Changes Over Time in Intracranial Aneurysms Monitored with MRA/I

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INTRODUCTION: Intracranial aneurysms pose a substantial risk for subsequent neurological events. These can result from aneurysm rupture resulting in hemorrhagic stroke or from mass effect generated by the enlarging aneurysm pressing on critical brain structures. There is little knowledge about the rate of progression of untreated aneurysms as it relates to aneurysm location, size, or other anatomical or biophysical parameters. An important reason for this is the lack of reliable and accurate non-invasive imaging methods that can be used to monitor this disease over time. We report here on the use of 3D MRA/I methods that were used to evaluate the progression of disease in patients with intracranial aneurysms where no intervention was planned, either because of unfavorable treatment options or because of patient choice.

METHODS: 32 patients with 35 aneurysms of the intracranial circulation were recruited for serial imaging using an IRB-approved protocol. Patients were imaged at baseline and then in intervals that ranged between 6 months and 1 year. Of the 32 patients, 1 had 4 follow-up studies, 6 had 3 follow-up studies, 3 had 2 follow-up studies, and the remaining 22 had one follow-up study. This results in a total of 50 interval measurements. At each imaging session MRA and MRI studies were conducted to assess the lumenal volume and whether there was any thrombus present in these aneurysms [1,2]. The MRA study used was a contrast-enhanced 3D acquisition with a parallel acceleration factor of 2 resulting in high-resolution (0.6 x 0.63 x 1.2 mm) CE-MRA images of the cerebral vessels. The MRI study used was a 3D balanced steady state free precession sequence with orientation and resolution selected to match the CE-MRA study.

Serial MR studies were co-registered using internal fiducial markers. Consistent threshholding was imposed by requiring that a reference segment of undiseased vessel maintained the same lumenal volume over time. The lumenal volume of the aneurysmal segment was then assessed on the CE-MRA studies for regional and global changes (Figure 1). In addition, the balanced steady state images were evaluated to identify the presence of thrombus within the vessel wall (Figure 2).

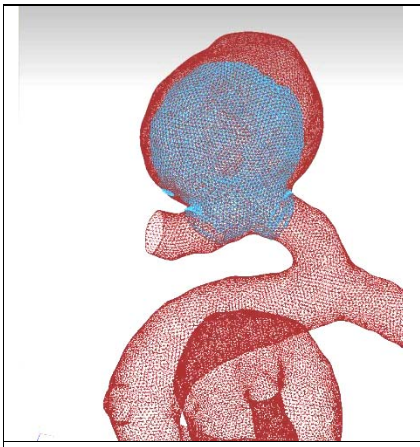

Fig. 1: Saccular ACA aneurysm showing growth on repeated CE-MRA studies from baseline (blue) to one-year follow-up (red)

Fig 2: Fusiform basilar aneurysm. Lumenal surface from CE-MRA (red) and juxta-lumenal thrombus from balanced steady-state MRI (yellow)

Changes in volume of the aneurysmal segment were calculated as a percentage of the baseline volume and were normalized on an annualized basis (Table 1). Previous studies have indicated that measurement error is typically less than 5%, and changes in volume were tabulated in 5% increments so that aneurysms were considered essentially unchanged if measured differences were between -5% to 5% of baseline.

RESULTS: The analysis of changes in lumenal volume as determined from the CE-MRA studies, is shown in Table 1. Of the interval measurements, 36% were consistent, within measurement error, with no change in aneurysm status. 30% showed a decrease in lumenal volume. In those cases, a review of the balanced steady state data confirmed that a decrease in lumenal volume only occurred when there was layering of thrombus in the lumen, and that the outer wall of the aneurysm either remained unchanged or showed an increase in volume. In 8% of cases, the lumenal volume increased by more than 5% but less than 10%, and in the remaining26% of cases, lumenal changes were found to be greater than 10%.

	<-5%	-5% to 5%	>5%	>10%
Basilar	4	2	1	6
Vertebral	5	2	1	0
ICA fusiform	1	4	1	0
ICA saccular	3	3	1	4
ACA	0	3	0	1
MCA	2	4	0	2

Table 1. Number of aneurysms showing change by location of aneurysm, and percentage change of volume for each of the 50 interval studies

DISCUSSION: MR provides a minimally invasive means to monitor intracranial aneurysms affording the opportunity to determine their natural history in ways that have not been possible before. In particular, 3D analyses remove the limitations of traditional methods that utilize measurements of linear dimensions: Measurements that are difficult to perform on a consistent basis because of the difficulty of obtaining identical views and of determining the most relevant anatomical feature. MR also provides the ability to define the presence of thrombus which is not available on catheter angiography, and which was shown to be an important component in identifying morphological changes over time in this series of patients. This study indicates that aneurysms can show substantial growth rates independent of whether they present in the anterior or posterior circulation. We are conducting parallel studies that seek to correlate the location of growth with hemodynamic features such as wall shear stress. Definitive conclusions on that correlation, as a function of anatomic territory, require greater subject numbers and we continue to recruit subjects to that end.

REFERENCES: [1] Dispensa, BP et al *JMRI* 2007; 26:177–183 [2]; Boussel et al. JVIR 2011; In Press.