Environment of Aneurysms and Endovascular Considerations

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Intracranial, saccular (berry) aneurysms arise from metamerically distributed, parent artery segments located within subarachnoid cisternal compartments, wherein they develop and eventually manifest themselves clinically.

Aneurysms research has been traditionally dominated by luminal hemodynamics and underlying vascular geometry, applied extensively on in-vitro vascular models and on flow-sensitive neuroimaging techniques in-vivo to investigate aneurysm formation and "growth", aneurysmal shapes and secondary lobulations ("daughter sacs"), aneurysmal size and propensity of aneurysms for rupture.

Daily observation of aneurysms cases shows an almost infinite variability of aneurysm shapes and sizes across all locations, characteristic (repeatedly observable) shapes of aneurysms at certain locations, usually different shapes and sizes of aneurysms at mirror locations, rare or absent occurrence of surface irregularities and "daughter sac" formation at certain aneurysm locations as opposed to other aneurysm locations with frequent occurrence of surface irregularities and of mono- or multilobular "daughter sac" formation, great variability in the orientation of the main axis of the fundus of aneurysms arising at the same location, great variability of "daughter sac" morphology and of indentations on the aneurysmal sac surface as well as a variable evolution of aneurysmal shapes and sizes over time.

Attempts at explaining these observations exclusively with the underlying vascular geometry and intrinsic luminal hemodynamics proved inadequate, prompting the consideration of

mural factors of aneurysmal pathobiology (i.e. segmental vulnerability and aneurysmal vasculopathy) as well as of extrinsic factors related to the perianeurysmal subarachnoid space in the investigation of aneurysmal morphology, phenomenology and dynamic behavior.

In the past five years we investigated the anatomy of the basal subarachnoid space, its compartmentalization into distinct apposing cisterns intercommunicating through characteristic entry and exit sites (openings), the subcompartmentalization of cisterns by characteristic intracisternal arachnoid membranes of loose network, dense network or true membranous texture and the intrinsic architectonic organization of the intracisternal compartmental and subcompartmental innervated trabecula, which stabilize the position of cisternal arterial segments in relation to the cisternal walls, the position and configuration of the cisternal arterial segments and the position and configuration of branches arising from the main arterial segments, by correlating anatomic dissection studies with advanced 3 Tesla-MR-cisternographic techniques performed in-vivo. In a second step, we correlated 3D-CTA, 3D-MRA, 3D-DSA visualizations as well as intraoperative demonstrations of unruptured and of ruptured aneurysms with the corresponding anatomic disposition of the individual subarachnoid cisternal subcompartment occupied by the aneurysm.

Here we show, that 1) the orientation, thickness, texture and strength of intracisternal arachnoid membranes determine the orientation of the main fundus axis mostly irrespective of the underlying vascular geometry pattern and

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contribute to the basic shape of aneurysms, 2) the architectonic arrangement of intracisternal perianeurysmal trabecula of the various types being in contact with the aneurysmal adventitia influences the aneurysmal configuration and the direction of intracisternal aneurysms extension, 3) characteristic tough diagonal or transverse arachnoid bands in certain cisterns, such as the lateral Sylvian, the carotid, the interpeduncular and premedullary cisterns, create marked short, long or circumferential extrinsic indentations on the outer aneurysm wall thus influencing the shape of the aneurysmal fundus and the number of aneurysmal lobes as well as the configuration and number of bulging parts, secondary lobulations and blebs, 4) in the early acute phase of SAH, contraction of innervated trabecula inserting on the aneurysmal adventitia elicited by the exiting "blood jet" and distortion/stretching of trabecula in contact with the aneurysm wall caused by the intertrabecularly deposited blood clots may deform or "strangulate" the fundus of the ruptured aneurysm thus altering temporarily its shape and decreasing its size. Endovascular treatment performed during this phase will be based on selection of smaller coils. Later relaxation of contracted of stretched trabecula will re-establish the original size and shape of the coiled aneurysms. This phenomenon may explain the observed and re-

ported significantly higher recanalization rate of aneurysms treated in the early acute phase of SAH as compared with the recanalization rates of aneurysms treated later or in the unruptured stage.

We conclude, that the compartmentalized perianeurysmal subarachnoid space and its complex intrinsic arachnoid-membranous and trabecular architectonic organization influence significantly the morphology and phenomenology of unruptured and ruptured aneurysms as well as the dynamic aneurysms behavior observed during the acute phase of SAH. We recommend consideration of these factors in the indication for, timing of and technique selection for the endovascular treatment of unruptured and ruptured aneurysms.

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