ON-LINE APPENDIX

Hemodynamic and Geometric Characterization

The aneurysmal hemodynamic environment was characterized by identifying different regions of the vascular geometry. First, the aneurysm neck was interactively delineated by joining selected points along lines of minimum geodesic distance along the surface. Then the aneurysm orifice was triangulated and used to split the volume into "aneurysm" and "parent artery" regions. The parent artery was further subdivided into a "near-vessel" region with a maximum distance to the neck of <1 cm, and a "far-vessel" region. After labeling the different regions of the vascular model, we calculated several variables over the aneurysm surface, orifice, and aneurysm volume to describe different characteristics of the wall shear stress distribution, the aneurysm inflow, and the intrasaccular flow pattern. A list of the hemodynamic and geometric variables considered in this work along with their meaning and definition is found in the On-line Tables 1–4. Further details and mathematic formulas to compute these variables are provided by Mut et al,[16] Cebral et al,[31] and Byrne et al.[17]

On-line Table 1: List of variables used to characterize and compare the aneurysmal WSS distribution between ruptured and unruptured aneurysms in patients with multiple aneurysms

WSS Distribution Characteristics		
Variable	**Units**	**Definition**
WSSmin	dyne/cm^2	Minimum WSS magnitude over aneurysm region and cardiac cycle[16,31]
WSSmax	dyne/cm^2	Maximum WSS magnitude over aneurysm region and cardiac cycle[16,31]
WSSmean	dyne/cm^2	WSS magnitude averaged over aneurysm region and cardiac cycle[16,31]
WSSnorm	1	WSSmean normalized with WSS averaged over near-vessel region (1 cm from neck) and cardiac cycle[16,31]
SCI	1	Total (integral) of WSS over regions of high WSS (>1 SD from the mean WSS over the near vessel) normalized with the mean aneurysm WSS and divided by the area of the high WSS region normalized with the aneurysm area[16,31]
LSA	%	Percentage of the aneurysm area that has WSS magnitude below 1 SD of the WSS averaged over the near-vessel region[16,31]
OSImax	1	Maximum OSI over the aneurysm region[16,31]
OSImean	1	OSI averaged over the aneurysm region[16, 31]

Note:—LSA indicates percentage area under low WSS; SCI, shear concentration index; norm, normal.

On-line Table 2: List of variables used to characterize and compare the aneurysm inflow jets between ruptured and unruptured aneurysms in patients with multiple aneurysms

Inflow Jet Characteristics		
Variable	**Units**	**Definition**
Q	mL	Inflow rate into the aneurysm across its orifice, averaged over the cardiac cycle[16,31]
ICI	1	

Note:—Q indicates aneurysm flow rate; ICI, inflow concentration index.

On-line Table 3: List of variables used to characterize and compare the intrasaccular flow patterns between ruptured and unruptured aneurysms in patients with multiple aneurysms

Intrasaccular Flow Characteristics		
Variable	**Units**	**Definition**
Vmax	cm/s	Maximum velocity over the aneurysm region and averaged over the cardiac cycle[16,31]
VE	cm/s	Velocity averaged over the aneurysm region and the cardiac cycle[16,31]
SR	1/s	Shear rate magnitude (second invariant of shear rate tensor) averaged over the aneurysm region and the cardiac cycle[16,31]
VO	1/s	Vorticity magnitude averaged over the aneurysm region and the cardiac cycle[16,31]
CORELEN	cm	Total length of vortex core lines detected over the aneurysm region and averaged over the cardiac cycle, a measure of intra-saccular flow complexity[17]
PODENT	1	Entropy (relative partition) of the coefficients of the proper orthogonal decomposition of the aneurysm velocity field over 100 time instances of the cardiac cycle, a measure of intrasaccular flow stability[17]

Note:—Vmax indicates maximum flow velocity; VE, mean aneurysm velocity; VO, mean aneurysm vorticity; SR, shear rates.

On-line Table 4: List of variables used to characterize and compare the aneurysm geometry between ruptured and unruptured aneurysms in patients with multiple aneurysms

Aneurysm Anatomic Characteristics		
Variable	**Units**	**Definition**
Asize	cm	Maximum aneurysm size: maximum Euclidean distance between any 2 points on the aneurysm sac[16,31]
Nsize	cm	Maximum neck size: maximum Euclidean distance between any 2 points on the aneurysm neck[16, 1]
AR	1	Aspect ratio: aneurysm depth (maximum distance from the sac surface to the aneurysm orifice) divided by the maximum neck size[16,31]
Distality	1	See On-line Table 5

Note:—Asize indicates aneurysm maximum size; Nsize, neck maximum size; AR, aspect ratio (≤depth/neck size).

On-line Table 5: Definition of anatomic variable used to characterize the “distality” of the arterial segment containing the aneurysm

Anterior Circulation	Posterior Circulation	Distality
ICA–cavernous	VA–proximal	0.0
ICA–ophthalmic	VA–PICA	0.1
ICA–paraclinoid	BA–trunk	0.2
ICA–PcomA		0.3
ICA–ant. choroidal		0.4
ICA–bifurcation	BA–tip	0.5
MCA–M1	PCA–P1	0.6
ACA–A1		0.7
MCA–bifurcation		0.8
AcomA		0.9
MCA–M2/M3		1.0
ACA–A2/A3		1.0

Note:—ACA indicates anterior cerebral artery; ant., anterior; PcomA, posterior communicating artery; AcomA, anterior communicating artery; VA, vertebral artery; BA, basilar artery; PCA, posterior cerebral artery; PICA, posterior inferior cerebellar artery.