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

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Abstract

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.

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

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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 aneurysms[4] 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 severe[13]; 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]

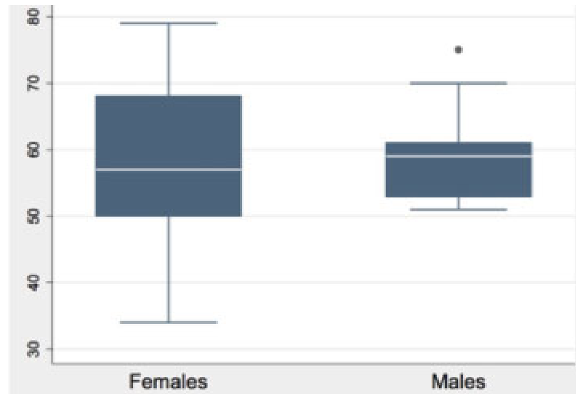

Fig. 5 Age according to sex.

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 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

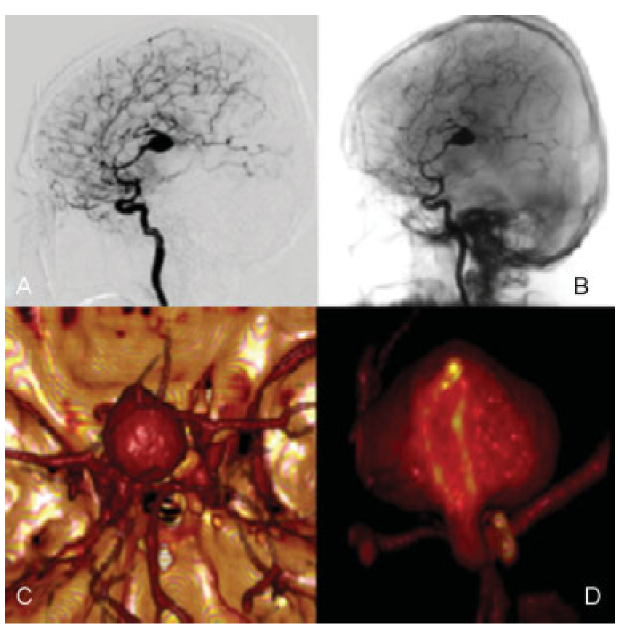

Fig. 4 (A) Digital subtraction angiography (DSA), (**B**) rotational angiography (RA), and (**C, D**) computed tomography angiography with three-dimensional reconstruction (3D-CTA).

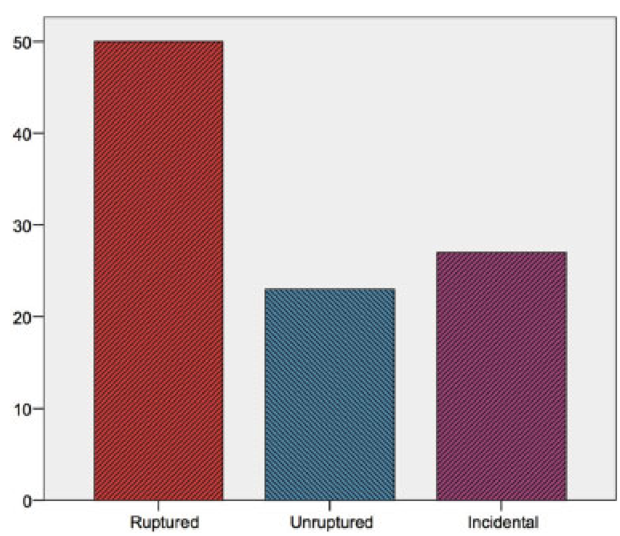

Fig. 6 Clinical presentation of aneurysm.

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

Parameters	RA	3D-CTA	*p*
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
p	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.

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