterization of the aneurysm and evaluation of the adjacent anatomical structures, being very useful for the planning of the procedure and in the follow-up.

Resumen

Introducción: En el manejo de los aneurismas intracraneales la tendencia ha sido realizar procedimientos endovasculares mínimamente invasivos. Nuevas herramientas en imágenes, como la angiografía por sustracción digital en 3D (ASD 3D), sumadas a la experiencia de los radiólogos neurointervencionistas, han llevado a una mayor definición y precisión en el estudio del aneurisma intracraneal. ***Objetivo:*** Describir la utilidad de la técnica de angiografía por sustracción digital tridimensional para el abordaje pre y postembolización de los aneurismas intracraneales. ***Metodología:*** Estudio de corte transversal entre enero de 2016 y abril de 2017 en pacientes diagnosticados con aneurisma de arterias cerebrales, en el Hospital Infantil Universitario San José, en Bogotá, Colombia. ***Resultados:*** Se incluyeron 32 pacientes, de los cuales 71,8 % (*n* = 23) fueron mujeres. Entre los factores de riesgo para ruptura del aneurisma, el más frecuente fue edad mayor a 40 años (81,8 %). La localización más usual fue en la arteria cerebral media (ACM) derecha (30,3 %). Todos los casos correspondieron a aneurismas saculares. En el control angiográfico postembolización inmediato se evidenció que 16 casos (48,5 %) presentaron saco residual. ***Conclusiones:*** La realización de proyecciones multiplanares con reconstrucción angiográfica 3D brinda información adicional para una mejor caracterización del aneurisma y evaluación de las estructuras anatómicas adyacentes, por lo que es de gran utilidad para planear el procedimiento y para el seguimiento.

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Introduction

In recent decades, the trend in the management of intracranial aneurysms is based on minimally invasive endovascular procedures, which shows that intravascular treatment compared to surgical treatment reduces the risk of death or long-term disability (1).

The factors involved in performing an appropriate procedure increasingly depend on the usefulness of new imaging tools, such as 3D digital subtraction angiography (3D ASD) and the experience of neurointerventional radiologists, which facilitates greater definition and accuracy in the characterization of the intracranial aneurysm, the physiological state of the communicating vessels (vasospasm), as well as the anatomical structures. This decreases the time of procedures and, in turn, the frequency of complications (2-4).

ASD with 2D projections was used as the modality of choice for the study of intracranial vascular structures for several years, with imaging in the anteroposterior, lateral, and oblique planes. ASD 3D is a technological evolution of ASD 2D that allows the visualization of intracranial vessels from any possible projection. The ASD 3D requires a flat detector angiograph with a rotating C-arm. Two rotational image acquisitions are performed, the first to obtain a subtraction mask and the second to acquire the images during the injection of the contrast medium. In the second acquisition, the arc rotates 180 degrees in approximately 4-8 seconds, while 13 ml of contrast medium is administered through an injector at a rate of 2.5 mL/s. Subsequent reconstructions with specialized software allow for suppression of unnecessary vessels, image rotation and magnification, among other applications (2).

The purpose of this article is to illustrate with clinical cases the usefulness of 3D digital subtraction angiography in the endovascular approach to brain aneurysms and to compare the results found before the intervention and in the immediate postoperative period with what has been published in the literature.

Methodology

A cross-sectional study was conducted between January 2016 and April 2017 with patients diagnosed with brain artery aneurysm. Thirty-two patients were included who underwent digital subtraction angiography with 3D reconstruction; 33 aneurysms were diagnosed; all of them were treated by means of coil embolization. As independent variables were taken into account sex, age, risk factors for the formation of cerebral aneurysms in each patient; location, size and shape of the aneurysm, characteristics of the afferent vessel and vessels originating in the aneurysm sac. Also recorded were: the duration of the procedure, the post-treatment results, and the characteristics of the afferent vessel in the immediate post-treatment control 3D angiography.

The data were obtained from the workstation of a TOSHIBA angiograph model INFX-8000V/W6, Series W6C12Y2019, using the VÍTREA FX application (Version 6.3). The demographics and clinical records of each patient.

For the realization of the angiography, the institutional protocol was followed in each one of the patients and later on, 3D reconstruction was performed with the mentioned software.

A univariate analysis of the variables included was made to establish absolute and relative frequencies by means of the statistical package SPSS Statistics V24.0. No missing data were available.

A literature search was carried out in the PubMed, OVID and ClinicalKey databases, with the keywords digital subtraction angiography, intracranial aneurysms, therapeutic embolization and endovascular procedures, to compare the results obtained with those described in the literature.

We had the approval of the hospital's medical ethics committee and complied with the regulations in force in Colombia.

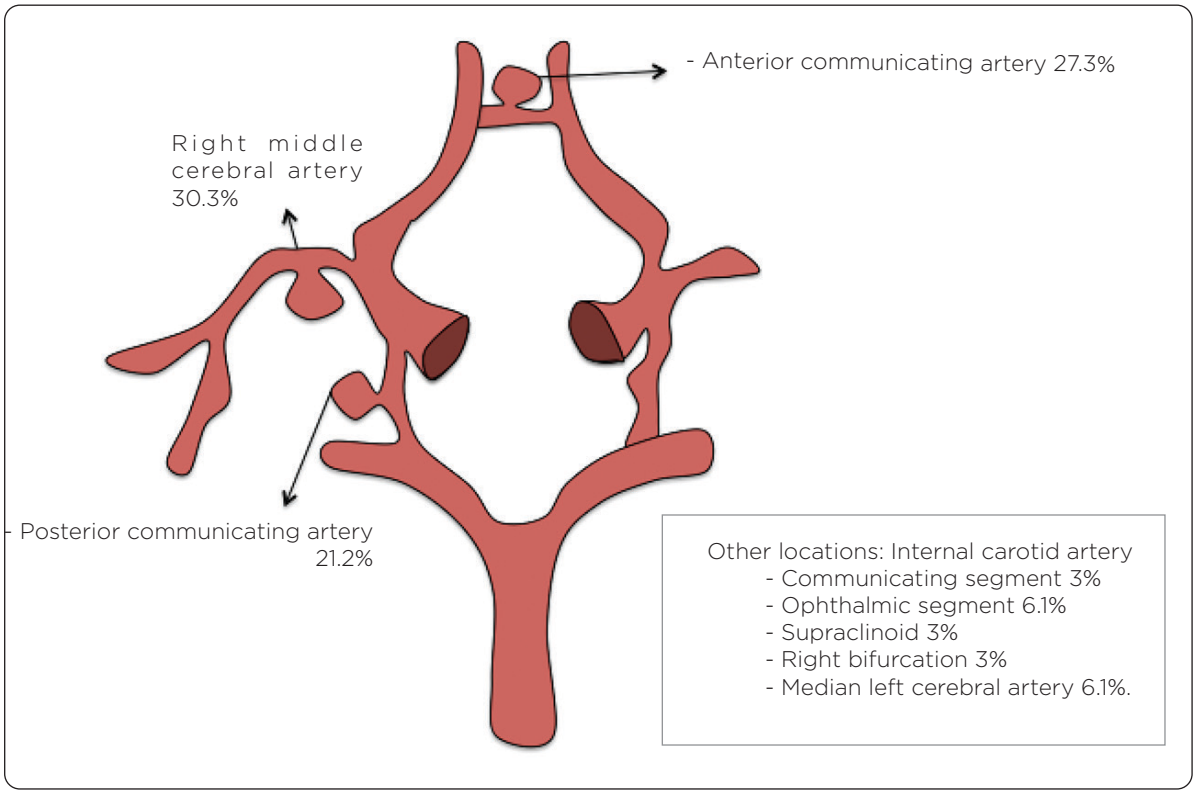

Figure 1. Graphic representation of the most frequent location of aneurysms in the population studied.

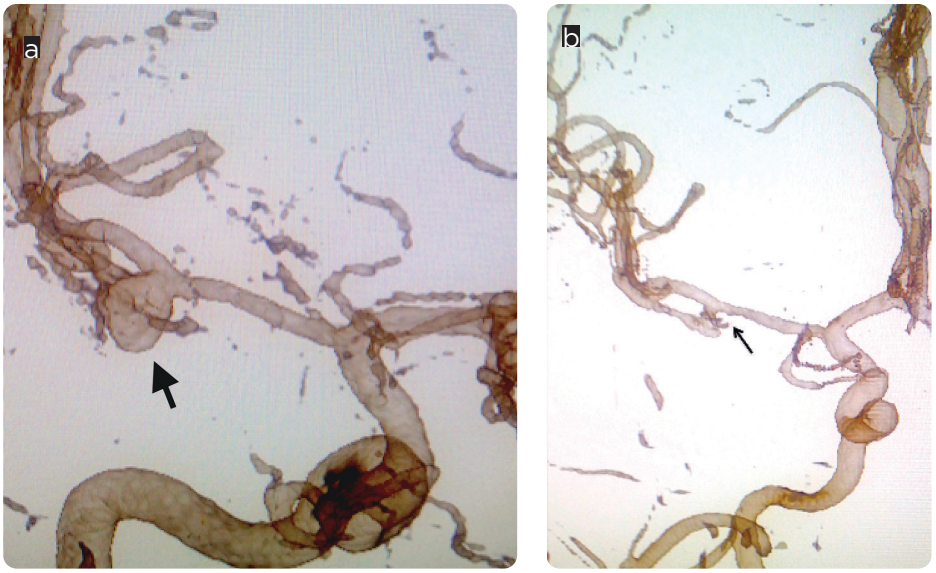

Figure 2. Right middle cerebral artery saccular aneurysm. a). 3D pre-embolization reconstruction (arrow). b) 3D post-embolization reconstruction. Note the neck portion of the remaining aneurysmal sac in the right middle cerebral artery (arrow).

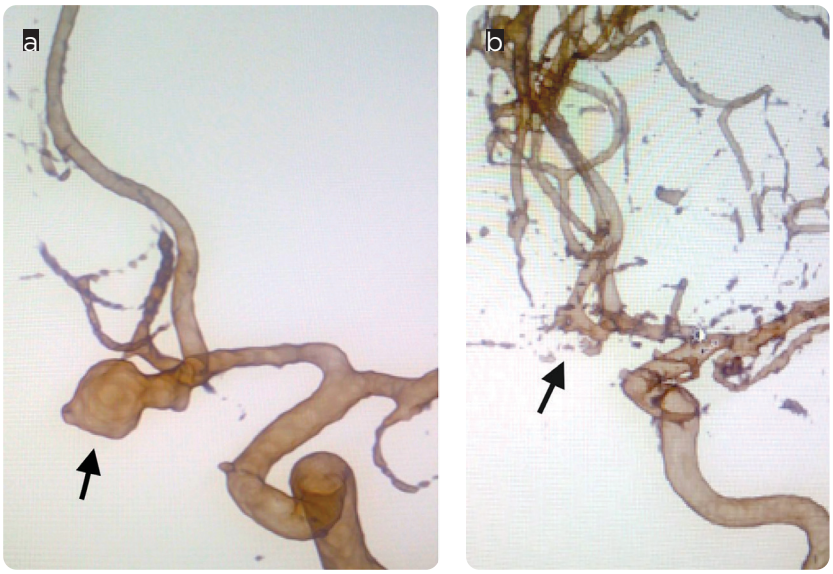

Figure 3. Saccular aneurysm of the anterior communicating artery. a) 3D pre-embolization reconstruction (arrow). b). 3D post-embolization reconstruction. Note the complete occlusion of the aneurysmal sac (arrow).

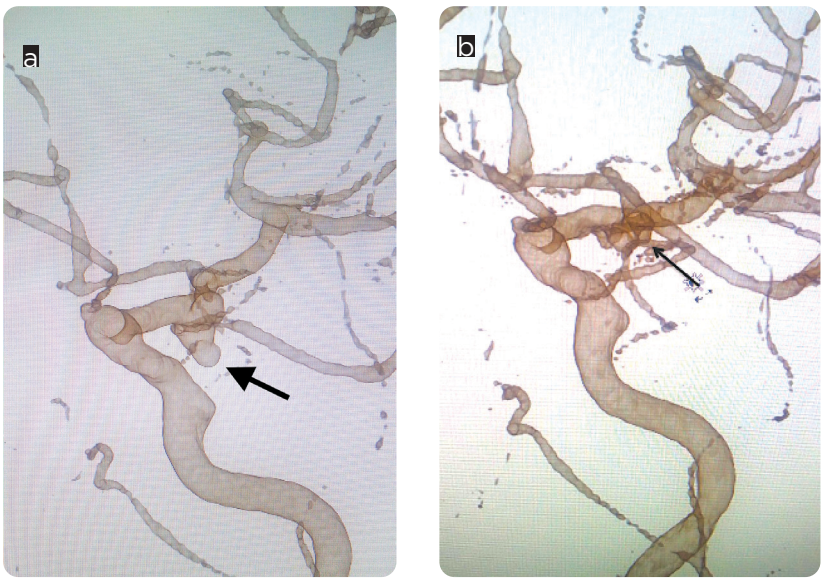

Figure 4. Saccular aneurysm of the posterior communicating artery. a) 3D pre-embolization reconstruction (arrow) b) 3D post-embolization reconstruction. Note the remaining aneurysmal sac portion in the posterior communicating artery (arrow).

Results

Of the 32 patients included in the study, 71.8% (n = 23) were women and 29.2% were men (n = 9). The minimum age was 3 years and the maximum was 90 years, with a mean of 55.5 years (Standard Deviation [SD] of 17.9 years). Among the risk factors for aneurysm rupture, age over 40 years was found in 27 patients (81.8%), 17 patients were hypertensive (53.1%) and 5 were smokers (15.6%). Table 1 shows the characteristics of the population studied. The most frequent locations were: right middle cerebral artery (MCA) with 10 cases (30.3%), anterior communicating artery (ACoA) with nine cases (27.3%) and posterior communicating artery (ACoP) with seven cases (21.2%) (Figure 1). The size of the aneurysms ranged from 3.6 mm to 26 mm, with an average of 8.44 mm; there was a greater frequency of small aneurysms (less than 10 mm), corresponding to 93.9% (n = 31). As for afferent vessel characteristics, it was documented that in most cases it was normal (60.6%). In 21 aneurysms 63.6% of the cases there were vessels originating from the aneurysm sac. All cases corresponded to saccular aneurysms (Figure 2). In the post-embolization angiographic control it was shown that 16 cases (48.5%) presented residual sac (figures 3 and 4) and that the characteristics of the afferent vessel were normal in most of these, 23 cases (69.7%) (figure 5). The duration of the procedure was in the range of 14 to 106 minutes with an average of 39 minutes (table 2).

Tabla 1. Características de la población estudiada

Variable	*n*	Porcentaje (%)
Sexo		
Mujer	23	69,7
Hombre	9	27,3
Edad		
Menores de 40 años	5	18,2
Mayores de 40 años	27	81,8
Factores de riesgo de ruptura de aneurisma		
Hipertensión arterial	17	53,1
Fumadores	5	15,6
Malformación arteriovenosa asociada	1	3,1
Ninguno	4	12,5

Discussion

Intracranial aneurysms are abnormal external dilations in the wall of intracranial blood vessels; the saccular variant is the most common. They are frequently located in the anterior circulation (90%) and commonly affect women in the 5th decade of life (5-7), all of which are frequent in the population of this study. The etiology of saccular aneurysms is still unknown (8); however, predisposing risk factors for their development and rupture have been studied, such as systemic arterial hypertension and smoking, present in 53.1% and 15.6% of our patients, respectively. Another risk factor per se is age over 40 years, which corresponds to 81.8% of the population. In this research with more than one year of follow-up there were no cases of aneurysm rupture, probably influenced by other factors such as: most of the patients presented small aneurysms and complete occlusion or only residual neck was obtained in more than half of the cases.

Some authors have considered 3D ASD as the reference diagnostic image for the evaluation of intracranial circulation in general and the planning of treatment of brain aneurysms, and complications as low as 0.3% have been found in expert hands (9).

Previously published studies have demonstrated the superior capability of 3D ASD when compared to 2D ASD and rotational angiography, evidencing the possibility of acquiring images in the cranio-flow axis in high resolution, the elimination of structures made of metallic material prostheses and spirals (stents, coils) or overlapping structures and the performance of simulation processes. In addition, it is an intracranial hemodynamic technique, which achieves in real time the assessment of the physiological state of the collateral vessels, the afferent vessel of the aneurysm and the vessels within the aneurysm sac (10, 11).

In our research, regarding the size of the aneurysm with the 3D ASD technique, we were able to detect small aneurysms from 3.6 mm. Previous research has documented that 3D angiography can detect aneurysms up to 0.5 mm.

2D angiography has been attributed a sensitivity and specificity greater than 90% for detecting aneurysms measuring 3 mm; however, it has marked limitations for visualizing aneurysms smaller than 2 mm (12, 13).

In the 33 aneurysms in our study, their shape could be adequately classified as saccular and images of sufficient quality were obtained to plan endovascular treatment. The literature describes that the ability of 2D angiography to accurately show the shape of the aneurysm has a lower performance compared to 3D ASD images (3).

Regarding the definition of the afferent vessel characteristics and the presence of vessels originating from the aneurysm sac, this technique manages to eliminate the overlapping of vascular structures, thanks to the post-processing in the working console and the 360-degree view of the aneurysm. In this way it was possible to detect that in 18.2% of the cases the afferent vessel was dysplastic and that 63.6% of the cases there were vessels in the aneurysm sac. Although the role of 3D ASD to avoid the overlapping of vascular structures was not specifically described in the present research, several studies have been published that support the superiority of this characteristic of 3D ASD over 2D when characterizing these findings (11).

In some studies, 3D ASD is recommended as the standard study for angiographic follow-up of patients with coiled embolized aneurysms, to increase the detection rate of remaining aneurysms and to identify afferent vessel stenosis (6, 8, 9, 12). In our study, the remaining aneurysm sac (most of it small size) was identified as the main immediate post-treatment result by 48.5%.

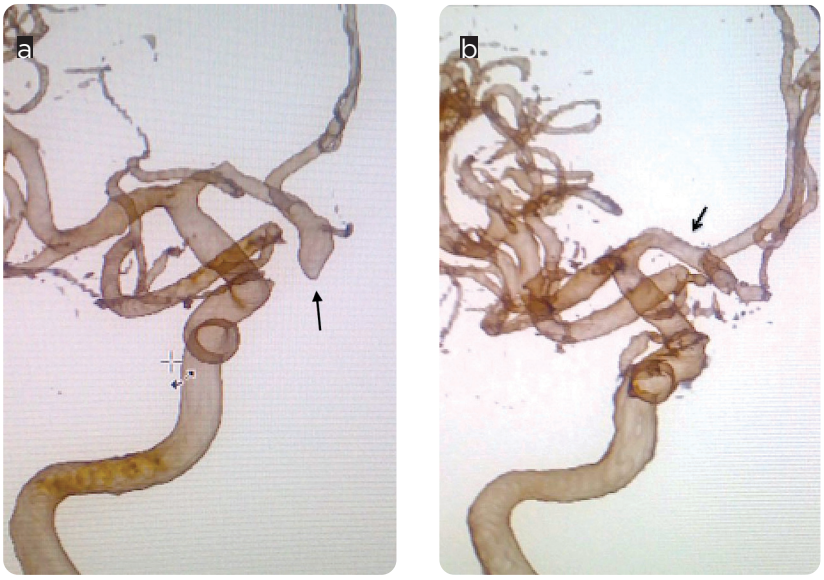

Figure 5. Saccular aneurysm of the anterior communicating artery. a) 3D pre-embolization reconstruction (arrow) b) 3D post-embolization reconstruction. Note the normal state of the afferent vessel (arrow).

Table 2. Characteristics evaluated in 3D angiography of the aneurysm and afferent vessel before and after embolization

Variable	*n*	Percentaje (%)
Size		
Small (< 10 mm)	31	94
Large (> 10 mm)	1	3
Giant (> 25 mm)	1	3
Afferent vessel characteristics		
Normal	20	60,6
Dysplastic	6	18,2
With vasospasm	7	21,2
Vessels in the aneurysm sac		
Yes	21	63,6
No	12	36,4
Post-treatment result		
Residual bag	16	48,5
Residual neck	10	30,3
Complete occlusion	7	21,2
Characteristics of post-embossing afferent cup		
Normal	23	69,7
With vasoespasm	6	18,2
Dysplastic	3	9,1
With stenosis	1	3,0

Study limitations and recommendations for further studies

Our findings should be replicated with medium- and long-term follow-up controls to determine aneurysm recurrence, shrinkage, or stabilization, since, depending on the size and configuration of the aneurysm, subsequent re-interventions may be necessary to complete treatment. This medium- and long-term follow-up was not possible, partly due to administrative factors derived from the health system, since some patients were referred for follow-up and control in other institutions. However, the vast majority of patients were assessed by the treating physician, with evidence of complete closure of the aneurysms. Additionally, it is considered that a classification should be applied to determine the percentage of remaining sac, with that it would be easier and more objective the way to compare in the follow-up studies the significant variations that the aneurysms present.

Conclusion

This observational study shows that multiplanar projections with 3D reconstruction allow a complete characterization of the aneurysm and evaluation of the adjacent anatomical structures, which is very useful for planning the procedure and in the post-embolization follow-up, especially to determine the degree of occlusion of the treated aneurysms.

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