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Can we now dispense with DSA in the evaluation of aneurysm occlusion even in the most crucial first follow-up after endovascular treatment?

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ABSTRACT

Objectives: Catheter angiography (DSA) as gold standard for the evaluation of aneurysmal occlusion after coiling has now been largely replaced by MRI or CTA in long term observations. However, the first year after treatment is crucial because most recurrences occur in this time. Until now no guidelines exist concerning the imaging modality to adopt in this period. Aim of the study was to determine whether DSA could also be omitted in the first follow-up examination after coiling due to MRI results.
Patients and methods: 489 consecutive half-year follow-up examinations consisting of DSA, CE-MRA and TOF-MRA at 1.5 or 3T were reviewed retrospectively. Visualization of residual or recurrent aneurysms in both MRA-techniques was compared to DSA by two experienced readers.
Results: Remnants/recurrences could be visualized in at least one of the three techniques in 190 (38.9%) aneurysms. Remnants/recurrences requiring retreatment (n = 52) were detectable with at least one of the two MRI-techniques. In three cases (0.6%) remnants/recurrences were only visible on DSA but neither on CE-MRA nor on TOF-MRA. However, they were small (<2 mm) and therapy concept did not change. In one case (0.2%) they were only visible on the CE-MRA and TOF-MRA but not on the DSA, in five cases (1%) visible on DSA and TOF-MRA but not on the CE-MRA and in four cases (0.8%) not visible on the TOF-MRA but on both of the other imaging modalities.
Conclusion: The combination of CE-MRA und TOF-MRA is also an appropriate alternative to DSA concerning the evaluation of residual or recurrent aneurysms in the crucial first follow-up.

1. Introduction

Endovascular embolization is nowadays the treatment of choice for many cerebral aneurysms [1–3] but has several shortcomings. One drawback is the possibility of aneurysm recurrence with time [4,5], which occurs in about 13–20% of coiled aneurysms [4–8]. Even in aneurysms that appear completely occluded after initial endovascular coiling, aneurysm recurrence may occur as a result of coil compaction, coil migration, aneurysm growth or dissolution of an intraluminal thrombus [9–13]. Additional embolization is often possible and may prevent growth and subsequent potential subarachnoidal hemorrhage (SAH) [10,14,15]. Therefore half of the recurrent aneurysms have to be retreated [5,13]. Thus, follow-up examinations after endovascular treatment are recommended. For many years, digital subtraction angiography has been the method of choice for the follow-up of coiled aneurysms and is still regarded as gold standard for the evaluation of aneurysm occlusion [8]. In recent years, however, several studies have proven a high diagnostic performance of magnetic resonance angiography in detecting incomplete aneurysm occlusion [4,6,8,16–20]. The main advantages of MRA over DSA are the non-invasiveness, lower risk and less patient discomfort [6,8,21]. CTA as the second non-invasive

Abbreviations: CE-MRA, contrast-enhanced MRA; TOF-MRA, time-of-flight MRA; MPR, multiplanar reconstructions; SAH, subarachnoid hemorrhage; CTA, computed tomography angiography.

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imaging possibility also requires exposure to ionizing radiation and iodinated contrast media and has been limited a long time by streak- and other coil-related artefacts [2]. However, in screening it may be cost effective and progress in this area has led to advantages in reducing metal artefacts [22] and could reveal benefits after stent-assisted coiling [23]. The first year after treatment is crucial because most recurrences occur in this time and until now no guidelines exist concerning the imaging modality to adopt in this period or the appropriate time schedule of follow-up imaging [10,13,24]. In clinical practice a large variety of follow-up schemes is utilized among different departments and different countries, from centers exclusively performing MRA or CTA and those using DSA regularly or additionally [8]. The aim of our study was to determine whether also the first follow-up DSA after embolization would be already dispensable as MRI might provide equivalent results concerning reliable visualization of aneurysm recurrence requiring retreatment.

2. Materials and methods

The local ethics review board approved the study. One thousand consecutive patients endovascularly treated between 2003 and 2012 in the University hospital Essen (Germany) were analyzed retrospectively. Only patients with complete short-term follow-up examination including DSA, TOF-MRA and CE-MRA were included in the study. Retreatments of the same aneurysm were excluded. The count of follow-up examinations exceeded the number of patients because in some patients more than one aneurysm was treated. Therefore the study comprised of a total of 430 patients with 489 examinations. Most of the follow-up examinations were performed exactly half a year after coiling. However, some examinations were performed at a later stage due to a variety of reasons. In all cases only the first follow-up after endovascular treatment was included in the study, because it is considered the most important examination and in our institution the only one including both techniques constantly. The interval between DSA and MRI did not exceed one week in any case.

2.1. MRI

Unenhanced 3D-TOF MRA and CE-MRA were performed in the same imaging session. Patients received intravenous injection of gadobutrol (0.2 mmol/kg body weight; Gadovist, Bayer Schering, Germany)in an antecubital vein with a rate of 2 ml/s manually or since 2007 by using an MRI-compatible power-injector (Medrad® Spectris Solaris® EP MR Injection System, MEDRAD Medizinische Systeme GmbH, Volkach, Germany). All contrast administrations were followed by a 20 ml-flush of 0.9% saline injected at the same flow rate.

Different MRI scanners were used: five 1.5T scanner: Symphony, Sonata, Avanto, Espree, Aera and one 3T scanner: Skyra; (all Siemens Medical Systems, Erlangen, Germany).

Parameter settings for all scanners and both sequences can be found in Tables 1 and 2 in the Supplementary material.

2.2. DSA

All cerebral catheter angiograms were performed by a standard transfemoral access. Until 2008 DSA of the intracranial vascular territories was performed on a Toshiba Infinix biplane unit (Toshiba Medical, Nasu, Japan). At least a total of 4 projections were acquired. Additionally one series in targeted orientation on the aneurysm was performed. Since 2008, when a Philips Allura (Philips Healthcare, Best, The Netherlands) biplane DSA-unit was introduced, the previously performed “oblique” 2-plane projections of the posterior circulation and both ACI territories were replaced by one rotational series. Rotational angiograms were acquired within a single C-arm rotation of 240° over a period of 4.1 s. 18 ml of nonionic contrast agent was injected automatically in the internal carotid artery with a flow rate of 3 ml/s or 15 ml of contrast agent with a flow rate of 2 ml/s in the posterior circulatory system using an injector (MedRad, Mark V ProVis®, MEDRAD Medizinische Systeme GmbH, Volkach, Germany). In one rotation of the c-arm, 122 images were acquired and used to create 3-dimensional reconstructions.

2.3. Data analysis

Image post-processing and analysis were performed by two experienced neuroradiologists (C.G., M.S.) by consensus. The examinations were evaluated on a PACS workstation (Centricity Radiology R 1000, GE Healthcare, IL, USA). Image sets for each patient comprised source images of the two MRA techniques, 3D maximum-intensity-projections (MIP) of the TOF-MRA data, MPR of the CE-MRA data, catheter angiograms in two standard projections, data of the 3D rotational angiogram images (since 2008) or catheter angiograms in four planes (until 2008; this applied to 272 image sets). In case of a residual or recurrent aneurysm dimensions were documented. Furthermore, remnants visible in the initial DSA after treatment and recurrences or persistent remnants visible in the follow-up DSA were classified according to the classification of Raymond [4,5–8]. Further parameters assessed were aneurysm location, devices used for treatment other than coils, i.e. stents or flow diverters, field strength of the MR-scanner, patients’ age, number of previous recoilings and the time interval between treatment and first follow-up examination. To compare the techniques, maximum recurrence size in two dimensions was assessed for DSA and both MRA-techniques. Values from all three techniques were rounded to the nearest decimal point starting with one millimeter as the size of minimal recurrence. Their mean values, standard deviations, maximum and minimum values were determined. For analyzing size differences between DSA and MRA of those recurrences that required retreatment Wilcoxon signed-rank test was used. Finally, the proportion of cases was evaluated in which results from DSA changed treatment decisions based on the findings of the MRA-techniques alone.

3. Results

In total 489 follow-up examinations of endovascular treated intracranial aneurysms of a total of 430 consecutive patients (315 women and 115 men) treated between 2003 and 2012 were reviewed retrospectively. The patients’ age ranged from 20 to 82 years (mean ± standard deviation, 50.75 ± 11.12 years). Among the 430 patients 171 had suffered subarachnoid hemorrhage. The remaining 259 patients had unruptured aneurysms. In 283 patients only one aneurysm was detected, in 90 patients two, in 35 patients three, in eight patients four, in eight patients five, in four patients six, in one patient seven and in another one patient 13 aneurysms.

In total, 429 first follow-up examinations were performed exactly six month after coiling and 60 at a later stage due to several reasons. In these 60 cases the minimum time interval was 7 month and the maximum interval was 46 month (mean ± standard deviation, 12.72 ± 7.05; median 10.5).

Among all follow-up examinations 346 treated aneurysms were located in the anterior circulation and 143 in the posterior circulation (for more detailed information Table 3 is provided in the Supplementary material). The smallest aneurysm (1.5 × 1 mm) was located at the callosomarginal artery, the largest (33 × 21 mm) at the right internal carotid artery.