

Computed Tomography Angiography with Three-Dimensional Reconstruction versus Rotational Angiography as a Screening Test in Patients with Suspected Cerebral Aneurysm

Antonio Maximiano Zárate Méndez¹ Nadia Pérez Peña Rosas¹ Juan Carlos Lujan Guerra¹
Antonio García Mayagoitia¹ Aleixandre Betanzos Villegas¹ Eduardo Walter Lizararu Gutiérrez¹
Gabriel Emmanuel Cachon Camara¹ Jorge Octavio Olvera Castro¹ José Luis Aceves Chimal¹

¹Division of Neurosciences, Department of Neurosurgery, Centro Médico Nacional “20 de Noviembre” Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE), Mexico City, Mexico

Address for correspondence Antonio Maximiano Zárate Méndez, MD, Av. Félix Cuevas 540 Col. Del Valle, Delegación Benito Juárez, Mexico City, CP 03100, Mexico (e-mail: narmmaesse@gmail.com).

Indian J Neurosurg 2016;5:95–100.

Abstract

Keywords

- ▶ computed tomography angiography
- ▶ cerebral aneurysm
- ▶ rotational angiography
- ▶ digital subtraction angiography

Introduction The digital subtraction angiography is considered the gold standard in detecting cerebral aneurysms. Other less invasive techniques that require a lesser dose of contrast medium are currently employed such as rotational angiography (RA) and computed tomography angiography with three-dimensional reconstruction (3D-CTA). The aim of this study is to recommend 3D-CTA as a screening test for cerebral aneurysms in patients with suspected cerebrovascular pathology, having compared it to other tests requiring the use of less contrast medium, in this case, RA and 3D-CTA.

Materials and Methods The study was performed between 2010 and 2014 among all patients referred to the Centro Médico Nacional “20 de Noviembre” ISSSTE, in Mexico City, presenting a total of 332 patients with suspected cerebral aneurysm; 182 patients who had undergone angiography or digital subtraction angiography in a different hospital were not included, and 50 patients who tested negative for cerebral aneurysm were also excluded. Experts in neurological imaging examined the results, comparing those diagnosed with cerebral aneurysms, using RA and 3D-CTA against the gold standard.

Results Both RA and 3D-CTA registered the same aneurysm dimensions. Differences were observed in aneurysm’s dome only.

Conclusion The RA should be reserved for those cases where a DSA is deemed necessary, but cannot be performed due to the high amount of contrast medium required and risk of adverse reactions in allergic population; in this case, the 3D-CTA is a better test.

received
November 21, 2015
accepted
January 18, 2016
published online
August 25, 2016

DOI <http://dx.doi.org/10.1055/s-0036-1581976>.
ISSN 2277-954X.

© 2016 Neurological Surgeons’ Society
of India

License terms



Introduction

Nontraumatic (spontaneous) subarachnoid hemorrhages (SAHs) occur in 75 to 80% of cases due to a ruptured cerebral aneurysms; the reported incidence varies from 6 to 8 person per 100,000.¹ These reveal a high prevalence, and as such a preventative medicine approach should be taken toward this condition. It is also necessary to mention incidental aneurysms, with a prevalence that can vary from 0.8 to 6% and up to 12.2%.^{2,3} Incidental aneurysms include those presenting neurological symptomatology other than rupture, “unruptured aneurysms” which do not present any of these symptoms, and “hidden aneurysms” which are discovered incidentally during surgical procedures but which escaped diagnosis during preoperative digital subtraction angiography (DSA). Incidental and hidden aneurysms⁴ can bleed and cause death at any given time.⁵

Technology has improved since E. Moniz performed the first cerebral angiography in 1927,⁶ and although DSA is currently the gold standard for detecting cerebral aneurysms, its associated complications have not been reduced by technological advances. These can be divided into two main groups: neurological complications and nonneurological complications.

Among the potential neurological complications that can arise, vascular dissection is reported in 4% of cases,⁷ events provoked by arterial embolism are reported in 0.08%,⁸ alterations to cerebral vascular tone level and hypercoagulability, which cause cerebral infarction, in 0.14% of cases,⁹ transient neurologic deficits in 1.2%, and permanent neurologic deficits in 1 to 2.63% of cases with a mortality rate of 0.1%.^{7,10,11} The most frequently reported nonneurological complications are renal failure at 0.15%, arterial occlusion requiring surgical treatment at 0.4%, and arteriovenous fistula or pseudoaneurysm in up to 0.22% of cases.¹²

Although the administration of premedication to patients allergic to iodine-containing contrast medium is an option, the test is contraindicated when the allergy is severe¹³; this has led to the development of rotational angiography (RA), which requires a lesser dose of contrast medium. Selective catheterization of the vessel is performed using the equipment's power injector to inject a bolus of contrast medium, while images are acquired from an arc of movement of 180 degrees around the head for 4 seconds. The three-dimensional reconstruction is an option; however, it continues to be an invasive and costly method that takes longer to carry out.^{14,15} As a result, computed tomography angiography with three-dimensional reconstruction (3D-CTA) has gained importance as a diagnostic tool in pathologies of cerebrovascular origin.¹⁶ Not only is 3D-CTA a noninvasive procedure, but also images are obtained more quickly, it can be performed as an emergency procedure, visuospatial resolution is higher, volumetric acquisition is permitted,⁵ and both the vessel wall and the lumen can be simultaneously visualized. Independently of the diagnostic test employed, the information to be obtained in the case of cerebral

aneurysms should include the anatomic location, the number of aneurysms (single or multiple), the shape (saccular, fusiform, lobulated, multilobulated), and the size.¹⁷

The aim of this study is to measure the precision of 3D-CTA compared with RA when used as a screening test in suspected cases of cerebral aneurysms, taking DSA as the gold standard.

Materials and Methods

The study was performed between 2010 and 2014 among all patients referred to the Centro Médico Nacional “20 de Noviembre” Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado, in Mexico City, presenting with suspected cerebral aneurysm. A total of 332 patients were tested, independently of the clinical way in which they had been diagnosed; all were confirmed via DSA and cerebral aneurysms were selected and classified as unruptured or incidental; morphological characteristics of the cerebral aneurysm (size, shape, and number) were not included in the selection criteria, nor anatomical location or complexity (clipping difficulty, location, and giant and partially thrombosed aneurysms).

The details of the study and the diagnostic tests that the patient would undergo were explained to the patient's family and the appropriate informed consent was obtained. Hospital's ethics committee also approved this study.

A total of 182 patients who had undergone angiography or DSA in a different hospital were not included. In total, 50 patients who tested negative for cerebral aneurysm were excluded.

The DSA and RA were performed with SIEMENS Artis Zeego equipment (►Fig. 1) and iodinated contrast medium, with an injection volume of 8 mL and a total volume of 150 mL, given at an injection rate of 5 mL/s for the internal carotid artery and 3 mL/s for the external carotid artery before being processed and sent to the picture archiving and communication system (PACS). Both the DSA and RA were performed during the same test session. The RA was performed with a single selective shot to the vessel in which the aneurysm was located, while images were acquired from an arc of movement of 180 degrees around the head for 4 seconds. The amount of contrast medium used was dependent upon the location of the cerebral aneurysm. Following this, a 3D-CTA was performed. We then performed 64-slice multislice CT, with over 300 slices of 1 mm each. We employed 90 mL of contrast medium with an injection time of ~30 seconds. Tests took an average of 5 to 10 minutes, and results were available immediately afterwards. The 3D-CTA reconstructions were performed by a vascular neurosurgeon, expert in the use of PACS for 3D-CTA (►Fig. 2); and in each of the three tests, the aneurysm was measured as laid out in Sadato et al,¹⁸ where the dome, neck, and width of the aneurysm are measured (►Fig. 3) comparing the RA and 3D-CTA with the DSA gold standard (►Fig. 4). The following variables were obtained from medical records: age, sex, and date of SAHs.



Fig. 1 Angiography suite with SIEMENS Artis Zeego.



Fig. 2 CT suite. (A) 64-slice multislice computed tomography with power injector. (B) Contrast medium administration device. (C) Picture archiving and communications system (PACS).

Results

The 300 tests (DSA, RA, and 3D-CTA) performed on 100 patients were analyzed; 82% were females and 18% were males (►Fig. 5). Each case presented with at least two aneurysms; 31% were complex, and 79% were saccular and 21% lobular. The anatomical location of each aneurysm was also noted: paraclinoid (46%), middle cerebral artery (22%), anterior communicating artery (9%), anterior cerebral artery (8%), posterior cerebral artery (7%), basilar artery (5%), and vertebral artery (3%). As expected with the clinical presentation of SAH, it was found that 50% of the aneurysms had ruptured within an average bleeding time of 16 days, 23% were unruptured, and 27% were diagnosed

as incidental (►Fig. 6). Both diagnostic methods (RA and 3D-CTA) registered the same aneurysm dimensions (dome, neck, and width) and did not find any significant differences in the neck diameter. Differences were observed only in the aneurysm dome (►Table 1).

The 3D-CTA displayed similar utility to the RA, with the same sensitivity, specificity, and negative predictive value (►Table 2). Inter- and intraobserver variability was 0.08 and 0.05, respectively.

Discussion

DSA, currently considered the gold standard, has become an indispensable tool, displaying an aneurysm diagnosis



Fig. 3 Aneurysm measurements: dome (A), neck (B), and width (C).¹⁸

sensitivity of over 95% in several studies; however, its inconvenience lies in its invasiveness and the use of elevated quantities of contrast medium leading to a higher disease burden.^{19–21}

RA can diagnose cerebral aneurysms up to 2 mm, but is inconvenient as it requires an invasive method, although it uses less amount of contrast medium than DSA.²² The RA may be an option for patients requiring assessment of laterality and flow with anterior communicating artery aneurysms, in which case it is considered necessary to perform DSA. If the patient is allergic to contrast medium but have never experienced anaphylactic reactions, 3D-CTA may be performed. 3D-CTA may also be used as a screening

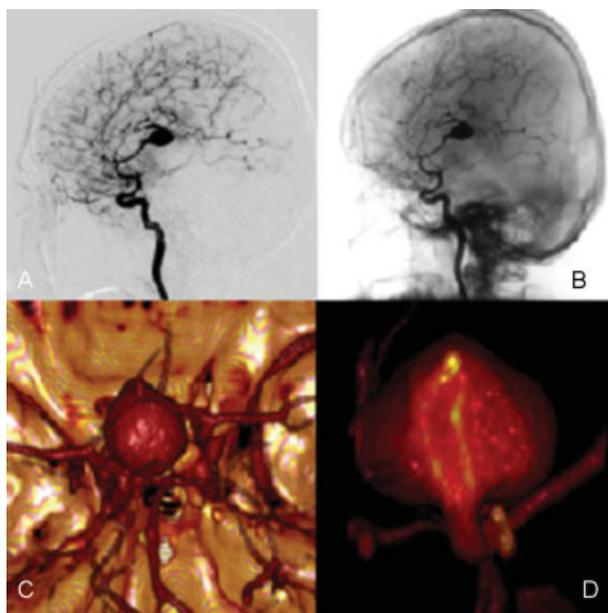


Fig. 4 (A) Digital subtraction angiography (DSA), (B) rotational angiography (RA), and (C, D) computed tomography angiography with three-dimensional reconstruction (3D-CTA).

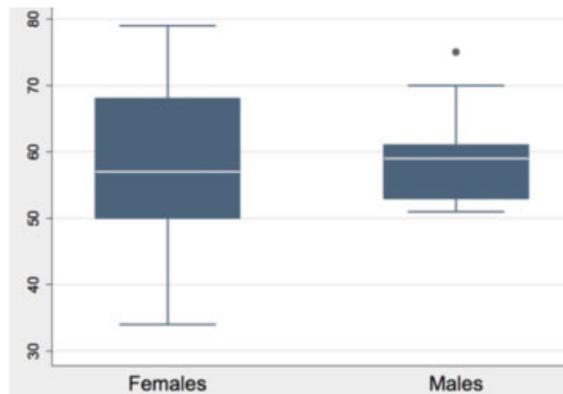


Fig. 5 Age according to sex.

test in patients suspected of cerebral aneurysm lesions, due to clinical symptoms or a family history of the disease.

An advantage of 3D-CTA is that, rather than require aggressive vascular invasion, it uses a peripheral vein and it is also capable of detecting cerebral aneurysms of 2 mm.²³

During this study, the 3D-CTA showed no significant differences compared with the RA test with regard to its utility in detecting cerebral aneurysms, demonstrating a diagnostic sensitivity of 93 versus 98% ($p = 0.50$) and a positive predictive value of 91 versus 100% ($p = 0.10$), respectively. Specificity was measured at 100% in both studies (RA and 3D-CTA). Therefore, 3D-CTA is recommended as a diagnostic tool to be employed for the detection of cerebral aneurysms, offering less morbidity and good results when used as an initial study or screening test for those at risk of cerebral aneurysm or where clinical suspicion exists.

The complications associated with cerebral angiography procedures may be transitory or permanent. The neurological morbidity in various studies shows up to 2.63% of complications result in permanent consequences (seizures, cerebral infarction, and arterial embolism).¹⁰ Transitory complications (ictus, minor bruising, and

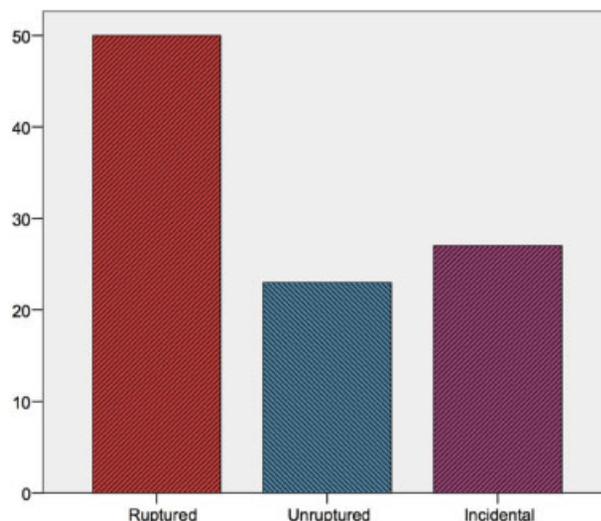


Fig. 6 Clinical presentation of aneurysm.

Table 1 Aneurysm dimensions obtained from RA and 3D-CTA

Parameters	RA	3D-CTA	<i>p</i>
Neck (cm)	0.58 ± 0.03	0.56 ± 0.02	0.43
Dome (cm)	0.86 ± 0.04	1.04 ± 0.03	0.05
Width (cm)	0.72 ± 0.02	0.65 ± 0.03	0.06

Abbreviations: 3D-CTA, computed tomography angiography with three-dimensional reconstruction; RA, rotational angiography.

Note: *p*-values are calculated using the Student *t*-test.

Table 2 Utility of rotational angiography (RA) and computed tomography angiography with three-dimensional reconstruction (3D-CTA) in detecting cerebral aneurysms

Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
3D-CTA	93	100	91	100
RA	98	100	100	100
<i>p</i>	0.50 ^a	1.0	0.10 ^b	1.0

Abbreviations: 3D-CTA, computed tomography angiography with three-dimensional reconstruction; NPV, negative predictive value; PPV, positive predictive value; RA, rotational angiography.

^a*p*-value calculated using chi-square test.

^b*p*-value calculated using Fisher exact test.

cerebral ischemia) occur in 0.14% of cases, but they imply longer hospitalization and close medical surveillance, leading to an increased use of the material and financial resources of health institutions.^{3,4,24–27}

During this study, no patient presented adverse reactions or complications as a result of the 3D-CTA. However, as a result of the DSA and RA, three patients presented with vasospasm and transient neurological deficit; it was here that the 3D-CTA proved to be superior than the other tests with noninvasive and quick results, and with a diagnostic precision similar to the gold standard.

Conclusion

The RA should be reserved for those cases where a DSA is deemed necessary, but cannot be performed due to the high amount of contrast medium required and risk of adverse reactions in allergic population. As mentioned above, the 3D-CTA also shows good sensitivity and specificity, similar to the DSA and RA, as well as lesser morbidity; and as such, it is recommended for use in preventative medicine as a diagnostic screening test in patients with suspected cerebral aneurysms or who fall within the “at risk” category as a result of their family history.

Conflict of Interest

The authors declare no conflict of interest.

References

- Zacharia BE, Hickman ZL, Grobelny BT, et al. Epidemiology of aneurysmal subarachnoid hemorrhage. *Neurosurg Clin N Am* 2010;21(2):221–233
- Ruiz-Sandoval JL, Cantú C, Chiquete E, et al; RENAMEVASC Investigators. Aneurysmal subarachnoid hemorrhage in a Mexican multicenter registry of cerebrovascular disease: the RENAMEVASC study. *J Stroke Cerebrovasc Dis* 2009;18(1):48–55
- Cloft HJ, Joseph GJ, Dion JE. Risk of cerebral angiography in patients with subarachnoid hemorrhage, cerebral aneurysm, and arteriovenous malformation: a meta-analysis. *Stroke* 1999;30(2):317–320
- Heiserman JE, Dean BL, Hodak JA, et al. Neurologic complications of cerebral angiography. *AJNR Am J Neuroradiol* 1994;15(8):1401–1407, discussion 1408–1411
- Xing W, Chen W, Sheng J, et al. Sixty-four-row multislice computed tomographic angiography in the diagnosis and characterization of intracranial aneurysms: comparison with 3D rotational angiography. *World Neurosurg* 2011;76(1–2):105–113
- Ligon BL. Biography: history of developments in imaging techniques: Egas Moniz and angiography. *Semin Pediatr Infect Dis* 2003;14(2):173–181
- Hankey GJ, Warlow CP, Sellar RJ. Cerebral angiographic risk in mild cerebrovascular disease. *Stroke* 1990;21(2):209–222
- Gupta R, Vora N, Thomas A, et al. Symptomatic cerebral air embolism during neuro-angiographic procedures: incidence and problem avoidance. *Neurocrit Care* 2007;7(3):241–246
- Bridcut RR, Murphy E, Workman A, Flynn P, Winder RJ. Patient dose from 3D rotational neurovascular studies. *Br J Radiol* 2007;80(953):362–366
- Leffers AM, Wagner A. Neurologic complications of cerebral angiography. A retrospective study of complication rate and patient risk factors. *Acta Radiol* 2000;41(3):204–210
- Kaufmann TJ, Huston J III, Mandrekar JN, Schleck CD, Thielen KR, Kallmes DF. Complications of diagnostic cerebral angiography: evaluation of 19,826 consecutive patients. *Radiology* 2007;243(3):812–819
- Citron SJ, Wallace RC, Lewis CA, et al; Society of Interventional Radiology; American Society of Interventional and Therapeutic Neuroradiology; American Society of Neuroradiology. Quality improvement guidelines for adult diagnostic neuroangiography. Cooperative study between ASITN, ASNR, and SIR. *J Vasc Interv Radiol* 2003;14(9, Pt 2):S257–S262

- 13 Sattenberg RL, Saver JL, Gobin PY, Liebeskind DS. Cerebral angiography. In: Mohr JP, Wolf PA, Grotta JC, Moskowitz MA, Mayberg MR, von Kummer R eds. *Stroke: Pathophysiology, Diagnosis, and Management*. 5th ed. Philadelphia, PA: Elsevier; 2011:910–928
- 14 Matsumoto M, Sato M, Nakano M, et al. Three-dimensional computerized tomography angiography-guided surgery of acutely ruptured cerebral aneurysms. *J Neurosurg* 2001;94(5):718–727
- 15 Agarwal N, Gala NB, Choudhry OJ, et al. Prevalence of asymptomatic incidental aneurysms: a review of 2,685 computed tomographic angiograms. *World Neurosurg* 2014; 82(6):1086–1090
- 16 Vlak MH, Algra A, Brandenburg R, Rinkel GJ. Prevalence of unruptured intracranial aneurysms, with emphasis on sex, age, comorbidity, country, and time period: a systematic review and meta-analysis. *Lancet Neurol* 2011;10(7):626–636
- 17 Göllitz P, Struffert T, Knossalla F, et al. Angiographic CT with intravenous contrast injection compared with conventional rotational angiography in the diagnostic work-up of cerebral aneurysms. *AJNR Am J Neuroradiol* 2012;33(5):982–987
- 18 Sadato A, Hayakawa M, Tanaka T, Hirose Y. Comparison of cerebral aneurysm volumes as determined by digitally measured 3D rotational angiography and approximation from three diameters. *Interv Neuroradiol* 2011;17(2):154–158
- 19 Karamessini MT, Kagadis GC, Petsas T, et al. CT angiography with three-dimensional techniques for the early diagnosis of intracranial aneurysms. Comparison with intra-arterial DSA and the surgical findings. *Eur J Radiol* 2004;49(3):212–223
- 20 Kojima A, Yamaguchi N, Okui S. Three dimensional digital subtraction angiography imaging of a ruptured aneurysm on the anterior communicating artery. *Surg Neurol* 2002;58(1): 49–52, discussion 53
- 21 Kumar A, Kato Y, Motoharu H, et al. An update on three-dimensional CT angiography in aneurysms: a useful modality for a neurosurgeon. *Turk Neurosurg* 2013;23(3):304–311
- 22 Lv F, Li Q, Liao J, et al. Detection and characterization of intracranial aneurysms with dual-energy subtraction CTA: comparison with DSA. *Acta Neurochir Suppl* 2001; 110:239–245
- 23 Teksam M, McKinney A, Cakir B, Truwit CL. Multi-slice CT angiography of small cerebral aneurysms: is the direction of aneurysm important in diagnosis? *Eur J Radiol* 2005;53(3): 454–462
- 24 Bharatha A, Yeung R, Durant D, et al. Comparison of computed tomography angiography with digital subtraction angiography in the assessment of clipped intracranial aneurysms. *J Comput Assist Tomogr* 2010;34(3):440–445
- 25 Luo Z, Wang D, Sun X, et al. Comparison of the accuracy of subtraction CT angiography performed on 320-detector row volume CT with conventional CT angiography for diagnosis of intracranial aneurysms. *Eur J Radiol* 2012;81(1): 118–122
- 26 Willinsky RA, Taylor SM, TerBrugge K, Farb RI, Tomlinson G, Montanera W. Neurologic complications of cerebral angiography: prospective analysis of 2,899 procedures and review of the literature. *Radiology* 2003;227(2):522–528
- 27 Bendszus M, Koltzenburg M, Burger R, Warmuth-Metz M, Hofmann E, Solymosi L. Silent embolism in diagnostic cerebral angiography and neurointerventional procedures: a prospective study. *Lancet* 1999;354(9190):1594–1597