European Journal of Radiology 81 (2012) 2794–2800

Contents lists available at SciVerse ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Three-dimensional volume rendering digital subtraction angiography in comparison with two-dimensional digital subtraction angiography and rotational angiography for detecting aneurysms and their morphological properties in patients with subarachnoid hemorrhage

Fahrettin Kucukay[a,*], R. Sarper Okten[a], Ayhan Tekiner[b], Mustafa Dagli[a], Cevdet Gocek[b], Mehmet Akif Bayar[b], Turhan Cumhur[a]

[a] Turkiye Yuksek Ihtisas Hospital, Department of Radiology, Ankara, Turkey
[b] Ankara Education and Teaching Hospital, Department of Neurosurgery, Ankara, Turkey

ARTICLE INFO

Article history:
Received 8 September 2011
Accepted 14 October 2011

Keywords:
Intracranial aneurysm
Rupture
Cerebral angiography
Digital subtraction angiography
Three-dimensional imaging

ABSTRACT

Objective: Subarachnoid hemorrhage (SAH), which can cause mortality and severe morbidity, is a serious condition whose underlying cause must be determined. We aimed to compare 2D digital subtraction angiography (2DDSA), rotational angiography (RA) and 3D volume rendering digital subtraction angiography (3DVRDSA) for detecting aneurysms and their morphological properties in patients with subarachnoid hemorrhage.
Materials and methods: After an initial diagnosis of SAH with computed tomography, 122 patients (52 males and 70 females with a mean age of 47.77 ± 12.81 ranging between 20 and 83 years) underwent 2DDSA imaging, RA and 3DVRDSA imaging for detection of aneurysms. The location of the aneurysm, the best working angles, the dome/neck ratios, the largest diameter of the aneurysm, the shape of the aneurysm, the presence of spasms or pseudostenoses, and the relationship to the neighboring arteries were recorded.
Results: 2DDSA missed 15.6% of the aneurysms that had a mean size of 2.79 ± 0.74 mm. RA was superior to 2DDSA for detecting aneurysm neck, and 3DVRDSA was superior to RA for detecting aneurysm neck. 3DVRDSA conclusively depicted the shape of the aneurysms in all patients. 3DVRDSA imaging was superior to 2DDSA and RA in the detection of the aneurysm relationship to neighboring arteries. The sensitivity and specificity of 3DVRDSA imaging for the detection of vasospasms were 100 and 84%, respectively.
Conclusions: 3DVRDSA imaging is superior to 2DDSA and RA for detecting intracranial aneurysms and their morphological properties, especially those of small, ruptured aneurysms. However, 2DDSA should not be neglected in cases of vasospasm.

1. Introduction

Subarachnoid hemorrhage (SAH) is an emergent condition with case-fatality rates that vary between 8.3% and 66.7% in different studies [1]. The risk of sudden death before reaching a hospital is 12.4% [2]. In patients with subarachnoid hemorrhages, the underlying cause remains to be determined. Aneurysms are the cause of subarachnoid hemorrhage in 85% of cases [3]. For this reason, a detailed examination with diagnostic imaging modalities to detect intracranial aneurysms is necessary.

Two-dimensional digital subtraction angiography (2DDSA) is accepted as the gold standard imaging technique for the diagnosis of intracranial aneurysms [4–10]. However, detecting small aneurysms that can also rupture and restrictions in identifying the morphological properties of aneurysms (location, neck, shape, and the relationship to the neighboring artery) are limitations of 2DDSA. Rotational angiography (RA) and three-dimensional digital subtraction imaging (3DDSA) are advantageous not only because they detect small aneurysms and identify morphological properties of intracranial aneurysms but also because they reduce the radiation dose, reduce the contrast volume that needs to be injected, and have a shorter procedure time [4–12]. There are a number of reports related to this topic, but few have

* Corresponding author at: Turkiye Yuksek Ihtisas Hospital, Department of Radiology, Kizilay sokak No. 4, 06100 Sihhiye, Ankara, Turkey. Tel.: +90 3123061619; fax: +90 3123124120.
E-mail address: fkucukay@hotmail.com (F. Kucukay).

0720-048X/$ – see front matter © 2011 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.ejrad.2011.10.006

been performed with three-dimensional volume rendering digital subtraction angiography (3DVRDSA) imaging [5,8]. Although 3DVRDSA imaging has many advantages, it is limited in the detection of vasospasms, which are important prognostic factors [13,14].

In this study, we aimed to compare 2DDSA, RA and 3DVRDSA imaging for detecting intracranial aneurysms and their morphological properties in patients with subarachnoid hemorrhages. Our second aim was to compare 2DDSA and 3DVRDSA imaging for detecting vasospasms.

2. Materials and methods

2.1. Patient population

Patients with a subarachnoid hemorrhage on computed tomography (CT) scans were included in the study. After the initial diagnosis with CT, all patients underwent 2DDSA imaging and RA for detection of aneurysms. Rotational images were reconstructed, and 3DVRDSA images were obtained. Patients with multiple aneurysms were excluded from the study. In cases with multiple aneurysms, it could be difficult to determine the aneurysm that caused SAH. A total of 122 patients were included in the study (52 males and 70 females with a mean age of 47.77 ± 12.81 ranging between 20 and 83 years old). Locoregional anesthesia with 20 ml prilocaine hydrochloride (Priloc, 2% 400 mg, VEM Ilac san., Istanbul, Turkey) was the preferred anesthetic method for most patients. After the detection of aneurysms, patients were treated either with an endovascular approach or surgery. Written informed consent was obtained from all patients, and the study was approved by the hospital review board.

2.2. Imaging techniques

2DDSA imaging with a monoplane system (Integris Allura, Philips Medical Systems, Netherlands) was performed after selective catheterization of vertebral and carotid arteries. Anteroposterior, oblique (right or left anterior oblique with 45° rotation), lateral and Towne's (30° angulation in craniocaudal direction) views were obtained. The X-ray parameters were 80 kV and 400 mA, a 512×512 matrix size, a 20 cm field of view and the acquisition of two images per second. The injection rate was 4–5 ml/s, and a total of 9–10 ml contrast agent (Omnipaque (Ioheksol), 350 mg/ml, Amersham Health, Ireland) was injected for each view. After the completion of 2DDSA imaging, RA was performed. To obtain RA images, two techniques can be used. One is the standard rotation technique, in which the range of RA extends over 180° (left oblique 90° and right oblique 90°) at a maximum rotational speed of 30°/s within 7 s. In this technique, the C arm is placed perpendicular to the head axis. The other technique is the propeller rotation technique, in which the range of RA extends over 240° (left oblique 120° and right oblique 120°) at a maximum rotational speed of 55°/s within 4 s. In this technique, the C arm remains in the same position as conventional angiography in the propeller rotation technique. Compared to the standard rotational technique, the propeller RA technique is faster, easier to perform and requires less contrast material without limiting image quality [4]. The propeller rotation technique [4] was used for RA in this study. A total of 100 masked and 100 contrast-injected images with a 512×512 matrix were obtained. Contrast injection rates and total injected contrast volumes were 4 ml/s and 16 ml, respectively, for carotid arteries and 3 ml/s and 12 ml, respectively, for vertebral arteries. A power injector (Medrad Mark V Provis, USA) was used for contrast injection. The same contrast agent that was used in the 2DDSA imaging was used for RA. There was a 1.5 s delay between the beginning of the injection and acquisition of the first image. All obtained images (mask and contrast runs) were transferred to a workstation (Integris 3-D RA Release 4.2, Koninklijke, Philips Electronics, 2004) for 3DVRDSA image reconstruction, which took 10–15 min. 3DVRDSA images were generated by three radiologists (FK, SO, and MD). The surrounding structures were removed, and vessel visualization was optimized with fine adjustments. In 3DVRDSA imaging, the best working angle for the identification of the aneurysm localization, neck, shape and relationship to the neighboring arteries was determined. Using this angle, a final 2DDSA image was reproduced (Fig. 1(a) and (b)).

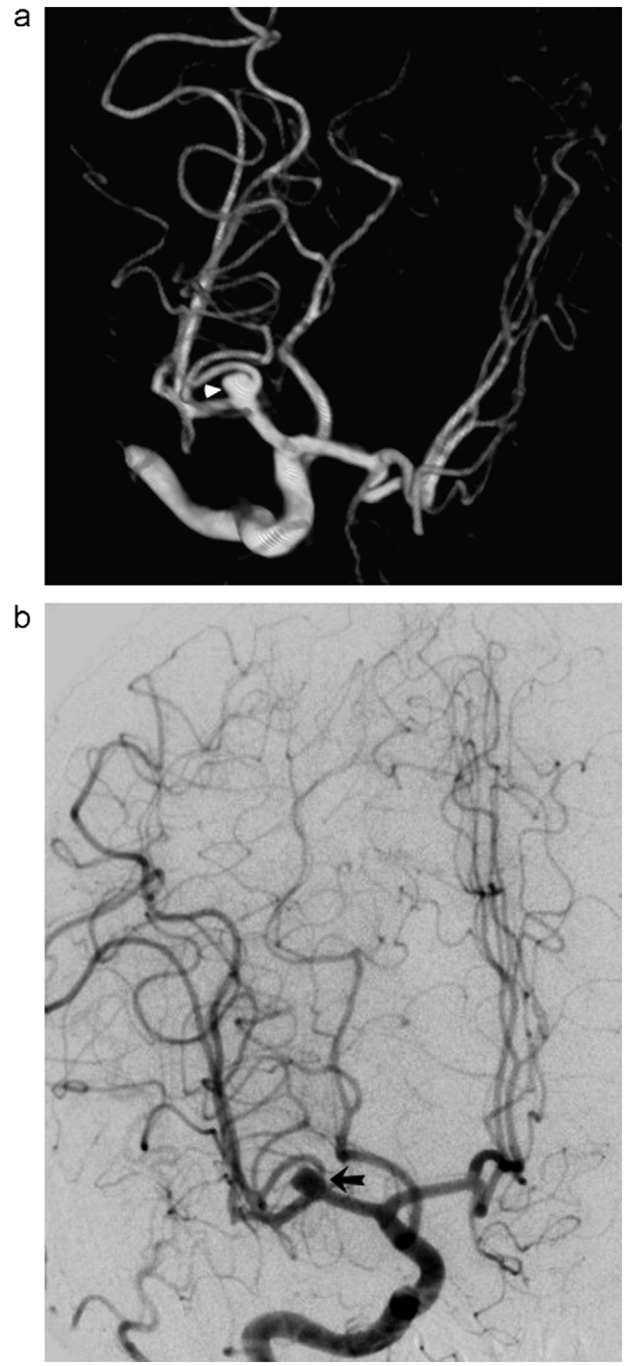

Fig. 1. (a) 3DVRDSA image of a cerebral aneurysm obtained at the BWA (the white arrowhead shows the aneurysm). (b) 2DDSA image that was obtained at the BWA (the black arrow shows the aneurysm).